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OF THE

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FOR THE

FISCAL YEAR ENDED JUNE 30, 1897.

EIGHTEENTH ANNUAL REPORT

OF THE

UNITED STATES GEOLOGICAL SURVEY,

CHARLES D. WALCOTT, DIRECTOR.

PART V—Continued.

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1897.

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EIGHTEENTH ANNUAL REPORT

OF THE

UNITED STATES GEOLOGICAL SURVEY.

PART V (continued).—MINERAL RESOURCES OF THE UNITED STATES, 1896,
NONMETALLIC PRODUCTS, EXCEPT COAL.

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CONTENTS.

COKE, BY EDWARD W. PARKER.

	Page.
Introduction	659
Production of coke in the United States	661
Total number of coke works in the United States	667
Number of coke ovens in the United States	669
Number of ovens building in the United States	671
Production of coke from 1880 to 1896	672
Rank of coke-producing States	674
Value and average selling price of coke	676
Coal consumed in the manufacture of coke	680
Condition in which coal is charged into ovens	689
Imports	692
The coking industry by States	693
Alabama	693
Colorado	695
Georgia	697
Illinois	699
Indiana	700
Indian Territory	702
Kansas	703
Kentucky	704
Missouri	705
Montana	706
New Mexico	707
New York	708
Ohio	708
Cincinnati district	709
Ohio district	709
Total production of coke in Ohio	710
Pennsylvania	711
Connellsville district	717
Upper Connellsville district	721
Allegheny Mountain district	721
Clearfield-Center district	722
Broad Top district	723
Pittsburg district	724
Beaver district	726
Allegheny Valley district	726
Reynoldsville-Walston district	727
Blossburg district	729
Greensburg district	729
Irwin district	730
Tennessee	731
Texas	732
Utah	732
Virginia	733

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The coking industry by States—Continued.	Page.
Washington	734
West Virginia	736
Production by districts	737
Pocahontas Flat Top district	740
New River district	741
Kanawha district	741
Upper Monongahela district	742
Upper Potomac district	743
Wisconsin	744
Wyoming	745

PETROLEUM, BY F. H. OLIPHANT.

Important features of the year	747
Total production in the United States	747
Increase in Appalachian oil field	748
Increase in Lima, Ohio, oil field	748
Comparison of other States	748
Increase in stocks	749
Decrease in price	749
Production and value	750
Total production and value	750
Production by fields	751
Production of crude petroleum in the United States, 1859–1896	752
Exports	756
Foreign markets	759
Production by States and foreign countries	764
Appalachian oil field	764
Extension of the Appalachian oil field	764
New York	764
Pennsylvania	764
McKean County	764
Forest County	764
Butler County	764
Allegheny County	764
Washington County	764
Greene County	764
Southern Ohio	765
Monroe County	765
West Virginia	765
Tyler County	765
Pleasants County	765
Ritchie County	765
Wood County	765
Early production	766
Doddridge County	766
Wetzel County	766
Marion County	766
Monongalia County	767
Marshall County	767
Lewis County	767
Kentucky	767
Eastern Kentucky	767
Southern-central Kentucky	768
Tennessee	769
Production of the Appalachian oil field from 1889 to 1896	770

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Production by States and foreign countries—Continued.	Page.
Appalachian oil field—Continued.	
Production in the Appalachian oil field, by months	771
Average daily production of the Appalachian oil field from 1890 to 1896	772
Pipe-line runs in the Appalachian oil field in 1896	772
Shipments of oil from the Appalachian oil field	774
Stocks of petroleum in the Appalachian oil field	776
Prices of crude petroleum in the Appalachian oil field	777
Well records in the Appalachian oil field	782
Pennsylvania-New York oil field	790
Production	790
Shipments of petroleum from Pennsylvania and New York	797
Drilling wells in the Pennsylvania and New York oil regions	799
West Virginia	799
Lima field of Ohio and Indiana	803
Ohio	803
Lima district	807
Pipe-line runs in the Lima-Indiana field	809
Shipments from the Lima-Indiana field	810
Stocks of crude petroleum in the Lima-Indiana field	811
Prices of crude petroleum in the Lima-Indiana field	812
Well record in the Lima district	813
Eastern or Southern Ohio district	818
Pipe-line runs	820
Stocks of crude petroleum	822
Well records	823
Mecca-Belden district	827
Indiana	828
Production	830
Well records	831
Tennessee	835
Kentucky	838
Record of Bear Creek well, near Pine Knot, Whitley County	839
Colorado	810
California	841
Refining	845
Wyoming	846
Kansas	847
Texas	848
Missouri	849
Illinois	850
Indian Territory	850
Canada	851
Austria-Hungary	857
Galicia	857
Pipe lines	860
Refineries	860
Production	861
Roumania	865
Germany	869
Great Britain	871
Italy	873
India	876
Japan	877
Java	879
Sumatra	880

www.libtool.com.cn

Production by States and foreign countries—Continued. Page.
Russia ... 883
Wells and their production ... 886
Exports of Russian oil ... 890
Peru ... 891
Ecuador ... 892
Appendix ... 893

NATURAL GAS, BY F. H. OLIPHANT.

Introduction ... 895
Tests ... 898
Test of gas-pumping engine at Roystone, Pennsylvania ... 898
Performance of boilers burning petroleum as fuel at Laketon, Indiana. 899
Value of natural gas consumed in the United States ... 900
Consumption and distribution of natural gas ... 901
The record by States ... 905
Pennsylvania ... 905
Ohio ... 906
Indiana ... 907
Kentucky ... 910
Illinois ... 911
Kansas ... 911
California ... 912
New York ... 913
West Virginia ... 914
Colorado ... 915
Utah ... 915
Missouri, Arkansas, and Texas ... 916
Canada ... 916
Imports ... 918

ASPHALTUM, BY EDWARD W. PARKER.

Production ... 919
Imports ... 922
Asphalt from petroleum ... 922
Production by States ... 923
California ... 923
Bituminous deposits in Santa Barbara County ... 925
Kentucky ... 929
Oklahoma Territory ... 929
Texas ... 929
The asphalt deposits of western Texas, by T. W. Vaughan ... 930
Utah and Colorado ... 935
The chemistry of gilsonite ... 937
Production of asphaltum in France ... 945
Production of asphaltum in Germany ... 946
Production of ozocérite in Galicia ... 946
Statistics of Trinidad asphaltum ... 946

STONE, BY WILLIAM C. DAY.

Acknowledgments ... 949
Value of stone produced in 1895 and 1896 ... 949
Value of stone produced in 1896, by States ... 950
Granite ... 951
Value of the granite product, by States, from 1890 to 1896 ... 954
Electricity in stone quarries and yards ... 957

www.libtool.com.cn

	Page.
Granite—Continued.	
Pneumatic tools and compressed air	957
The granite industry in individual States	957
California	957
Colorado	957
Connecticut	957
Delaware	960
Georgia	960
Maine	961
Maryland	962
Massachusetts	964
Minnesota	966
Missouri	966
Nevada	969
New Hampshire	969
New Jersey	970
New York	970
North Carolina	970
Oregon	971
Pennsylvania	973
Rhode Island	974
South Carolina	974
South Dakota	974
Vermont	974
Virginia	974
Wisconsin	974
Marble	975
Value of the marble products, by States	975
California	978
Colorado	978
Georgia	980
Idaho	980
Iowa	980
Maryland	980
Massachusetts	980
New York	981
Pennsylvania	981
Tennessee	981
Vermont	984
New Discoveries	986
Arizona	987
Idaho	987
Massachusetts	987
Utah	991
West Virginia	992
Slate	992
The slate industry in the various States	997
California	997
Georgia	997
Maine	998
Maryland	998
Massachusetts	999
Minnesota	999
New Jersey	1000
New York	1000
Pennsylvania	1000

www.libtool.com.cn

	Page.
Slate—Continued.	
The slate industry in the various States—Continued.	
Tennessee	1001
Vermont	1001
Virginia	1002
Tests of slate	1002
Welsh slate quarries	1009
Sandstone	1012
The sandstone industry in the various States	1015
Arizona	1015
California	1016
Colorado	1017
Connecticut	1017
Idaho	1022
Illinois	1022
Indiana	1022
Iowa	1023
Kansas	1023
Maryland	1023
Massachusetts	1023
Michigan	1023
Minnesota	1023
Missouri	1023
Montana	1023
New Jersey	1024
New York	1024
North Carolina	1024
Ohio	1025
Pennsylvania	1025
Brownstones of Pennsylvania, by T. C. Hopkins	1025
South Dakota	1043
Tennessee	1043
Texas	1043
Utah	1043
Washington	1043
West Virginia	1043
Wisconsin	1043
Wyoming	1043
Limestone	1043
The limestone product, by States, from 1890 to 1896	1045
Alabama	1047
Arizona	1048
Arkansas	1048
California	1048
Colorado	1049
Connecticut	1049
Florida	1049
Georgia	1049
Idaho	1049
Illinois	1049
Indiana	1049
The Bedford oölitic limestone, by T. C. Hopkins and C. E. Siebenthal	1050
Iowa	1058
Kansas	1058
Kentucky	1058

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Limestone—Continued. Page.
The limestone product, by States, from 1890 to 1896—Continued.
Maine ... 1058
Maryland ... 1058
Massachusetts ... 1059
Michigan ... 1059
Minnesota ... 1060
Missouri ... 1060
Montana ... 1061
Nebraska ... 1061
New Jersey ... 1061
New York ... 1061
Ohio ... 1063
Pennsylvania ... 1064
Rhode Island ... 1066
South Carolina ... 1066
South Dakota ... 1066
Tennessee ... 1066
Texas ... 1066
Utah ... 1067
Vermont ... 1067
Virginia ... 1067
Washington ... 1067
West Virginia ... 1067
Wisconsin ... 1068

SOAPSTONE, BY EDWARD W. PARKER.

Occurrence ... 1069
Production ... 1069
Fibrous talc ... 1071
The talc deposits of St. Lawrence County, New York ... 1072
Imports ... 1074
Canadian production ... 1074

STATISTICS OF THE CLAY-WORKING INDUSTRIES IN THE UNITED STATES IN 1896, BY JEFFERSON MIDDLETON.

Brick and tile ... 1077
Introduction ... 1077
Production ... 1077
Pottery ... 1099
Introduction ... 1099
Production and value ... 1099
Imports ... 1103

THE CLAY-WORKING INDUSTRY IN 1896, BY HEINRICH RIES.

Structural materials ... 1105
The tile industry ... 1106
Paving brick ... 1107
Tests of paving brick ... 1107
Specifications for abrasion test ... 1109
Specifications for absorption test ... 1110
Specifications for cross-breaking tests ... 1110
Specifications for crushing test ... 1111
Effect of structure on wearing power ... 1111
Tests of building and other brick ... 1112
Tests of paving brick made at Peoria, Illinois ... 1117

www.libtool.com.cn

	Page.
Fire brick	1119
Pottery and pottery clays	1120
Chromolithography in ceramics	1121
The testing of clays	1122
Seger's cones	1124
Deposits of useful clay	1127
Alabama	1127
California	1130
Colorado	1131
Brick clays	1132
Fire clays and pottery clays	1134
Vitrified wares	1137
Refractory wares	1137
Indiana	1138
Iowa	1139
Missouri	1140
New York	1144
Ohio	1145
Wyoming	1145
Literature	1146
Clay analyses	1147
CEMENT.	
Portland cement, by Spencer B. Newberry	1169
Production	1169
Imports	1171
Relation of domestic production to importation	1173
The Portland cement industry in the various States	1174
Arkansas	1174
Michigan	1175
Ohio	1175
Materials	1175
Processes	1175
Imitation Portland cements	1176
Proposed standard specifications for cement testing	1176
Rock cement, by Uriah Cummings	1178
Production and price	1178
Consumption	1179
Standards of weight	1179
Tests	1180
Imports	1181
PRECIOUS STONES, BY GEORGE F. KUNZ.	
Introduction	1183
Diamonds	1183
Genesis of the diamond	1191
Ruby	1197
North Carolina	1197
Burma	1197
Sapphire	1199
Montana	1199
Burma	1202
Beryl and emerald	1203
Topaz	1203
Tourmaline	1204

www.libtool.com.cn

Page.
Chrysolite 1204
Garnet 1204
Quartz 1204
Amethyst 1205
Chrysoprase 1207
Agate 1207
Opal 1208
Turquoise 1209
Jadeite 1211
Wardite 1211
Smithsonite 1212
Amber 1212
Use of gems 1213
Gem literature 1215
Production in the United States 1217

ABRASIVE MATERIALS, BY EDWARD W. PARKER.

Buhrstones 1219
Production 1219
Imports 1221
Grindstones 1222
Occurrence 1222
Production 1222
Imports 1223
Canadian production 1224
Oilstones and whetstones 1224
Production 1224
Imports 1227
Corundum and emery 1227
Production 1227
Imports 1228
Infusorial earth 1229
Occurrence 1229
Production 1229
Garnet 1230
Quartz crystal 1231
Tripoli 1231

PHOSPHATE ROCK.

Production 1233
South Carolina 1234
Florida 1237
Tennessee 1238
Imports 1242

SULPHUR AND PYRITES, BY EDWARD W. PARKER.

Sulphur 1243
Production 1243
Domestic consumption 1244
Review of the industry 1245
Prices 1247
Imports 1248
Exports of Sicilian sulphur 1255
Ports in the United States receiving Sicilian sulphur 1256

www.libtool.com.cn

	Page.
Pyrites	1259
Production	1259
Imports	1260
Consumption	1261
Occurrences in the United States	1261
GYPSUM, BY EDWARD W. PARKER.	
Occurrence	1263
Production	1265
Imports	1268
The chemical composition of some Kansas gypsums	1269
SALT, BY EDWARD W. PARKER.	
Production	1273
Establishments and processes	1276
Production in previous years	1278
Review of the industry in 1896	1281
Imports and exports	1282
History of salt making in the United States	1288
New York	1290
Onondaga district	1290
Sale of lands on the Onondaga salt springs reservation	1291
Moneys arising from sale	1292
Amount of salt inspected	1293
Warsaw district	1294
Genesee district	1295
Ithaca or southern New York district	1295
Rock-salt mining	1296
Louisiana	1296
West Virginia	1298
Ohio	1301
Michigan	1303
Kansas	1306
Brine salt	1306
Rock salt	1307
Texas	1309
California	1309
Utah	1312
FLUORSPAR AND CRYOLITE, BY EDWARD W. PARKER.	
Fluorspar	1315
Production	1315
Cryolite	1316
Imports	1316
MICA, BY EDWARD W. PARKER.	
Production	1317
Imports	1318
Uses	1318
Review of the industry	1319
ASBESTOS, BY EDWARD W. PARKER.	
Production	1323
Imports	1324
Canadian production	1325

www.libtool.com.cn

Page.
Some uses for asbestos 1326
Asbestos mining and dressing 1329
Asbestos in South Africa 1331

GRAPHITE.

Production 1332
Imports 1332
Uses 1334

MINERAL PAINTS, BY EDWARD W. PARKER.

Minerals used as pigments 1335
Production 1336
Ocher, umber, and sienna 1337
Production 1337
Imports 1340
Metallic paint 1341
Venetian red 1343
Slate as a pigment 1343
White lead, etc 1344
Production 1344
Imports 1346
Prices 1347

BARYTES, BY EDWARD W. PARKER.

Production 1348
Imports 1349

FULLER'S EARTH.

New discoveries 1351
Development and production 1351
South Dakota 1351
Nebraska 1353
Colorado 1353
New Mexico 1354
New York 1354
Indian Territory 1354
Florida 1356
Georgia 1359

LITHOGRAPHIC STONE.

Occurrence 1361
Prices 1362
Imports 1363

FELDSPAR AND QUARTZ, BY HEINRICH RIES.

Feldspar 1365
Connecticut 1365
Maine 1365
Missouri 1365
New York 1366
Pennsylvania 1367
Quartz 1367

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MINERAL WATERS, BY ALBERT C. PEALE.

	Page.
Production	1369
List of commercial springs	1376
Alabama	1376
Arkansas	1376
California	1376
Colorado	1376
Connecticut	1377
District of Columbia	1377
Florida	1377
Georgia	1377
Idaho	1377
Illinois	1377
Indiana	1377
Iowa	1378
Kansas	1378
Kentucky	1378
Louisiana	1379
Maine	1379
Maryland	1379
Massachusetts	1379
Michigan	1380
Minnesota	1380
Mississippi	1380
Missouri	1380
Montana	1380
Nebraska	1381
New Hampshire	1381
New Jersey	1381
New Mexico	1381
New York	1381
North Carolina	1382
Ohio	1382
Oregon	1382
Pennsylvania	1382
Rhode Island	1383
South Carolina	1383
South Dakota	1383
Tennessee	1383
Texas	1383
Utah	1384
Vermont	1384
Virginia	1384
Washington	1385
West Virginia	1385
Wisconsin	1385
Imports and exports	1387

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COKE.

By Edward W. Parker.

[The ton used in this report is uniformly the short ton of 2,000 pounds.]

INTRODUCTION.

In the preceding volumes of Mineral Resources the annual reports on the manufacture of coke, as well as those on the production of crude petroleum and natural gas, were prepared by Mr. Joseph Dame Weeks, of Pittsburg, Pa. The sudden death of Mr. Weeks on December 26, 1896, necessitated the distribution of the work formerly done by him among his former associates in the statistical division of the Geological Survey. The preparation of the report on the manufacture of coke for 1896 has accordingly devolved upon the writer. To have accepted such an undertaking under ordinary circumstances would have meant the entering upon a difficult task. In the matter of coke production it has been made comparatively easy by the thoroughness with which Mr. Weeks has already covered the ground. The work done by Mr. Weeks in his reports for the Tenth and Eleventh Censuses and the annual volumes of Mineral Resources have left little for his successor but the continuation of the statistical tables and the preparation of such text as refers directly to them. Mr. Weeks, at the time of his death, had the work for collecting the statistics of coke production in 1896 well advanced, and the excellence of his system and methods have been shown in the fact that the work of collecting the statistics was carried out on his lines uninterruptedly.

Mr. Weeks, during his connection with the Geological Survey, was assisted by Miss Belle Hill, also of Pittsburg. The writer desires to acknowledge here the invaluable assistance rendered by Miss Hill in the collection of reports from producers and in the preparation of the statistical tables contained in this report. Miss Hill's long association with Mr. Weeks has made her thoroughly familiar with all the details of his office work, and this, more than anything else, has made it possible to have the report on coke ready for the printer in reasonable time. In addition to the coke report Miss Hill has also prepared the statistical tables relating to the production of petroleum and natural gas.

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The present report will be of a character nearly uniform with the preceding ones. The plan adopted by Mr. Weeks was to limit the use of the word "coke" to that kind of coke which is made from bituminous coal in pits, ovens, retorts, etc., and which for convenience may be termed "oven coke." The statistics and text in no way refer to the product of coke made in the manufacture of illuminating gas, and which may be termed "gas coke;" that is to say, only that coke is considered which is primary product in the manufacture. By-product coke is not coke so far as these reports are concerned.

In one particular only has any change been made in this report as compared with preceding ones. This relates to the definition of the word "establishments." In previous reports an "establishment" was usually considered to cover all ovens and banks of ovens under one general management. In the present chapter an "establishment" means a separate report. Each oven or bank of ovens from which a separate report is received is considered a separate establishment. This makes the number of establishments seem unusually large for 1896—nearly 30 per cent over 1895—whereas the increase in the number of ovens was only 3 per cent.

The coal used in coking in the United States is mined from all five of its great coal fields: (1) The Appalachian; (2) the Central; (3) the Western; (4) the Rocky Mountain, and (5) the Pacific Coast. With the exception of that made from the coals of the Appalachian field, however, the tonnage of coke produced in the United States is quite small, but 445,473 tons of the total of 13,333,714 tons made in 1895, or about 3.34 per cent, and 553,863 tons out of 11,788,773 tons, or 4.7 per cent in 1896, being produced outside of this field. While the production in the fields outside of the Appalachian region is quite small in percentage, it is really a growing one, the amount there made in 1895 being somewhat larger than the amount produced in 1893 or 1894, and still larger in 1896 than in 1895. The production of coke increased in nine States outside of the Appalachian field in 1896 and decreased in four.

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PRODUCTION OF COKE IN THE UNITED STATES.

In the following table will be found a statement of the production of coke in the United States in 1896, by States, followed, for purposes of comparison, by similar tables for 1895 and 1894:

Manufacture of coke in the United States, by States and Territories, in 1896.

State or Territory.	Establishments.	Ovens.		Coal used.	Yield of coal in coke.	Coke produced.	Total value of coke.	Value of coke per ton.
		Built.	Building.					
				Short tons.	*Per ct.*	*Short tons.*		
Alabama	24	5,363	0	2,573,713	57.5	1,479,437	$3,064,960	$2.07
Colorado (*a*)	11	*b* 1,275	0	639,238	56.9	363,760	1,046,306	2.88
Georgia	1	334	0	109,655	49	53,673	68,486	1.276
Illinois	3	127	0	3,900	66.7	2,600	5,200	2.00
Indiana	2	94	0	8,956	49	4,353	8,647	1.99
Indian Territory	2	130	0	53,028	40	21,021	73,574	3.50
Kansas	6	55	0	8,940	53.5	4,785	8,676	1.813
Kentucky	4	264	0	55,719	48.6	27,107	42,062	1.55
Missouri	3	7	0	4,471	55.9	2,500	4,131	1.65
Montana	3	303	0	113,165	53	60,078	425,483	7.08
New Mexico	1	50	0	39,286	61.7	24,228	48,453	2.00
New York (*c*)	1	25	0	.....	.....	.....	.....	.....
Ohio	9	431	0	128,923	62.7	80,868	208,789	2.58
Pennsylvania (*d*)	158	26,658	154	11,124,610	66.1	7,356,502	13,182,859	1.792
Tennessee	15	1,861	100	600,379	56.5	339,202	624,011	1.84
Texas	1	60	0	0	0	0	0	0
Utah	1	104	0	.....	.....	*e* 20,447	.....	.....
Virginia	7	1,138	101	454,964	58.9	268,081	404.573	1.509
Washington	3	120	0	38,685	67	25,949	104,894	4.04
West Virginia	84	8,351	28	2,687,104	61.4	1,649,755	2,259,999	1.37
Wisconsin	1	120	0	8,648	62	5,332	21,000	3.94
Wyoming	1	74	0	41,038	47.6	19,542	58,626	3.00
Total	341	46,944	383	18,694,422	63	11,788,773	21,660,729	1.837

a Includes coal used, coke produced, and its value in Utah.
b Includes 36 gas retorts.
c Included with Pennsylvania.
d Includes coal used, coke produced, and its value in New York.
e Included with Colorado.

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In the following tables are given, by States, a statement of the production of coke in the United States in 1894 and 1895:

Manufacture of coke in the United States, by States and Territories, in 1895.

State or Territory.	Establishments.	Ovens.		Coal used.	Yield of coal in coke.	Coke produced.	Total value of coke.	Value of coke per ton.
		Built.	Building.					
				Short tons.	*Per ct.*	*Short tons.*		
Alabama	22	5,658	50	2,459,465	58.7	1,444,339	$3,033,521	$2.10
Colorado (*a*)	9	*b* 1,169	0	580,584	58.6	340,357	940,987	2.76
Georgia	1	330	0	118,900	50.6	60,212	70,580	1.17
Illinois	3	129	0	3,600	62.5	2,250	4,500	2.00
Indiana	2	94	0	9,898	48.5	4,804	9,333	1.94
Indian Territory	1	80	0	11,825	43.8	5,175	17,657	3.41
Kansas	5	55	0	8,424	62.8	5,287	11,289	2.14
Kentucky	5	293	0	63,419	40.1	25,460	37,249	1.46
Missouri	3	10	0	3,120	65	2,028	2,442	1.20
Montana	3	303	0	55,770	45.4	25,337	189,856	7.49
New Mexico	1	50	0	22,385	65.5	14,663	29,491	2.01
New York	1	12	13	22,207	83.4	18,521	.....	.....
Ohio	8	377	0	51,921	56	29,050	69,655	2.40
Pennsylvania	99	26,042	170	14,211,567	66.2	9,404,215	11,908,162	1.266
Tennessee	12	1,903	0	684,655	57.9	396,790	754,926	1.90
Texas	1	6	0	530	54	286	.....	.....
Utah	1	84	0	.....	.....	*c* 22,519	.....	.....
Virginia	5	832	350	410,737	59.6	244,738	322,564	1.32
Washington	3	110	0	22,973	65.9	15,129	64,632	4.27
West Virginia	78	7,834	55	2,067,816	61.6	1,285,206	1,724,239	1.34
Wisconsin	1	120	0	8,287	60	4,972	26,103	5.25
Wyoming	1	74	0	10,240	47.8	4,895	17,133	3.50
Total	265	45,565	638	20,848,323	64	13,333,714	19,234,319	1.44

a Includes Utah's production of coal and coke and value of same.
b Includes 36 gas retorts.
c Included with Colorado's coke production.

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Manufacture of coke in the United States, by States and Territories, in 1894.

State or Territory.	Establishments.	Ovens.		Coal used.	Yield of coal in coke.	Coke produced.	Total value of coke.	Value of coke per ton.
		Built.	Building.					
				Short tons.	*Per ct.*	*Short tons.*		
Alabama	22	5,551	50	1,574,245	58.7	923,817	$1,871,348	$2.025
Colorado (a)	8	b1,154	250	542,429	58.5	317,196	903,970	2.85
Georgia	1	338	0	166,523	55.9	93,020	116,286	1.25
Illinois	1	24	0	3,800	57.9	2,200	4,400	2.00
Indiana	2	94	0	13,489	48.6	6,551	13,102	2.00
Indian Territory	1	80	0	7,274	42	3,051	10,693	3.50
Kansas	6	61	0	13,288	63.5	8,439	15,660	1.855
Kentucky	6	293	0	66,418	44.8	29,748	51,566	1.73
Missouri	3	10	0	3,442	65.4	2,250	3,563	1.58
Montana	2	153	0	33,313	52.2	17,388	165,187	9.50
New Mexico	1	50	0	13,042	50	6,529	28,213	4.32
Ohio	8	363	0	55,324	59	32,640	90,875	2.78
Pennsylvania	101	25,824	118	9,059,118	66.9	6,063,777	6,585,489	1.086
Tennessee	11	1,860	0	516,802	56.6	292,646	480,124	1.64
Utah	1	83	0	.....	.....	c16,056	.....	.....
Virginia	2	736	100	280,524	64.2	180,091	295,747	1.84
Washington	3	84	0	8,563	61.2	5,245	18,249	3.48
West Virginia	78	7,858	60	1,976,128	60.4	1,193,933	1,639,687	1.373
Wisconsin	1	120	0	6,343	67	4,250	19,465	4.58
Wyoming	1	24	0	8,685	50	4,352	15,232	3.50
Total	259	44,760	578	14,348,750	64	9,187,132	12,328,856	1.34
New York	1	12	13	.....	.....	16,500	.....	.....
	260	44,772	591	.....	.....	9,203,632	.....	.....

a Includes Utah's production of coal and coke and value of same.
b Includes 36 gas retorts.
c Included with Colorado's coke production.

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As shown in the foregoing tables the production of coke in the United States during 1896 was 11,788,773 short tons, as compared with 13,333,741 tons in 1895 and 9,203,632 tons in 1894. Comparing the production in 1896 with that of 1895, it is seen that there was a decrease of 1,544,968 tons. But the year 1895 was one of excessive coke production—the largest in the history of coke making. The amount of pig iron smelted with coke, or a mixture of coke and anthracite coal, in 1895 was 9,164,365 tons against 6,314,891 tons smelted in 1894. This would readily account for the increase of over 4,000,000 tons in the amount of coke made in 1895 as compared with the preceding year, estimating 1½ tons of fuel to the ton of pig iron made. The amount of pig iron made with coke and with a mixture of coke and anthracite in 1896 was 8,201,216 tons, a decrease of 963,149 tons, nearly proportionate to the decrease in coke tonnage. But 1895 was an exceptional year. The preceding year (1894) was also exceptional by reason of its small production. Just as 1895 was the year of largest production, so 1894 was the year of smallest production in eight years. For better comparison an average of several years shows that the production of coke in 1896 was 782,334 tons more than the average of the four years next preceding and 911,132 tons more than the average of the seven years from 1889 to 1895, inclusive.

While Pennsylvania still maintains her supremacy as the principal coke producing State, her percentage of production was less than it has been in five years. In 1896 Pennsylvania yielded 62.4 per cent of the total; in 1895 she produced 70.5 per cent; in 1894, 65.9 per cent; in 1893, 65.7, and in 1892, 69 per cent. For the first time in several years Pennsylvania produced less than 65 per cent of the total. West Virginia recovered from her depression in 1895 and increased her percentage to 14 as compared with 9.6 the preceding year and 13 per cent in 1894. Alabama had 10 per cent of the product in 1894; 10.9 per cent in 1895, and increased her percentage in 1896 to 12.5. Alabama's actual production, however, increased only about 35,000 tons, or nearly 2.4 per cent. Colorado yielded a little over 3 per cent of the total in 1896, and Tennessee a little less than 3 per cent, reversing their positions and percentages in 1895. Virginia produced a little more than 2 per cent, about the same as in 1894 and 1895.

Comparing the production in 1895 and 1896 by States it will be seen that there were 14 States in which the production increased and 7 in which it decreased. This does not consider New York as a producer, the product for that State being included with Pennsylvania as the one establishment in New York will not permit the publication of the separate figures.

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The increases and decreases in the several States during 1896, as compared with 1895, are shown in the following table:

Increases and decreases in coke production, by States, in 1896 as compared with 1895.

INCREASES.

State.	Amount of increase.	Per cent of increase.	State.	Amount of increase.	Per cent of increase.
	Short tons.			*Short tons.*	
Alabama	35,098	2.43	Ohio	51,818	178.37
Colorado	25,475	8.01	Virginia	23,343	9.53
Illinois	350	15.56	Washington	10,820	71.52
Indian Territory	15,846	306.20	West Virginia	364,549	28.37
Kentucky	1,647	6.47	Wisconsin	360	7.24
Missouri	472	23.27	Wyoming	14,647	299.22
Montana	34,741	137.12	Total	588,731	.....
New Mexico	9,565	65.23			

DECREASES.

State.	Amount of decrease.	Per cent of decrease.	State.	Amount of decrease.	Per cent of decrease.
	Short tons.			*Short tons.*	
Georgia	6,539	10.86	Texas	286	100
Indiana	451	9.39	Utah	2,072	9.20
Kansas	502	9.5	Total	2,133,672	.....
Pennsylvania & New York	2,066,234	21.93	Net decrease	1,544,941	11.587
Tennessee	57,588	14.52			

While the output of coke in 1896 was 1,544,941 short tons less than in 1895, there was a marked increase in the value of the product. In 1895 13,333,714 tons of coke brought $19,234,319, an average of $1.44 per ton. The product of 11,788,773 tons in 1896 sold for $21,660,729, an average of $1.837 per ton. This was a gain over 1895 of $2,426,410. As Pennsylvania was responsible for 2,047,713 tons in the decrease column of the preceding table, she is also responsible for $1,274,697, or more than 50 per cent of the increase in value. West Virginia is to be given credit for an increase of $535,760. Montana's product increased $235,627 in value, though the average price declined from $7.49 to $7.08 per ton. The value of Ohio's output increased $139,134 and Colorado's a little more than $100,000.

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There were six States whose product of coke in 1896 exceeded 200,000 tons; five of these produced over 300,000 tons, and three produced over a million tons. The six States in order are Pennsylvania, West Virginia, Alabama, Colorado, Tennessee, and Virginia. The same statement in regard to the number of States producing more than 200,000, 300,000, and 1,000,000 tons applies to the record for 1895, but the order was different, viz, Pennsylvania, Alabama, West Virginia, Tennessee, Colorado, and Virginia. As will be seen, West Virginia displaces Alabama for second place, and Colorado exchanges fifth for fourth place with Tennessee. Pennsylvania, of course, remains in first and Virginia in sixth place. Outside of these six States production did not exceed 100,000 tons in any State.

In the following table are consolidated the statistics of the manufacture of coke in the United States from 1880 to 1896, inclusive:

Statistics of the manufacture of coke in the United States, 1880 to 1896, inclusive.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per ct.*
1880..	186	12,372	1,159	5,237,741	3,338,300	$6,631,267	$1.99	63
1881..	197	14,119	1,005	6,546,662	4,113,760	7,725,175	1.88	63
1882..	215	16,356	712	7,577,648	4,793,321	8,462,167	1.77	63
1883..	231	18,304	407	8,516,670	5,464,721	8,121,607	1.49	64
1884..	250	19,557	812	7,951,974	4,873,805	7,242,878	1.49	61
1885..	233	20,116	432	8,071,126	5,106,696	7,629,118	1.49	63
1886..	222	22,597	4,154	10,688,972	6,845,369	11,153,366	1.63	64
1887..	270	26,001	3,584	11,859,752	7,611,705	15,321,116	2.01	64
1888..	261	30,059	2,587	12,945,350	8,540,030	12,445,963	1.46	66
1889..	252	34,165	2,115	15,960,973	10,258,022	16,630,301	1.62	64
1890..	253	37,158	1,547	18,005,209	11,508,021	23,215,302	2.02	64
1891..	243	40,245	911	16,344,540	10,352,688	20,393,216	1.97	63
1892..	261	42,002	1,893	18,813,337	12,010,829	23,536,141	1.96	64
1893..	258	44,201	717	14,917,146	9,477,580	16,523,714	1.74	63.5
1894..	260	44,772	591	a14,348,750	9,203,632	a12,328,856	1.34	64
1895..	265	45,565	638	20,848,323	13,333,714	b19,234,319	1.44	64
1896..	341	46,944	383	18,694,422	11,788,773	21,660,729	1.837	63

a Excluding New York.

b Excluding New York and Texas.

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TOTAL NUMBER OF COKE WORKS IN THE UNITED STATES.

The following table gives the number of establishments manufacturing coke in the United States at the close of each year from 1880 to 1896, by States:

Number of establishments in the United States manufacturing coke on December 31 of each year from 1880 to 1896.

State or Territory.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
Alabama	4	4	5	6	8	11	14	15	18
Colorado	1	2	5	7	8	7	7	7	7
Georgia	1	1	1	1	1	2	2	2	1
Illinois	6	6	7	7	9	9	9	8	8
Indiana	2	2	2	2	2	2	4	4	3
Indian Territory	1	1	1	1	1	1	1	1	1
Kansas	2	3	3	4	4	4	4	4	6
Kentucky	5	5	5	5	5	5	6	6	10
Missouri	0	0	0	0	0	0	0	1	1
Montana	0	0	0	1	3	2	4	2	1
New Mexico	0	0	2	2	2	2	2	1	1
New York	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ohio	15	15	16	18	19	13	15	15	15
Pennsylvania	124	132	137	140	145	133	108	151	120
Tennessee	6	6	8	11	13	12	12	11	11
Texas	0	0	0	0	0	0	1	0	0
Utah	1	1	1	1	1	1	1	0	0
Virginia	0	0	0	1	1	1	2	2	2
Washington	0	0	0	0	1	1	1	1	3
West Virginia	18	19	22	24	27	27	29	39	52
Wisconsin	0	0	0	0	0	0	0	0	1
Wyoming	0	0	0	0	0	0	0	0	0
Total	186	197	215	231	250	233	222	270	261

State or Territory.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
Alabama	19	20	21	20	23	22	22	24
Colorado	9	8	7	9	8	8	9	11
Georgia	1	1	1	1	1	1	1	1
Illinois	4	4	1	1	1	1	3	3
Indiana	4	4	2	2	2	2	2	2
Indian Territory	1	1	1	1	1	1	1	2
Kansas	6	7	6	6	6	6	5	6
Kentucky	9	9	7	5	4	6	5	4
Missouri	3	3	3	3	3	3	3	3
Montana	2	2	2	2	2	2	3	3

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Number of establishments in the United States manufacturing coke on December 31 of each year from 1880 to 1896—Continued.

State or Territory.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
New Mexico	2	2	1	1	1	1	1	1
New York	.....	.....	.....	.....	1	1	1	1
Ohio	13	13	9	10	9	8	8	9
Pennsylvania	109	106	109	109	102	101	99	158
Tennessee	12	11	11	11	11	11	12	15
Texas	0	0	0	0	0	0	1	1
Utah	1	1	1	1	1	1	1	1
Virginia	2	2	2	2	2	2	5	7
Washington	1	5	2	3	3	3	3	3
West Virginia	53	55	55	72	75	78	78	84
Wisconsin	1	1	1	1	1	1	1	1
Wyoming	1	1	1	1	1	1	1	1
Total	253	253	243	261	258	260	265	341

According to the above table it would appear that the number of establishments increased largely in 1896. This is, however, not the case. Heretofore it has been customary to include under one establishment all coke works reported from one general office, and to consider them separate establishments when reported individually from the central office. In the statistics for 1896 the word establishment is used to designate the number of ovens or banks of ovens which were in operation, whether reported from one office or not. When one company reported production at two or more banks of ovens, each is considered a separate establishment.

The number of establishments in the country for each year since 1850 for which there are any returns is as follows:

Number of coke establishments in the United States since 1850.

Year.	Number.	Year.	Number.
1850 (census year)	4	1887, December 31	270
1860 (census year)	21	1888, December 31	261
1870 (census year)	25	1889, December 31	253
1880 (census year)	149	1890, December 31	253
1880, December 31	186	1891, December 31	243
1881, December 31	197	1892, December 31	261
1882, December 31	215	1893, December 31	258
1883, December 31	231	1894, December 31	260
1884, December 31	250	1895, December 31	265
1885, December 31	233	1896, December 31	341
1886, December 31	222		

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NUMBER OF COKE OVENS IN THE UNITED STATES.

The following table shows the number of coke ovens in each State and Territory on December 31 of each year from 1880 to 1895, together with the total number of ovens in the United States at the close of each of these years. In the earlier years covered by this table some coke was made in pits and on the ground, and in testing the adaptability of certain coals to the manufacture of coke this is still customary, though in the latter years but little of the coke reported as produced in the United States was made by any other method than in ovens. The statistics for 1896 show an interesting increase in the number of by-product ovens built. The first by-product ovens to be used in the United States were 12 Semet-Solvay ovens erected in New York. Two years later 60 Otto Hoffman ovens were built in Pennsylvania. The returns for 1896 show 13 Semet-Solvay ovens added to the plant in New York; 75 of the same design were built in Pennsylvania, and the latter State has also added 30 Newton-Chambers ovens and 3 Slocum ovens to her coke-making plants.

Number of coke ovens in the United States on December 31 of each of the years from 1880 to 1896.

State or Territory.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
Alabama	316	416	536	767	976	1,075	1,301	1,555	2,475
Colorado	200	267	344	352	409	434	483	532	602
Georgia	140	180	220	264	300	300	300	300	290
Illinois	176	176	304	316	325	320	335	278	221
Indiana	45	45	37	37	37	37	100	119	103
Indian Territory.	20	20	20	20	20	40	40	80	80
Kansas	6	15	20	23	23	23	36	39	58
Kentucky	45	45	45	45	45	33	76	98	132
Missouri	0	0	0	0	0	0	0	4	4
Montana	0	0	0	2	5	2	16	27	40
New Mexico	0	0	0	12	70	70	70	70	70
New York	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ohio	616	641	647	682	732	642	560	585	547
Pennsylvania	9,501	10,881	12,424	13,610	14,285	14,553	16,314	18,294	20,381
Tennessee	656	724	861	992	1,105	1,387	1,485	1,560	1,634
Texas	.....	.....	.....	.....	.....	.....	.....	.....	.....
Utah	20	20	20	20	20	20	20	0	0
Virginia	0	0	0	200	200	200	350	350	550
Washington	0	0	0	0	0	2	11	30	30
West Virginia	631	689	878	962	1,005	978	1,100	2,080	2,792
Wisconsin	0	0	0	0	0	0	0	0	50
Wyoming	0	0	0	0	0	0	0	0	0
Total	12,372	14,119	16,356	18,304	19,557	20,116	22,597	26,001	30,059

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Number of coke ovens in the United States on December 31 of each of the years from 1880 to 1896—Continued.

State or Territory.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
Alabama	3,944	4,805	5,068	5,320	5,548	5,551	5,658	5,363
Colorado	834	916	948	a1,128	a1,154	a1,154	a1,169	a1,275
Georgia	300	300	300	300	338	338	330	334
Illinois	149	148	25	24	24	24	129	127
Indiana	111	101	84	84	94	94	94	94
Indian Territory	78	78	80	80	80	80	80	130
Kansas	68	68	72	75	75	61	55	55
Kentucky	166	175	115	287	283	293	293	264
Missouri	9	10	10	10	10	10	10	7
Montana	90	140	140	153	153	153	303	303
New Mexico	70	70	b0	50	50	50	50	50
New York	.....	.....	.....	.....	c12	c12	c12	c25
Ohio	462	443	421	436	435	363	377	431
Pennsylvania	22,143	23,430	25,324	25,366	25,744	25,824	d26,042	d26,658
Tennessee	1,639	1,664	1,995	1,941	1,942	1,860	1,903	1,861
Texas	.....	.....	.....	.....	.....	.....	6	60
Utah	34	80	80	83	83	83	84	104
Virginia	550	550	550	594	594	736	832	1,138
Washington	30	30	80	84	84	84	110	120
West Virginia	3,438	4,060	4,621	5,843	7,354	7,858	7,834	8,351
Wisconsin	50	70	120	120	120	120	120	120
Wyoming	0	20	24	24	24	24	74	74
Total	34,165	37,158	40,057	42,002	44,201	44,772	45,565	46,944

a Includes 36 gas retorts.
b Coke was made in pits.
c Semet-Solvay ovens.
d Includes 60 Otto-Hoffmann ovens, 75 Semet-Solvay ovens, 30 Newton-Chambers ovens, and 8 Slocum ovens.

From the above table it will be seen that the number of ovens increased from 45,565 in 1895 to 46,944 in 1896, notwithstanding the decreased production of coke. A calculation based on this table and the one showing the production by States indicates that there was considerably more activity in some States than in others. In Pennsylvania and Alabama the number of tons of coke made per oven during the year was 275. In Colorado the average was 285 tons of coke per oven; West Virginia averaged 199; Tennessee 182, and Virginia about 240. The product per oven in Pennsylvania in 1895 was 361 tons; in Alabama 255 tons, and in West Virginia 164 tons. These averages were much higher than in 1894, when they were for Pennsylvania, 235; for Alabama, 166, and for West Virginia, 152.

Most of the coke ovens in the United States are of the solid wall type, in which coal is coked by heat generated in the oven itself. Most of these ovens are of the regular beehive shape. A few are somewhat

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modified in form, the oven being long and shaped like a muffle. Other ovens, while they retain the beehive form, have hollow tiles near the top, into which the air, previously heated, enters for combustion. As stated before, the use of by-product ovens is increasing, and it may not be very long before coke manufacturers will become convinced that the greatest economy in coke making is not to be accomplished by saving on the first cost. One hundred and eight by-product ovens were built in 1896, and, as will be seen in the table following, 120 ovens of the Otto-Hoffmann type were building at the close of the year.

NUMBER OF OVENS BUILDING IN THE UNITED STATES.

The following table gives the number of ovens actually in course of construction at the close of each year from 1880 to 1895. It should be understood that this table does not include the increase in the number of ovens during the year. It only gives the number of ovens actually in course of construction at the close of each year. It will be noted that the number in course of erection at the close of 1896 was 383. This is the smallest number of ovens building at the close of the year that has been reported since the volumes of Mineral Resources began.

Number of coke ovens building in the United States at the close of each of the years from 1880 to 1896.

State or Territory.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
Alabama	100	120	0	122	242	16	1,012	1,362	406
Colorado	50	0	0	0	24	0	0	0	100
Georgia	40	40	44	36	0	0	0	0	0
Illinois	0	0	0	0	0	0	0	0	0
Indiana	0	0	0	0	0	0	18	0	0
Indian Territory	0	0	0	0	0	0	0	0	0
Kansas	0	0	0	0	0	0	0	0	0
Kentucky	0	0	0	0	0	0	2	0	2
Missouri	0	0	0	0	0	0	0	0	0
Montana	0	0	0	0	12	0	0	0	0
New Mexico	0	0	12	28	0	0	0	0	0
New York									
Ohio	25	0	0	0	0	0	0	223	12
Pennsylvania	836	761	642	211	232	317	2,558	802	1,565
Tennessee	68	84	14	10	175	36	126	165	84
Texas	0	0	0	0	0	0	0	0	0
Virginia	0	0	0	0	0	0	100	300	0
Washington	0	0	0	0	0	0	21	0	100
West Virginia	40	0	0	0	127	63	317	742	318
Wisconsin	0	0	0	0	0	0	0	0	0
Wyoming	0	0	0	0	0	0	0	0	0
Total	1,159	1,005	712	407	812	432	4,154	3,594	2,587

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Number of coke ovens building in the United States at the close of each of the years from 1880 to 1896—Continued.

State or Territory.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
Alabama	427	371	50	90	60	50	50	0
Colorado	50	30	21	220	200	250	0	0
Georgia	0	0	0	0	0	0	0	0
Illinois	0	0	0	0	0	0	0	0
Indiana	0	0	0	0	0	0	0	0
Indian Territory	0	0	0	0	0	0	0	0
Kansas	0	0	0	0	0	0	0	0
Kentucky	100	303	24	100	100	0	0	0
Missouri	0	0	0	0	0	0	0	0
Montana	50	0	0	0	0	0	0	0
New Mexico	0	0	0	0	0	0	0	0
New York	.....	.....	.....	.....	.....	*a* 13	*a* 13	0
Ohio	0	1	0	0	0	0	0	0
Pennsylvania	567	74	11	269	19	118	*b* 170	*c* 154
Tennessee	40	292	0	0	0	0	0	100
Texas	0	0	0	0	0	0	0	0
Virginia	250	250	250	206	206	100	350	101
Washington	0	80	0	30	0	0	0	0
West Virginia	631	334	555	978	132	60	55	28
Wisconsin	0	0	0	0	0	0	0	0
Wyoming	0	0	0	0	0	0	0	0
Total	2,115	1,735	911	1,893	717	591	638	383

a Semet-Solvay.
b Includes 60 Otto-Hoffmann and 50 Semet-Solvay ovens.
c Includes 120 Otto-Hoffmann ovens.

PRODUCTION OF COKE FROM 1880 TO 1896.

The production of coke in the several States and Territories from 1880 to 1896 is shown in the following table:

Amount of coke produced, in short tons, in the United States from 1880 to 1896, inclusive, by States and Territories.

State or Territory.	1880.	1881.	1882.	1883.	1884.	1885.
Alabama	60,781	109,033	152,940	217,531	244,009	301,180
Colorado	25,568	48,587	102,105	133,997	115,719	131,960
Georgia	38,041	41,376	46,602	67,012	79,268	70,669
Illinois	12,700	14,800	11,400	13,400	13,095	10,350
Indiana	0	0	0	0	0	0
Indian Territory	1,546	1,768	2,025	2,573	1,912	3,584
Kansas	3,070	5,670	6,080	8,430	7,190	8,050
Kentucky	4,250	4,370	4,070	5,025	2,223	2,704

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Amount of coke produced, in short tons, in the United States from 1880 to 1896, inclusive, by States and Territories—Continued.

State or Territory.	1880.	1881.	1882.	1883.	1884.	1885.
Missouri	0	0	0	0	0	0
Montana	0	0	0	0	75	175
New Mexico	0	0	1,000	3,905	18,282	17,940
Ohio	100,596	119,469	103,722	87,834	62,709	39,416
Pennsylvania	2,821,384	3,437,708	3,945,034	4,438,464	3,822,128	3,991,805
Tennessee	130,609	143,853	187,695	203,691	219,723	218,842
Texas	0	0	0	0	0	0
Utah	1,000	0	250	0	0	0
Virginia	0	0	0	25,340	63,600	49,139
Washington	0	0	0	.....	400	311
West Virginia	138,755	187,126	230,398	257,519	223,472	260,571
Wisconsin	0	0	0	0	0	0
Wyoming	0	0	0	0	0	0
Total	3,338,300	4,113,760	4,793,321	5,464,721	4,873,805	5,106,696

State or Territory.	1886.	1887.	1888.	1889.	1890.	1891.
Alabama	375,054	325,020	508,511	1,030,510	1,072,942	1,282,496
Colorado	142,797	170,698	179,682	187,638	245,756	277,074
Georgia	82,680	79,241	83,721	94,727	102,233	103,057
Illinois	8,103	9,198	7,410	11,583	5,000	5,200
Indiana	6,124	17,658	11,956	8,301	6,013	3,798
Indian Territory	6,351	10,060	7,502	6,639	6,639	9,464
Kansas	12,493	14,950	14,831	13,910	12,311	14,174
Kentucky	4,528	14,565	23,150	13,021	12,343	33,777
Missouri	0	2,970	2,600	5,275	6,136	6,872
Montana	0	7,200	12,000	14,043	14,427	29,009
New Mexico	10,236	13,710	8,540	3,460	2,050	2,300
New York	.....	0	0	0	0	0
Ohio	34,932	93,004	67,194	75,124	74,633	38,718
Pennsylvania	5,406,597	5,832,849	6,545,779	7,659,055	8,560,245	6,954,846
Tennessee	368,139	396,979	385,693	359,710	348,728	364,318
Texas	0	0	0	0	0	0
Utah	0	0	0	761	8,528	7,949
Virginia	122,352	166,947	149,199	146,528	165,847	167,516
Washington	825	14,625	0	3,841	5,837	6,000
West Virginia	264,158	442,031	531,762	607,880	833,377	1,009,051
Wisconsin	0	0	500	16,016	24,976	34,387
Wyoming	0	0	0	0	0	2,682
Total	6,845,369	7,611,705	8,540,030	10,258,022	11,508,021	10,352,688

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Amount of coke produced, in short tons, in the United States from 1880 to 1896, inclusive, by States and Territories—Continued.

State or Territory.	1892.	1893.	1894.	1895.	1896.
Alabama	1,501,571	1,168,085	923,817	1,444,339	1,479,437
Colorado	365,920	346,981	301,140	317,838	343,313
Georgia	81,807	90,726	92,029	60,212	53,673
Illinois	3,170	2,200	2,200	2,250	2,600
Indiana	2,207	5,724	6,551	4,804	4,353
Indian Territory	3,569	7,135	3,051	5,175	21,021
Kansas	9,132	8,565	8,439	5,287	4,785
Kentucky	36,123	48,619	29,748	25,460	27,107
Missouri	7,299	5,905	2,250	2,028	2,500
Montana	34,557	29,945	17,388	25,337	60,078
New Mexico	0	5,803	6,529	14,663	24,228
New York	0	12,850	16,500	18,521	(*a*)
Ohio	51,818	22,436	32,640	29,050	80,868
Pennsylvania	8,327,612	6,229,051	6,063,777	9,404,215	*b* 7,356,502
Tennessee	354,096	265,777	292,646	396,790	339,202
Texas	0	0	0	286	0
Utah	7,309	16,005	16,056	22,519	20,447
Virginia	147,912	125,092	180,091	244,738	268,081
Washington	7,177	6,731	5,245	15,129	25,949
West Virginia	1,034,750	1,062,076	1,193,933	1,285,206	1,649,755
Wisconsin	33,800	14,958	4,250	4,972	5,332
Wyoming	0	2,916	4,352	4,895	19,542
Total	12,010,829	9,477,580	9,203,632	13,333,714	11,788,773

a Included with Pennsylvania.
b Includes production of New York.

RANK OF COKE-PRODUCING STATES.

The following table gives the relative rank of the States and Territories in the production of coke, from 1880 to 1896, inclusive:

Rank of the States and Territories in production of coke from 1880 to 1896.

State or Territory.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
Pennsylvania	1	1	1	1	1	1	1	1	1
West Virginia	2	2	2	2	3	3	4	2	2
Alabama	5	5	4	3	2	2	2	4	3
Colorado	7	6	6	5	5	5	5	5	5
Tennessee	3	3	3	4	4	4	3	3	4
Virginia	.....	.....	.....	8	7	7	6	6	6
Ohio	4	4	5	6	8	8	8	7	8

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Rank of the States and Territories in production of coke from 1880 to 1896—Continued.

State or Territory.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
Montana	.....	.....	.....	.....	15	15	.....	16	12
Georgia	6	7	7	7	6	6	7	8	7
Kentucky	9	10	10	11	12	13	14	12	9
Washington	.....	.....	.....	.....	14	14	15	11	10
New Mexico	.....	.....	12	12	9	9	10	13	14
Indian Territory	11	11	11	13	13	12	12	14	15
Utah	12	.....	13	.....	.....	.....	.....	.....	....
Wisconsin	.....	.....	.....	.....	.....	.....	.....	.....	18
Kansas	10	9	9	10	11	11	9	10	11
Indiana	.....	.....	.....	.....	.....	.....	13	9	13
Illinois	8	8	8	9	10	10	11	15	16
Missouri	.....	.....	.....	.....	.....	.....	.....	17	17
Texas	.....	.....	.....	.....	.....	.....	.....	.....	....

State or Territory.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
Pennsylvania	1	1	1	1	1	1	1	1
West Virginia	3	3	3	3	3	2	3	2
Alabama	2	2	2	2	2	3	2	3
Colorado	5	5	5	4	4	4	5	4
Tennessee	4	4	4	5	5	5	4	5
Virginia	6	6	6	6	6	6	6	6
Ohio	8	8	8	8	10	8	8	7
Montana	10	10	11	10	9	10	10	8
Georgia	7	7	7	7	7	7	7	9
Kentucky	12	11	10	9	8	9	9	10
Washington	17	17	16	15	16	16	13	11
New Mexico	18	19	20	.....	18	15	14	12
Indian Territory	15	14	13	16	15	19	16	13
Utah	19	13	14	13	11	12	11	14
Wyoming	.....	.....	19	.....	20	17	18	15
New York	.....	.....	.....	.....	13	11	12	16
Wisconsin	9	9	9	11	12	18	17	17
Kansas	11	12	12	12	14	13	15	18
Indiana	14	16	18	17	19	14	19	19
Illinois	13	18	17	18	21	21	20	20
Missouri	16	15	15	14	17	20	21	21
Texas	.....	.....	.....	.....	.....	.....	22	22

An inspection of the above table shows that the six chief coke-producing States have resumed the same relative positions they occupied in 1894. During 1895, owing to the strike in the Pocahontas region, West Virginia dropped from second to third place, but recovered

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second place in 1896. From 1888 to 1891, inclusive, Tennessee and Colorado occupied fourth and fifth places, respectively. Colorado took fourth place in 1892, and held it for three years; fell back to fifth place in 1895, and regained fourth position in 1896.

VALUE AND AVERAGE SELLING PRICE OF COKE.

In the following table is given the total value of coke produced in the United States in each year from 1880 to 1896, inclusive:

Total value at the ovens of the coke made in the United States in the years from 1880 to 1896, inclusive, by States and Territories.

State or Territory.	1880.	1881.	1882.	1883.	1884.	1885.
Alabama	$183,063	$326,819	$425,940	$598,473	$609,185	$755,645
Colorado	145,226	267,156	476,665	584,578	409,930	512,162
Georgia	81,789	88,753	100,194	147,166	169,192	144,198
Illinois	41,950	45,850	29,050	28,200	25,639	27,798
Indiana	0	0	0	0	0	0
Indian Territory	4,638	5,304	6,075	7,719	5,736	12,902
Kansas	6,000	10,200	11,460	16,560	14,580	13,255
Kentucky	12,250	12,630	11,530	14,425	8,760	8,499
Missouri	0	0	0	0	0	0
Montana	0	0	0	0	900	2,063
New Mexico	0	0	6,000	21,478	91,410	89,700
Ohio	255,905	297,728	266,113	225,660	156,294	109,723
Pennsylvania	5,255,040	5,898,579	6,133,698	5,410,387	4,783,230	4,981,656
Tennessee	316,607	342,585	472,505	459,126	428,870	398,459
Utah	10,000	0	2,500	0	0	0
Virginia	0	0	0	44,345	111,300	85,993
Washington	0	0	0	0	1,900	1,477
West Virginia	318,797	429,571	520,437	563,490	425,952	485,588
Wisconsin	0	0	0	0	0	0
Wyoming	0	0	0	0	0	0
Total	6,631,265	7,725,175	8,462,167	8,121,607	7,242,878	7,629,118

State or Territory.	1886.	1887.	1888.	1889.	1890.	1891.
Alabama	$993,302	$775,090	$1,189,679	$2,372,417	$2,589,447	$2,986,242
Colorado	569,120	682,778	716,305	643,479	959,246	896,984
Georgia	179,031	174,410	177,907	149,059	150,995	231,878
Illinois	21,487	19,594	21,038	29,764	11,250	11,700
Indiana	17,953	51,141	31,993	25,922	19,706	7,596
Indian Territory	22,229	33,435	21,755	17,957	21,577	30,483
Kansas	19,204	28,575	29,073	26,593	29,116	33,296

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Total value at the ovens of the coke made in the United States in the years from 1880 to 1896, inclusive, by States and Territories—Continued.

State or Territory.	1886.	1887.	1888.	1889.	1890.	1891.
Kentucky	$10,082	$31,730	$47,244	$29,769	$22,191	$68,281
Missouri	0	10,395	9,100	5,800	9,240	10,000
Montana	0	72,000	96,000	122,023	125,655	258,523
New Mexico	51,180	82,260	51,240	18,408	10,025	10,925
Ohio	94,042	245,981	166,330	188,222	218,090	76,901
Pennsylvania	7,664,023	10,746,352	8,230,759	10,743,492	16,333,674	12,679,826
Tennessee	687,865	870,900	490,491	731,496	684,116	701,803
Utah	0	0	0	3,042	37,196	35,778
Virginia	305,880	417,368	260,000	325,861	278,724	265,107
Washington	4,125	102,375	0	30,728	46,696	42,000
West Virginia	513,843	976,732	905,549	1,074,177	1,524,746	1,845,043
Wisconsin	0	0	1,500	92,092	143,612	192,804
Wyoming	0	0	0	0	0	8,046
Total	11,153,366	15,321,116	12,445,963	16,630,301	23,215,302	20,393,216

State or Territory.	1892.	1893.	1894.	1895.	1896.
Alabama	$3,464,623	$2,648,632	$1,871,348	$3,033,521	$3,064,960
Colorado	*a* 1,234,320	*a* 1,137,488	*a* 903,970	*a* 940,987	*a* 1,046,306
Georgia	163,614	136,089	116,286	70,580	68,486
Illinois	7,133	4,400	4,400	4,500	5,200
Indiana	6,472	9,048	13,102	9,333	8,647
Indian Territory	12,402	25,072	10,693	17,657	73,574
Kansas	19,906	18,640	15,660	11,289	8,676
Kentucky	72,563	97,350	51,566	37,249	42,062
Missouri	10,949	9,735	3,563	2,442	4,131
Montana	311,013	239,560	165,187	189,856	425,483
New Mexico	0	18,476	28,213	29,491	48,453
New York	.....	35,925	.....	.....	(*b*)
Ohio	112,907	43,671	90,875	69,655	208,789
Pennsylvania	15,015,336	9,468,036	6,585,489	11,908,162	*c* 13,182,859
Tennessee	724,106	491,523	480,124	754,926	624,011
Utah	.....	.....	.....	.....	(*d*)
Virginia	322,486	282,898	295,747	322,564	404,573
Washington	50,446	34,207	18,249	64,632	104,894
West Virginia	1,821,965	1,716,907	1,639,687	1,724,239	2,259,999
Wisconsin	185,900	95,851	19,465	26,103	21,000
Wyoming	0	10,206	15,232	17,133	58,626
Total	23,536,141	16,523,714	12,328,856	19,234,319	21,660,729

a Includes value of Utah coke.
b Included with Pennsylvania.
c Includes value of New York coke.
d Included with Colorado.

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While this table gives the totals of the value as returned in the schedules, the figures do not always represent the same thing. A statement as to the actual selling price of the coke was asked for, and in most cases, including possibly 80 per cent of all the coke produced, the figures are the actual selling price. In some cases, however, the value is an estimate. Considerable of the coke made in the United States is produced by proprietors of blast furnaces for consumption in their own furnaces, none being sold. The value, therefore, given for this coke would be an estimate, based in some instances, where there are coke works in the neighborhood selling coke for the general market, upon the price obtained for this coke; in other cases the cost is estimated at the cost of the coke at the furnace, plus a small percentage for profit on the coking operation, while in still other cases the value given is only the actual cost of the coke at the ovens.

In the following table is given the average value per short ton of the coke made in the United States for each year from 1880 to 1896, inclusive, by States and Territories:

Average value per short ton at the ovens of the coke made in the United States in the years from 1880 to 1896, inclusive, by States and Territories.

State or Territory.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
Alabama	$3.01	$3.00	$2.79	$2.75	$2.50	$2.50	$2.65	$2.39	$2.34
Colorado	5.68	5.29	4.67	4.36	3.45	3.88	3.99	4.00	4.00
Georgia	2.15	2.15	2.15	2.20	2.13	2.04	2.17	2.20	2.12
Illinois	3.30	3.10	2.55	2.10	1.96	2.68	2.65	2.13	2.84
Indiana	.....	.....	.....	.....	.....	.....	2.93	2.81	2.68
Indian Territory	3.00	3.00	3.00	3.00	3.00	3.60	3.50	3.33	2.90
Kansas	1.95	1.80	1.70	1 96	2.02	1.65	1.54	1.91	1.96
Kentucky	2.88	2.89	2.83	2.87	3.94	3.14	2.23	2.18	2.04
Missouri	.....	.....	.....	.....	.....	.....	.....	3.50	3.50
Montana	.....	.....	.....	.....	12.00	11.72	.....	10.00	8.00
New Mexico	.....	.....	6.00	5.50	5.00	5.00	5.00	6.00	6.00
Ohio	2.54	2.49	2.57	2.57	2.49	2.78	2.69	2.65	2.48
Pennsylvania	1.86	1.70	1.55	1.22	1.25	1.25	1.42	1.84	1.26
Tennessee	2.42	2.33	2.52	2.25	1.95	1.31	1.87	2.19	1.27
Utah	10.00	.....	10.00	.....	.....	.....	.....	.....	.....
Virginia	.....	.....	.....	1.75	1.75	1.75	2.50	2.50	1.74
Washington	.....	.....	.....	.....	4.75	4.75	5.00	7.00	0
West Virginia	2.30	2.30	2.26	2.19	1.19	1.86	1.94	2.22	1.70
Wisconsin	.....	.....	.....	.....	.....	.....	.....	.....	3.00
Average	1.99	1.88	1.77	1.49	1.49	1.49	1.63	2.01	1.46

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Average value per short ton at the ovens of the coke made in the United States in the years from 1880 to 1896, inclusive, by States and Territories—Continued.

State or Territory.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
Alabama	$2.30	$2.41	$2.33	$2.31	$2.27	$2.025	$2.10	$2.07
Colorado	3.43	3.90	3.24	3.31	*a* 3.13	*a* 2.85	*a* 2.76	*a* 2.88
Georgia	1.57	1.48	2.25	2.00	1.50	1.25	1.17	1.276
Illinois	2.57	2.25	2.25	2.25	2.00	2.00	2.00	2.00
Indiana	3.12	3.28	2.00	2.02	1.58	2.00	1.94	1.99
Indian Territory	2.70	3.25	3.22	3.47	3.51	3.50	3.41	3.50
Kansas	1.91	2.37	2.35	2.18	2.18	1.855	2.14	1.813
Kentucky	2.28	1.80	2.02	2.01	2.00	1.73	1.46	1.55
Missouri	1.10	1.51	1.46	1.50	1.65	1.58	1.20	1.65
Montana	8.69	8.71	8.91	9.00	8.00	9.50	7.49	7.08
New Mexico	5.32	4.89	4.75	0	3.18	4.32	2.01	2.00
New York	.....	.....	.....	.....	2.80	.....	.....	.....
Ohio	2.50	2.92	1.99	2.18	1.95	2.78	2.40	2.58
Pennsylvania	1.40	1.91	1.82	1.80	1.52	1.086	1.266	*b* 1.792
Tennessee	2.03	1.96	1.93	2.05	1.85	1.64	1.90	1.84
Utah	4.00	4.36	4.50	0	.....	.....	.....	.....
Virginia	2.22	1.68	1.58	2.18	2.26	1.64	1.32	1.509
Washington	8.00	8.00	7.00	7.03	5.08	3.48	4.27	4.04
West Virginia	1.76	1.83	1.83	1.76	1.62	1.373	1.34	1.37
Wisconsin	5.75	5.75	5.61	5.50	6.41	4.58	5.25	3.94
Wyoming	.....	.....	3.00	0	3.50	*c* 3.50	3.50	3.00
Average	1.62	2.02	1.97	1.96	1.74	1.34	1.44	1.837

a Average value, including Utah.
b Average value, including New York.
c Value estimated.

From this table it appears that the average value per ton of coke in the United States in 1896 was practically $1.84, against $1.44 in 1895, a gain of 40 cents per ton, or about 27 per cent. Pennsylvania is responsible for most of this advance. The average price for coke in Pennsylvania in 1895 was $1.266 per ton, an advance from $1.086 in 1894. The price in 1896, as shown, advanced 52.6 cents, or more than 40 per cent. This advance in price was not due to any improved trade conditions but to the determination on the part of some of the larger Connellsville coking interests to maintain prices at a profitable figure. The increased prices were obtained, but at a sacrifice in tonnage of more than 30 per cent. By this advance in price of Connellsville coke, competitive regions secured a foothold in markets heretofore almost exclusively supplied by Connellsville coke. The other coke regions of Pennsylvania and the New River region of West Virginia reaped the benefit, as is shown by increased production from those districts. The advance in price of coke was felt in all the Appalachian States except Ala-

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bama and Tennessee, the two southernmost coke producers. Ohio shows an increase from $2.40 to $2.58; Virginia from $1.32 to $1.509; West Virginia from $1.34 to $1.37; Kentucky from $1.46 to $1.55, and Georgia from $1.17 to $1.276. The average price in Alabama declined from $2.10 to $2.07; in Tennessee from $1.90 to $1.84.

In the Rocky Mountain fields it is seen that the price in Colorado increased from $2.76 to $2.88, while it decreased in all the other States; Montana from $7.49 to $7.08; New Mexico from $2.01 to $2, and Wyoming from $3.50 to $3. In the intermediate States the value per ton increased in three cases and decreased in two. The increases were in Indiana, Indian Territory, and Missouri; the decreases in Kansas and Wisconsin. Coke is made in only one of the Pacific Coast States—Washington. Here the average price per ton declined from $4.27 to $4.04.

COAL CONSUMED IN THE MANUFACTURE OF COKE.

In the following table is given the total number of tons of coal used in the manufacture of coke in the United States for the years 1880 to 1896:

Amount of coal used in the manufacture of coke in the United States from 1880 to 1896, inclusive, by States and Territories.

[Short tons.]

State or Territory.	1880.	1881.	1882.	1883.	1884.	1885.
Alabama	106,283	184,881	261,839	359,699	413,184	507,934
Colorado	51,891	97,508	180,549	224,089	181,968	208,069
Georgia	63,402	68,960	77,670	111,687	132,113	117,781
Illinois	31,240	35,240	25,270	31,370	30,168	21,487
Indian Territory	2,494	2,852	3,266	4,150	3,084	5,781
Kansas	4,800	8,800	9,200	13,400	11,500	15,000
Kentucky	7,206	7,406	6,006	8,437	3,451	5,075
Montana	.....	.....	.....	.....	165	300
New Mexico	.....	.....	1,500	6,941	29,990	31,889
Ohio	172,453	201,145	181,577	152,502	108,164	68,796
Pennsylvania	4,347,558	5,393,503	6,149,179	6,823,275	6,204,604	6,178,500
Tennessee	217,656	241,644	313,537	330,961	348,295	412,538
Utah	2,000	.....	500	.....	.....	.....
Virginia	.....	.....	.....	39,000	99,000	81,899
Washington	.....	.....	.....	.....	700	544
West Virginia	230,758	304,823	366,653	411,159	385,588	415,533
Total	5,237,741	6,546,762	7,577,646	8,516,670	7,951,974	8,071,126

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Amount of coal used in the manufacture of coke in the United States from 1880 to 1896, inclusive, by States and Territories—Continued.

[Short tons.]

State or Territory.	1886.	1887.	1888.	1889.	1890.	1891.
Alabama	635,120	550,047	858,608	1,746,277	1,809,964	2,144,277
Colorado	228,060	267,487	274,212	299,731	407,023	452,749
Georgia	136,133	158,482	140,000	157,878	170,388	164,875
Illinois	17,806	16,596	13,020	19,250	9,000	10,000
Indiana	13,030	35,600	26,547	16,428	11,753	8,688
Indian Territory	10,242	20,121	13,126	13,277	13,278	20,551
Kansas	23,062	27,604	24,934	21,600	21,809	27,181
Kentucky	9,055	29,129	42,642	25,192	24,372	64,390
Missouri	.....	5,400	5,000	8,485	9,491	10,377
Montana	.....	10,800	20,000	30,576	32,148	61,667
New Mexico	18,194	22,549	14,628	7,162	3,980	4,000
Ohio	59,332	164,974	124,201	132,828	126,921	69,320
Pennsylvania	8,290,849	8,938,438	9,673,097	11,581,292	13,046,143	10,588,544
Tennessee	621,669	655,857	630,099	626,016	600,387	623,177
Utah	.....	.....	.....	2,217	24,058	25,281
Virginia	200,018	235,841	230,529	238,793	251,683	285,113
Washington	1,400	22,500	.....	6,983	9,120	10,000
West Virginia	425,002	698,327	863,707	1,001,372	1,395,266	1,716,976
Wisconsin	.....	.....	1,000	25,616	38,425	52,904
Wyoming	.....	.....	.....	.....	.....	4,470
Total	10,688,972	11,859,752	12,945,350	15,960,973	18,005,209	16,344,540

State or Territory.	1892.	1893.	1894.	1895.	1896.
Alabama	2,585,966	2,015,398	1,574,245	2,459,465	2,573,713
Colorado	*a* 599,200	*a* 628,935	*a* 542,429	*a* 580,584	*a* 639,238
Georgia	158,978	171,645	166,523	118,900	109,655
Illinois	4,800	3,300	3,800	3,600	3,900
Indiana	6,456	11,549	13,489	9,898	8,956
Indian Territory	7,138	15,118	7,274	11,825	53,028
Kansas	15,437	13,645	13,288	8,424	8,940
Kentucky	70,783	97,212	66,418	63,419	55,719
Missouri	11,088	8,875	3,442	3,120	4,471
Montana	64,412	61,770	33,313	55,770	113,165
New Mexico	0	14,698	13,042	22,385	39,286
New York	.....	15,150	.....	22,207	(*b*)
Ohio	95,236	42,963	55,324	51,921	128,923

a Includes coal consumed in Utah.
b Included with Pennsylvania.

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Amount of coal used in the manufacture of coke in the United States from 1880 to 1896, inclusive, by States and Territories—Continued.

State or Territory.	1892.	1893.	1894.	1895.	1896.
Pennsylvania ...	12,591,345	9,386,702	9,059,118	14,211,567	*a* 11,124,610
Tennessee	600,126	449,511	516,802	684,655	600,379
Texas	.....	.....	.....	530	0
Utah	.....	.....	.....	.....	(*b*)
Virginia	226,517	194,059	280,524	410,737	454,964
Washington.....	12,372	11,374	8,563	22,973	38,685
West Virginia...	1,709,183	1,745,757	1,976,128	2,087,816	2,687,104
Wisconsin.....	54,300	24,085	6,343	8,287	8,648
Wyoming	0	5,400	8,685	10,240	41,038
Total	18,813,337	14,917,146	14,348,750	20,848,323	18,694,422

a Includes coal consumed in New York.
b Included with Colorado.

In regard to this table, it is to be noted that in many cases the statement as to the amount of coal used in the production of coke is an estimate. At but few works is the coal weighed before being charged into the ovens. A great deal of the coke made in the United States is from run of mine—that is, all of the product of mining, lump, nut, and slack, as it comes to the mouth of the pit in the mine car, is charged into the ovens—and if no coal is sold as coal it is comparatively easy to ascertain from the amounts paid for mining what is the amount of coal charged into the ovens. But even in such cases considerable difficulty arises from the fact that mining is paid for by the measured bushel or ton of so many cubic feet, while our statistics are by weight, and the measured bushel or ton is often not the equivalent of the weighed bushel or ton. It is also true that in certain districts where the men are paid by the car the car contains even of measured tons more than the men are paid for. Under such circumstances it is not to the interest of the operator to weigh the coal as it is charged into the oven.

Further, in many districts coke making is simply for the purpose of utilizing the slack coal produced in mining or that which falls through the screen at the tipple when lump is sold. In such cases the slack is rarely, if ever, weighed as it is charged into the ovens, so that any statement as to the amount of coal used at such works will be an estimate. At some works the coal is often weighed for a brief period, and, the coke being weighed as it is sold, a percentage of yield is ascertained which is used in statements as to the amount of coal used and the yield of this coal in coke.

Great care has been exercised, in view of these facts, to reach a satisfactory estimate as to the amount of coal used in the production of coke, as given in the table immediately preceding, and the percentage

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yield of coal in coke as shown in the table next subsequent. Analyses of coals from most of the districts in the United States have been secured. These analyses, checked by information otherwise secured as to the methods of coking in each district, have made it possible to reach a conclusion as to whether the returns made were approximately correct or not. Where it has been judged that they were incorrect, correspondence has usually led to revision. It is sometimes the custom of coke manufacturers who do not weigh the coal charged into the ovens to estimate that the yield of coke is equal to the percentage of the fixed carbon and ash in the coal. A report from a certain coke works showed a yield of 77 per cent. This was equal to the average amount of fixed carbon and ash in the coal. Further inquiry developed the fact that at other mines in this district, using the same character of coal, the yield as reported varied from 50 to 66 per cent. Upon the attention of the party making the return being called to these facts, the yield was reduced from 77 to 63 per cent. As coke is sold by weight, it has always been assumed that the report of production of coke was accurate, and where the coal was not weighed, the yield of coal in coke being ascertained, a calculation could be made which would show approximately the amount of coal used.

But even under these conditions it is believed that more coal was actually used in the production of coke in each of the years covered by the above table than is shown.

The amount of coal necessary to produce a ton of coke, assuming that the above tables are approximately correct, was as follows:

Coal required to produce a ton of coke in tons or pounds.

Year.	Tons.	Pounds.	Year.	Tons.	Pounds.
1880.....	1.57	3,140	1889.....	1.55	3,100
1881.....	1.59	3,180	1890.....	1.56	3,120
1882.....	1.58	3,160	1891.....	1.58	3,160
1883.....	1.56	3,120	1892.....	1.57	3,140
1884.....	1.63	3,260	1893.....	1.57	3,140
1885.....	1.58	3,160	1894.....	1 56	3,120
1886.....	1.56	3,120	1895.....	1.56	3,120
1887.....	1.56	3,120	1896.....	1.58¼	3,170
1888.....	1.51	3,020			

In the following table is shown the percentage yield of coal in the manufacture of coke for the years 1880 to 1896. By the "yield" is of course meant the percentage of the constituents of the coal that remain as coke after the process of coking.

While these tables show an average of something like 64 per cent for most of the years, it is believed that even this is a little too high.

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Probably the actual yield of coal in coke throughout the United States, if the actual weight of coal charged into the ovens and the actual weight of the coke drawn had been taken, would not have exceeded 60 or 61 per cent.

Percentage yield of coal in the manufacture of coke in the United States in the years 1880 to 1896, inclusive, by States and Territories.

State or Territory.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.
Alabama	57	59	58	60	60	59	59	59	60
Colorado	49	50	57	60	64	63	62.6	64	65.6
Georgia	60	60	60	60	60	60	60	50	60
Illinois	41	42	45	43	43	48	46	55.5	56.9
Indiana	0	0	0	0	0	0	47	50	45
Indian Territory	62	62	62	62	62	62	62	50	57
Kansas	64	64.4	65	62.9	62.3	53.7	54.2	54	59
Kentucky	60	60	59	60	64	53	50	50	54
Missouri	0	0	0	0	0	0	0	55	52
Montana	0	0	0	0	46	58.5	0	66.7	60
New Mexico	0	0	66.7	57.3	57.5	56.3	56	61	58
Ohio	58	59	57	58	58	57	59	56	54
Pennsylvania	65	64	64	65	62	64.6	65.2	65.3	68
Tennessee	60	60	60	62	63	53	59	61	61
Texas	0	0	0	0	0	0	50	0	0
Utah	50	0	50	0	0	0	0	0	0
Virginia	0	0	0	64.5	64.3	60	61.1	70.8	64.7
Washington	0	0	0	0	57.5	57	58.9	65	0
West Virginia	60	61	63	63	62	63	62	63.3	61.6
Wisconsin	0	0	0	0	0	0	0	0	50
Wyoming	0	0	0	0	0	0	0	0	0
Total average.	63	63	63	64	61	63	64	64.2	66

State or Territory.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
Alabama	59	59	60	58	58	58.7	58.7	57.5
Colorado	63	60	61	63.9	*a*57.7	*a*58.5	*a*58.6	*a*56.9
Georgia	60	60	62.5	51.5	52.8	55.9	50.6	49
Illinois	60	55	52	66	66.7	57.9	62.5	66.7
Indiana	51	51	44	49.7	49.6	48.6	48.5	49
Indian Territory	50	50	46	50	47	42	43.8	40
Kansas	64	56	52	59.2	62.8	63.5	62.8	53.5
Kentucky	52	51	52	51	50	44.8	40.1	48.6
Missouri	62	65	66	65.8	66.5	65.4	65	55.9

a Average, including Utah.

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Percentage yield of coal in the manufacture of coke in the United States in the years 1880 to 1896, inclusive, by States and Territories—Continued.

State or Territory.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
Montana	46	45	47	53.6	48.5	52.2	45.4	53
New Mexico	48	51.5	57.5	0	39.5	50	65.5	61.7
New York	.....	.....	.....	.....	84.8	.....	83.4	.....
Ohio	56	59	56	54.4	52	59	56	62.7
Pennsylvania	66	65	66	66.1	66	66.9	66.2	a66.1
Tennessee	57	58	58	59	59	56.6	57.9	56.5
Texas	0	0	0	0	0	0	54	0
Utah	34	35	31	.....	.....	.....	.....	.....
Virginia	61	66	58.8	65.3	64.5	64.2	59.6	58.9
Washington	55	64	60	58	59	61.2	65.9	67
West Virginia	61	59	58.8	60.5	60.8	60.4	61.6	61.4
Wisconsin	62.5	65	65	62.2	62	67	60	62
Wyoming	0	0	60	0	54	50	47.8	47.6
Total average.	64	64	63	64	63.5	64	64	63

a Average, including New York.

The following tables contain an exhibit of the amount and value of coal used in the manufacture of coke in the United States during the past three years. These tables also show the average value per ton of coal used and the amount and value of coal necessary to make a ton of coke. The average price per ton of coal used in 1894 was 65.8 cents; in 1895, 66 cents; and in 1896, 65.9 cents, the variation in the three years being only .2 of a cent per ton. It can be seen from this that the advanced price for coke in 1896 was not due to any advance in the cost of the coal. Pennsylvania, in which the advance of the price in coke was most pronounced, paid 61.6 cents per ton for her coal in 1895, and 62.5 cents per ton in 1896, an advance of .9 cent. The causes leading to the advance in price have been already discussed. The value of coal per ton of coke made was 93 cents in 1895 and 94.4 cents in 1896, not by any means sufficient to account for an advance from $1.266 in the price of coke for 1895 to $1.792 in 1896. Making a further comparison, it will be seen that the difference between the value of coal per ton of coke and the value of the coke per ton in the United States during 1895 was 41 cents. In 1896 the value of coal used in a ton of coke was $1.04, and the value per ton of coke was $1.837, a difference of 79.7 cents. In Pennsylvania the difference was 84.8 cents, nearly 90 per cent over the value of the coal. In Alabama the value of coal was $1.385, while the selling price of coke was $2.07, a difference of 68.5 cents against a difference of 61 cents in 1895. In Colorado the relative figures in 1896 were $1.65 for coal and $2.88 for coke; in 1895 the figures were $1.66 for coal and $2.76 for coke. West Virginia, in 1896, placed 84.6 cents as the

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value of coal and $1.37 for coke; in 1895, 87 cents for coal and $1.34 for coke. In Tennessee the value of coal in 1896 was $1.29, of coke $1.84; in 1895, $1.31 and $1.90, respectively.

Amount and value of coal used in the manufacture of coke in the United States in 1896, and amount and value of same per ton of coke.

State or Territory.	Coal used.	Total value of coal.	Value of coal per ton.	Amount of coal per ton of coke.	Value of coal to a ton of coke.
	Short tons.			*Short tons.*	
Alabama	2,573,713	$2,049,732	$0.796	1.74	$1.385
Colorado (*a*)	639,238	601,362	.94	1.76	1.65
Georgia	109,655	54,827	.50	2.04	1.02
Illinois	3,900	975	.25	1.50	.375
Indiana	8,956	4,360	.49	2.06	1.01
Indian Territory	53,028	43,257	.816	2.52	2.056
Kansas	8,940	4,170	.466	1.87	.87
Kentucky	55,719	14,521	.26	2.06	.536
Missouri	4,471	2,520	.56	1.79	1.00
Montana	113,165	194,747	1.72	1.88	3.23
New Mexico	39,286	25,918	.66	1.62	1.069
Ohio	128,923	130,755	1.01	1.59	1.606
Pennsylvania (*b*)	11,124,610	6,957,038	.625	1.51	.944
Tennessee	600,379	438,212	.73	1.77	1.29
Virginia	454,964	282,926	.62	1.70	1.05
Washington	38,685	69,420	1.79	1.49	2.67
West Virginia	2,687,104	1,394,827	.519	1.63	.846
Wisconsin	8,648	17,207	2.00	1.62	3.24
Wyoming	41,038	28,727	.70	2.10	1.47
Total and averages	18,694,422	12,315,501	.659	1.585	1.04

a Figures given for Colorado include the statistics of Utah.
b Figures given for Pennsylvania include the statistics of New York.

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Amount and value of coal used in the manufacture of coke in the United States in 1895, and amount and value of same per ton of coke.

State or Territory.	Coal used.	Total value of coal.	Value of coal per ton.	Amount of coal per ton of coke.	Value of coal to a ton of coke.
	Short tons.			*Short tons.*	
Alabama	2,459,465	$2,153,233	$0.875	1.70	$1.49
Colorado (*a*)	580,584	568,067	.978	1.70	1.66
Georgia	118,900	77,285	.65	1.97	1.28
Illinois	3,600	900	.25	1.60	.40
Indiana	9,898	4,749	.48	2.06	.99
Indian Territory	11,825	2,956	.25	2.28	.57
Kansas	8,424	3,555	.42	1.59	.67
Kentucky	63,419	12,841	.20	2.49	.50
Missouri	3,120	1,248	.40	1.54	.62
Montana	55,770	146,967	2.64	2.20	5.81
New Mexico	22,385	12,024	.537	1.53	.82
Ohio	51,921	50,593	.97	1.79	1.74
Pennsylvania	14,211,567	8,752,418	.616	1.51	.93
Tennessee	684,655	518,401	.757	1.73	1.31
Virginia	410,737	271,056	.66	1.68	1.11
Washington	22,973	43,532	1.89	1.52	2.87
West Virginia	2,087,816	1,126,161	.539	1.62	.87
Wisconsin	8,287	19,474	2.35	1.67	3.92
Wyoming	10,240	7,680	.75	2.09	1.57
Total and averages	20,825,586	13,773,140	.66	1.56	1.03

a Figures given for Colorado include the statistics of Utah.

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Amount and value of coal used in the manufacture of coke in the United States in 1894, and amount and value of same per ton of coke.

State or Territory.	Coal used.	Total value of coal.	Value of coal per ton.	Amount of coal per ton of coke.	Value of coal to a ton of coke.
	Short tons.			*Short tons.*	
Alabama	1,574,245	$1,443,043	$0.917	1.70	$1.56
Colorado (*a*)	542,429	539,065	.994	1.71	1.70
Georgia	166,523	121,882	.73	1.79	1.31
Illinois	3,800	950	.25	1.73	.43
Indiana	13,489	6,265	.465	2.06	.96
Indian Territory	7,274	1,819	.25	2.38	.60
Kansas	13,288	6,275	.47	1.57	.74
Kentucky	66,418	14,304	.215	2.23	.48
Missouri	3,442	1,556	.45	1.53	.69
Montana	33,313	99,940	3.00	1.92	5.75
New Mexico	13,042	18,259	1.40	2.00	2.80
Ohio	55,324	52,689	.95	1.70	1.62
Pennsylvania	9,059,118	5,317,695	.589	1.49	.88
Tennessee	516,802	377,229	.73	1.77	1.29
Virginia	280,524	309,730	1.10	1.56	1.72
Washington	8,563	16,391	1.914	1.63	3.12
West Virginia	1,976,128	1,102,105	.558	1.66	.93
Wisconsin	6,343	17,443	2.75	1.50	4.13
Wyoming	8,685	5,211	*b* .60	2.00	1.20
Total and averages.	14,348,750	9,451,851	.658	1.56	1.03

a Figures given for Colorado include the statistics of Utah.
b Value estimated.

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CONDITION IN WHICH COAL IS CHARGED INTO OVENS.

In the following table will be found a statement of the condition of coal when charged into ovens—that is, whether it is run of mine, slack, washed, or unwashed. The tables for 1896, 1895, and 1894 are given. The headings explain themselves. It is only necessary to state that run of mine, washed, includes that run-of-mine coal which is crushed before being washed.

Character of coal used in the manufacture of coke in 1896.

State or Territory.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Alabama	1,292,191	70,125	51,674	1,159,723	2,573,713
Colorado (*a*)	143,604	0	378,776	116,858	639,238
Georgia	0	109,655	0	0	109,655
Illinois	0	0	0	3,900	3,900
Indiana	0	0	0	8,956	8,956
Indian Territory	0	0	0	53,028	53,028
Kansas	0	0	8,940	0	8,940
Kentucky	16,271	0	0	39,448	55,719
Missouri	0	0	4,471	0	4,471
Montana	0	50,000	0	63,165	113,165
New Mexico	0	0	39,286	0	39,286
Ohio	88,616	0	24,325	15,982	128,923
Pennsylvania (*b*)	9,289,089	273,082	1,463,047	99,392	11,124,610
Tennessee	0	206,319	219,231	174,829	600,379
Virginia	70,756	0	370,624	13,584	454,964
Washington	0	20,967	0	17,718	38,685
West Virginia	407,378	33,096	2,079,237	167,393	2,687,104
Wisconsin	0	0	5,183	3,465	8,648
Wyoming	0	0	41,038	0	41,038
Total	11,307,905	763,244	4,685,832	1,937,441	18,694,422

a Includes Utah's consumption of coal.
b Includes coal coked in New York.

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Character of coal used in the manufacture of coke in 1895 and 1894.

State or Territory.	1895.				
	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Alabama	1,208,020	0	32,068	1,219,377	2,459,465
Colorado (*a*)	119,868	0	453,597	7,119	580,584
Georgia	0	118,900	0	0	118,900
Illinois	0	0	0	3,600	3,600
Indiana	0	0	0	9,898	9,898
Indian Territory	0	0	0	11,825	11,825
Kansas	0	0	8,424	0	8,424
Kentucky	0	502	624	62,293	63,419
Missouri	0	0	3,120	0	3,120
Montana	0	0	0	55,770	55,770
New Mexico	10,000	0	12,385	0	22,385
New York	0	0	22,207	0	22,207
Ohio	28,053	0	10,868	13,000	51,921
Pennsylvania	13,618,376	34,728	440,869	117,594	14,211,567
Tennessee	96,744	59,284	285,906	242,721	684,655
Texas	0	0	0	530	530
Virginia	114,802	0	295,935	0	410,737
Washington	0	0	0	22,973	22,973
West Virginia	405,725	24,054	1,476,003	182,034	2,087,816
Wisconsin	8,287	0	0	0	8,287
Wyoming	0	0	10,240	0	10,240
Total	15,609,875	237,468	3,052,246	1,948,734	20,848,323

a Including Utah's consumption.

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Character of coal used in the manufacture of coke in 1895 and 1894—Continued.

State or Territory.	1894.				
	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
Alabama	411,097	7,429	477,820	677,899	1,574,245
Colorado (*a*)	126,642	0	415,787	0	542,429
Georgia	0	166,523	0	0	166,523
Illinois	0	0	0	5,800	3,800
Indiana	0	0	8,689	4,800	13,489
Indian Territory	0	0	0	7,274	7,274
Kansas	0	0	13,288	0	13,288
Kentucky	0	2,980	7,900	55,538	66,418
Missouri	0	0	3,442	0	3,442
Montana	0	33,313	0	0	33,313
New Mexico	0	0	13,042	0	13,042
Ohio	0	0	14,845	40,479	55,324
Pennsylvania	8,671,534	118,279	204,811	64,494	9,059,118
Tennessee	166,990	61,841	149,958	138,013	516,802
Virginia	103,874	0	176,650	0	280,524
Washington	0	0	0	8,563	8,563
West Virginia	162,270	14,901	1,607,735	191,222	1,976,128
Wisconsin	6,343	0	0	0	6,343
Wyoming	0	0	8,685	0	8,685
Total	9,648,750	405,266	3,102,652	1,192,082	14,348,750

a Including Utah's consumption.

From the above tables it will be seen that in 1894 70 per cent of the coal used was run of mine; in 1895 it was 76 per cent, and in 1896 60 per cent. In 1894 30 per cent of the coal used was slack, in 1895 24 per cent, and in 1896 40 per cent. The percentage of washed coal increased from 11 in 1894 and 10.5 in 1895 to 14 in 1896. The increase in washed coal was entirely in run of mine. The amount of washed slack used was within six-tenths of one per cent of what it was in 1895. The amount of washed run-of-mine coal used in 1896 was more than three times what it was in 1895, and nearly twice as much as in 1894, which was the year of previous largest consumption.

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In the following table the statistics regarding the character of the coal for the years 1890 to 1896, inclusive, are consolidated :

Character of coal used in the manufacture of coke in the United States since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	14,060,907	338,563	2,674,492	931,247	18,005,209
1891	12,255,415	290,807	2,945,359	852,959	16,344,540
1892	14,453,638	324,050	3,256,493	779,156	18,813,337
1893	10,306,082	350,112	3,049,075	1,211,877	14,917,146
1894	9,648,750	405,266	3,102,652	1,192,082	14.348,750
1895	15,609,875	237,468	3,052,246	1,948,734	20,848,323
1896	11,307,905	763,244	4,685,832	1,937,441	18,694,422

IMPORTS.

The following table gives the quantities and value of coke imported and entered for consumption in the United States from 1869 to 1896, inclusive. In the reports of the Treasury Department the quantities given are long tons. These have been reduced to short tons to make the tables consistent with the other tables in this report :

Coke imported and entered for consumption in the United States, 1869 to 1896, inclusive.

Year ending—	Quantity.	Value.	Year ending—	Quantity.	Value.
	Short tons.			*Short tons.*	
June 30, 1869		$2,053	June 30, 1883	20,634	$113,114
1870		6,388	1884	14,483	36,278
1871		19,528	1885	20,876	64,814
1872	9,575	9,217	Dec. 31, 1886	28,124	84,801
1873	1,091	1,366	1887	35,320	100,312
1874	634	4,588	1888	35,201	107,914
1875	1,046	9,648	1889	28,608	88,008
1876	2,065	8,657	1890	20,808	101,767
1877	4,068	16,686	1891	50,753	223,184
1878	6,616	24,186	1892	27,420	86,350
1879	6,035	24,748	1893	37,183	99,683
1880	5,047	18,406	1894	32,566	70,359
1881	15,210	64,987	1895	29,622	71,366
1882	14,924	53,244	1896	48,576	114,713

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THE COKING INDUSTRY, BY STATES.

ALABAMA.

Since 1880 Alabama has stood within the first five of the coke-producing States. In two years only (1880 and 1881) was she as low as fifth place. In 1882 Alabama advanced to fourth place; in 1883 to third place, and in 1884 to second place. Once since then (in 1887) the State has fallen back to fourth place and three times to third place. In each case West Virginia has been the successful contestant for second place—once in 1887, again in 1894, and once more in 1896. The drop of Alabama from second place in 1895 to third place in 1896 was not due to any decrease in the output of the latter year, for the amount of coke made in 1896 was 31,439 tons more than in 1895. West Virginia's output, however, increased more than 360,000 tons over 1895, and exceeded Alabama's product in 1896 by a little more than 170,000 tons.

The coal fields of Alabama are divided into three subdistricts, known as the Warrior, the Coosa, and the Cahaba, these districts being named from the rivers which drain them. Coke ovens are built in all three districts, but coke was made in 1895 and 1896 in but two—the Warrior and the Cahaba. The most important of these districts, both as a coal producer and coke maker, is the Warrior, the ovens in this district being located near Birmingham. Of the 5,363 coke ovens in Alabama, 4,726 are in the Warrior district, and of the total production of 1,479,437 tons of coke in 1896, 1,427,416 tons were made in the Warrior district.

While most of the ovens built in this State are of the ordinary beehive pattern—the more recent ones being of the usual dimensions, 12 feet in diameter and 7 feet high—it is evident from the frequent attempts that have been made to introduce other ovens that the beehive oven as a coker of Alabama coal is not entirely satisfactory. The ovens other than beehive, which have thus far been introduced successfully into Alabama, are solid-wall ovens, or ovens in which there are no flues in the walls, and in which the coking chamber or combustion chamber, wherein the heat for coking is produced, are the same. Two forms of these modified solid-wall ovens are in use in Alabama at the present time, one known as the "Thomas" oven, which has already been described in this series of reports, and the other as the "double oblong." These ovens are 21 feet long and 9 feet wide, open at both ends. The ovens are charged from the top and drawn at the ends. They produce in a given time some 75 per cent more coke than the ordinary beehive oven.

Another notable feature in the manufacture of coke in Alabama is the greatly increased amount of washed coal that is used. In 1891 but 8,570 tons of washed coal, all of which was slack, were used in the manufacture of coke in this State out of a total of 2,144,277 tons. In 1895, however, of the total consumption of 2,459,465 tons of coal in the

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manufacture of coke, practically one-half, or 1,219,377 tons, was washed. All but 32,068 tons of the slack used was washed. In 1896, out of 2,573,713 tons of coal used 1,229,848 tons was washed, and all but 51,674 tons out of 1,211,397 tons of slack was washed. From reports received it appears that this washing has greatly improved the character of the coke made in this State. It has not only reduced the ash and sulphur, but the physical structure of the coke has not been injured, if, indeed, in many cases it has not improved by the washing. The increase in the amount of run-of-mine coal washed before coking is also noticeable.

In the following table is shown the production of coke in Alabama for a series of years. It shows that with one exception the production of coke in 1896 was the largest ever attained. Two years before, in 1894, the yield of coke was the smallest in the eight years from 1889 to 1896. The industry recovered from this depression in 1895, the output in that year being 56 per cent more than in 1894, and maintained its standing in 1896 with an increase of about 35,000 tons:

The 50 ovens reported as building in 1895 were completed in 1896, but 345 ovens were abandoned, so that the number of ovens in existence in 1896 was 295 less than in 1895. The statistics of coke production in Alabama since 1880 are as follows:

Statistics of the manufacture of coke in Alabama from 1880 to 1896, inclusive.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.	*Short tons.*	*Short tons.*			*Per ct.*
1880 ..	4	316	100	106,283	60,781	$183,063	$3.01	57
1881 ..	4	416	120	184,881	109,033	326,819	3.00	59
1882 ..	5	536	.....	261,839	152,940	425,940	2.79	58
1883 ..	6	767	122	359,699	217,531	598,473	2.75	60
1884 ..	8	*a* 976	242	413,184	244,009	609,185	2.50	60
1885 ..	11	1,075	16	507,934	301,180	755,645	2.50	59
1886 ..	14	*a* 1,301	1,012	635,120	375,054	993,302	2.65	59
1887 ..	15	1.555	1,362	550,047	325,020	775,090	2.39	59
1888 ..	18	2,475	406	848,608	508,511	1,189,579	2.34	60
1889 ..	19	3,944	427	1,746,277	1,030,510	2,372,417	2.30	59
1890 ..	20	4,805	371	1,809,964	1,072,942	2,589,447	2.41	59
1891 ..	21	5,068	50	2,144,277	1,282,496	2,986,242	2.33	60
1892 ..	20	5,320	90	2,585,966	1,501,571	3,464,623	2.31	58
1893 ..	23	5,548	60	2,015,398	1,168,085	2,648,632	2.27	58
1894 ..	22	5,551	50	1,574,245	923,817	1,871,348	2.025	58.7
1895 ..	22	5,658	50	2,459,465	1,444,339	3,033,521	2.10	58.7
1896 ..	24	5,363	.....	2,573,713	1,479,437	3,064,960	2.07	57.5

a One establishment made coke on the ground.

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The character of the coal used in the manufacture of coke in Alabama since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Alabama since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	1,480,669	0	206,106	123,189	1,809,964
1891	1,943,469	0	192,238	8,570	2,144,277
1892	2,463,366	0	11,100	111,500	2,585,966
1893	1,246,307	51,163	292,198	425,730	2,015,398
1894	411,097	7,429	477,820	677,899	1,574,245
1895	1,208,020	0	32,068	1,219,377	2,459,465
1896	1,292,191	70,125	51,674	1,159,723	2,573,713

COLORADO.

Colorado still holds its place as the chief coke-producing State outside of the Appalachian region. Its coal fields and coking coals are thoroughly described in the Mineral Resources volumes for 1892 and 1894.

The districts in which coke is produced in this State are those named by Mr. R. C. Hills—the Raton, the Grand River, and the La Plata. In the first named, the Raton, are the Trinidad and the Raton Canyon subdistricts or fields, both in Las Animas County. These are so closely related as coking districts that we have regarded them as one, and included them under the common name of the Trinidad or Elmoro district. In this district are four coke works, with 810 ovens, which produced 198,507 tons of coke in 1896.

In the Grand River district are the Crested Butte and Coal Basin subdistricts. Coal from the former is coked at Crested Butte, and from the latter at Cardiff, the coal used at Cardiff being from Spring Gulch. Mr. Hills regards the Coal Basin subfield as the most important area of coking coal in the State. The coke produced, he suggests, is "better adapted for lead smelters' use than any other produced in the State, though it is probably not as well glazed as an iron smelter would desire." There are in this district two coke works—the Crested Butte, with 154 ovens, and the Cardiff, with 214 ovens. Of the latter, 124 are Belgian, the others beehive. The production of coke at these works in 1896 was 126,471 tons.

The La Plata district, which is the coking district we have called Durango, has three works with 58 ovens. The total production in this district in 1896 was 11,855 tons.

Coke is also produced in Denver from coal brought from other districts. It is coked in a species of retort, operated somewhat on the plan

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of a gas retort and somewhat as a by-product coke oven. The plant consists of 36 retorts. A portion of the gas is used to fire the benches, for lighting, and also to raise steam. In addition to the gas used for these purposes there is a surplus of some 120,000 cubic feet per day, which is sold to the Denver Consolidated Gas Company for illuminating purposes. The coke made is used for domestic purposes in place of anthracite coal.

The statistics of the production of coke in Colorado from 1880 to 1896 are given in the following table. From 1892 to 1896, both inclusive, the statements of production of coke in Utah are included in Colorado.

Statistics of the manufacture of coke in Colorado from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880	1	200	50	51,891	25,568	$145,226	$5.68	49
1881	2	267	0	97,508	48,587	267,156	5.29	50
1882	5	344	0	180,549	102,105	476,665	4.67	57
1883	7	352	0	224,089	133,997	584,578	4.36	60
1884	8	409	24	181,968	115,719	409,930	3.45	64
1885	7	434	0	208,069	131,960	512,162	3.88	63
1886	7	483	0	228,060	142,797	569,120	3.99	62.6
1887	7	532	0	267,487	170,698	682,778	4.00	64
1888	7	602	100	274,212	179,682	716,305	4.00	65.6
1889	9	834	50	299,731	187,638	643,479	3.43	63
1890	8	916	30	407,023	245,756	959,246	3.90	60
1891	7	948	21	452,749	277,074	896,984	3.24	61
1892 (*a*).	9	*b* 1,128	220	599,200	*c* 373,229	1,234,320	3.31	62.3
1893 (*a*).	8	*b* 1,154	200	628,935	*d* 362,986	1,137,488	3.13	57.7
1894 (*a*).	8	*b* 1,154	250	542,429	*e* 317,196	903,970	2.85	58.5
1895 (*a*).	9	*b* 1,169	0	580,584	*f* 340,357	940,987	2.76	58.6
1896 (*a*).	11	*b* 1,275	0	639,238	*g* 363,760	1,046,306	2.88	56.9

a Includes production and value of coke in Utah, and of coal coked.
b Includes 36 gas retorts.
c Colorado's coke production, 365,920 tons.
d Colorado's coke production, 346,981 tons.
e Colorado's coke production, 301,140 tons.
f Colorado's coke production, 317,838 tons.
g Colorado's coke production, 343,313 tons.

The returns for 1896 show that the practice of washing slack coal before coking is growing in Colorado. Washing was tried several years ago, but it was found that the process then employed removed a large quantity of the bituminous matter necessary to give the coke the proper physical structure. That washing is again being tried with

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good results is evinced by the reports for 1895 and 1896. In the former year 7,119 tons of slack were washed before coking; nearly one-fourth, or 116,858 out of 495,634 tons, of the slack used in 1896 was washed.

The character of the coal used in the manufacture of coke in Colorado and Utah since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Colorado and Utah since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	36,058	0	395,023	0	431,081
1891	93,752	0	384,278	0	478,030
1892	82,098	0	517,102	0	599,200
1893	109,915	0	519,020	0	628,935
1894	126,642	0	415,787	0	542,429
1895	119,868	0	453,597	7,119	580,584
1896	143,604	0	378,776	116,858	639,238

The following table shows analyses of cokes manufactured by the Colorado Fuel and Iron Company:

Analyses of Colorado cokes.

Kind of coke.	Fixed carbon.	Volatile combined matter.	Moisture.	Ash.	Sulphur.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Crested Butte	87.89	0.33	.....	11.78	0.55
Cardiff	87.56	.81	0.10	10.82	.68
Elmoro and Sopris—unwashed	79.46	1.35	.03	19.19	.49
Sopris—washed	82.65	1.35	.03	16.00	.49

GEORGIA.

Coking in Georgia is an industry of comparatively little importance. The only coal produced in the State is from the extreme northwestern portion, which is cut by the eastern border of the Appalachian coal field. In this small field there is one mine, nearly all of the coal from which is made into coke. The coal as it is mined is washed before being coked. The amount of coal charged into the ovens is the amount mined, and not the weight of the coal after being washed.

The production of coke in 1896 was 53,673 tons, against 60,212 tons in 1895 and 93,029 in 1894. It has amounted to over 100,000 tons. The

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product in 1890 was 102,233 tons, and in 1891 it was 103,057 tons, so that the output in 1896 was only a little more than half of what had been obtained previously.

The statistics of the production of coke in Georgia, 1880 to 1896, are as follows:

Statistics of the manufacture of coke in Georgia, 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880	1	140	40	63,402	38,041	$81,789	$2.15	60
1881	1	180	40	68,960	41,376	88,753	2.15	60
1882	1	220	44	77,670	46,602	100,194	2.15	60
1883	1	264	36	111,687	67,012	147,166	2.20	60
1884	1	300	0	132,113	79,268	169,192	2.13	60
1885	2	300	0	117,781	70,669	144,198	2.04	60
1886	2	300	0	136,133	82,680	179,031	2.17	60
1887	2	300	0	158,482	79,241	174,410	2.20	50
1888	1	290	0	140,000	83,721	177,907	2.12	60
1889	1	300	0	157,878	94,727	149,059	1.57	60
1890	1	300	0	170,388	102,233	150,995	1.48	60
1891	1	300	0	164,875	103,057	231,878	2.25	62.5
1892	1	300	0	158,978	81,807	163,614	2.00	51.5
1893	1	338	0	171,645	90,726	136,089	1.50	52.8
1894	1	338	0	166,523	93,029	116,286	1.25	55.9
1895	1	330	0	118,900	60,212	70,580	1.17	50.6
1896	1	334	0	109,655	53,673	68,486	1.276	49

The character of the coal used in the manufacture of coke in Georgia since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Georgia since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	0	0	0	170,388	170,388
1891	106,131	0	0	58,744	164,875
1892	0	0	0	158,978	158,978
1893	0	0	0	171,645	171,645
1894	0	166,523	0	0	166,523
1895	0	118,900	0	0	118,900
1896	0	109,655	0	0	109,655

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ILLINOIS.

The revival of coke making in Illinois which was predicted in the preceding report has not been borne out by results. The number of establishments increased from one in 1894 to three in 1895, and the number of ovens from 24 to 129. The output of coke did not increase materially, however, and what increase is reported in 1896 was from the same bank of 24 ovens which has furnished the entire product for five years. Of the 105 ovens added in 1895 none were fired and 1896 shows the number of ovens two less than in 1895.

Many of the coals in Illinois are true coking coals, but the coking qualities vary greatly. Some of them coke readily in the ordinary beehive oven; others only after wetting; while some will not coke at all in the beehive oven, although crucible tests show they are true coking or binding coals. The impurities in Illinois coal have worked against it in the manufacture of metallurgical coke, and until recently the attempts to improve the quality of the coal by washing have not been attended with marked success. In Mr. Weeks' report on coke for 1895 it was stated that two new washing plants had been built in the State that seemed to have solved the problem, the coal, after being washed, producing a fairly strong hard coke not too high in ash. So far as the record for 1896 goes, however, the benefits of these two washeries have not been apparent in the production. The output increased only 350 tons over 1895, and it was all produced at Equality, in Gallatin County, where all of the coke product of Illinois for several years has been made.

The following are the statistics of the manufacture of coke in Illinois for the years from 1880 to 1896:

Statistics of the manufacture of coke in Illinois from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880.....	6	176	0	31,240	12,700	$41,950	$3.30	41
1881.....	6	176	0	35,240	14,800	45,850	3.10	42
1882.....	7	304	0	25,270	11,400	29,050	2.55	45
1883.....	7	316	0	31,170	13,400	28,200	2.10	43
1884.....	9	325	0	30,168	13,095	25,639	1.96	43
1885.....	9	320	0	21,487	10,350	27,798	2.68	48
1886.....	9	335	0	17,806	8,103	21,487	2.65	46
1887.....	8	278	0	16,596	9,108	19,594	2.13	55.5
1888.....	8	221	0	13,020	7,410	21,038	2.84	56.9
1889.....	4	149	0	19,250	11,583	29,764	2.57	60

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Statistics of the manufacture of coke in Illinois from 1880 to 1896—Continued.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1890.....	4	148	0	9,000	5,000	$11,250	$2.25	55
1891.....	1	25	0	10,000	5,200	11,700	2.25	52
1892.....	1	24	0	4,800	3,170	7,133	2.25	66
1893.....	1	24	0	3,300	2,200	4,400	2.00	66.7
1894.....	1	24	0	3,800	2,200	4,400	2.00	57.9
1895.....	3	129	0	3,600	2,250	4,500	2.00	62.5
1896.....	3	127	0	3,900	2,600	5,200	2.00	66.7

The character of the coal used in the manufacture of coke in Illinois since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Illinois since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890.....	0	0	0	9,000	9,000
1891.....	0	0	10,000	0	10,000
1892.....	0	0	4,800	0	4,800
1893.....	0	0	0	3,300	3,300
1894.....	0	0	0	3,800	3,800
1895.....	0	0	0	3,600	3,600
1896.....	0	0	0	3,900	3,900

INDIANA.

In Indiana, as in Illinois, attempts at making coke on a large scale have met with very little success. There are plenty of coals in Indiana capable of producing good coke, but the markets which would be supplied by such coke can obtain Connellsville, New River, or Pocahontas coke of superior quality at very little difference in cost, and there has not been much to encourage the manufacture of coke in the State. As transportation to any distance would bring it into active competition with the other cokes, besides adding to its cost, the consumption of Indiana coke is limited to a market contiguous to the producing point.

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The statistics of the manufacture of coke in Indiana from 1886 to 1896, both inclusive, are given in the following table:

Statistics of the manufacture of coke in Indiana from 1886 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1886	4	100	18	13,030	6,124	$17,953	$2.93	47
1887	4	119	0	35,600	17,658	51,141	2.81	50
1888	3	103	0	26,547	11,956	31,993	2.68	45
1889	4	111	0	16,428	8,301	25,922	3.12	51
1890	4	101	0	11,753	6,013	19,706	3.28	51
1891	2	84	0	8,688	3,798	7,596	2.00	44
1892	2	84	0	6,456	3,207	6,472	2.02	49.7
1893	2	94	0	11,549	5,724	9,048	1.58	49.6
1894	2	94	0	13,489	6,551	13,102	2.00	48.6
1895	2	94	0	9,898	4,804	9,333	1.94	48.5
1896	2	94	0	8,956	4,353	8,647	1.99	49

As shown in the above table, there are only two establishments in Indiana where coke is made. There have been as many as four, namely, in 1886, 1887, 1889, and 1890, but since 1891 the number has been limited to two. In 1887, 119 ovens were in operation; 25 of these have been abandoned, and for four years the number of ovens has been 94. Coke making in the State at present is for the purpose of utilizing slack coal that would otherwise be wasted. All of the slack used in 1895 and 1896 was washed. This was also the case in 1890, 1891, and 1892. A small part of the coal used in 1893 and two-thirds of that used in 1894 was unwashed.

The character of the coal used in the manufacture of coke in Indiana since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Indiana since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	0	0	0	11,753	11,753
1891	0	0	0	8,688	8,688
1892	0	0	0	6,456	6,456
1893	0	0	930	10,619	11,549
1894	0	0	8,689	4,800	13,489
1895	0	0	0	9,898	9,898
1896	0	0	0	8,956	8,956

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INDIAN TERRITORY.

Coke making in the Indian Territory shows encouraging progress. In addition to the 80 ovens operated for several years by the Osage Coal and Mining Company at McAlester, 50 ovens were built and put into operation by the Choctaw Coke Company at Alderson for the purpose of utilizing the slack coal from the mines in the vicinity. As a result, the production shows an increase from 5,175 tons in 1895 to 21,021 tons in 1896. The ovens are all of the beehive type. Slack coal also is used in coke making at McAlester, and it is all washed before being charged into the ovens. The coke is marketed for smelting purposes in Kansas and Missouri.

The statistics of the manufacture of coke in the Indian Territory from 1880 to 1896 are as follows:

Statistics of the manufacture of coke in the Indian Territory from 1880 to 1896.

Year.	Establishments.	Ovens built.	Ovens building.	Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
				Short tons.	*Short tons.*			*Per cent.*
1880	1	20	0	2,494	1,546	$4,638	$3.00	62
1881	1	20	0	2,852	1,768	5,304	3.00	62
1882	1	20	0	3,266	2,025	6,075	3.00	62
1883	1	20	0	4,150	2,573	7,719	3.00	62
1884	1	20	0	3,084	1,912	5,736	3.00	62
1885	1	40	0	5,781	3,584	12,902	3.60	62
1886	1	40	0	10,242	6,351	22,229	3.30	62
1887	1	80	0	20,121	10,060	33,435	3.33	50
1888	1	80	0	13,126	7,502	21,755	2.90	57
1889	1	78	0	13,277	6,639	17,957	2.70	50
1890	1	78	0	13,278	6,639	21,577	3.25	50
1891	1	80	0	20,551	9,464	30,483	3.22	46
1892	1	80	0	7,138	3,569	12,402	3.47	50
1893	1	80	0	15,118	7,135	25,072	3.51	47
1894	1	80	0	7,274	3,051	10,693	3.50	42
1895	1	80	0	11,825	5,175	17,657	3.41	43.8
1896	2	130	0	53,028	21,021	73,574	3.50	40

The character of the coal used in the manufacture of coke in the Indian Territory since 1890 is shown in the table on the next page.

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Character of coal used in the manufacture of coke in the Indian Territory since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	0	0	0	13,278	13,278
1891	0	0	9,500	11,051	20,551
1892	0	0	0	7,138	7,138
1893	0	0	0	15,118	15,118
1894	0	0	0	7,274	7,274
1895	0	0	0	11,825	11,825
1896	0	0	0	53,028	53,028

KANSAS.

The coke industry of Kansas is only of local importance, the production of coke in this State being chiefly for domestic purposes and the smelting of lead and zinc. Most of the coke produced in the State is made by the lead and zinc smelters for their own use.

The statistics of the manufacture of coke in Kansas from 1880 to 1896 are as follows:

Statistics of the manufacture of coke in Kansas from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880	2	6	.....	4,800	3,070	$6,000	$1.95	64
1881	3	15	.....	8,800	5,670	10,200	1.80	64.4
1882	3	20	.....	9,200	6,080	11,460	1.70	65
1883	4	23	.....	13,400	8,430	16,560	1.96	62.9
1884	4	23	.....	11,500	7,190	14,580	2.02	62.5
1885	4	23	.....	15,000	8,050	13,255	1.65	53.7
1886	4	36	.....	23,062	12,493	19,204	1.54	54.2
1887	4	39	.....	27,604	14,950	28,575	1.91	54
1888	6	58	.....	24,934	14,831	29,073	1.96	59
1889	6	68	.....	21,600	13,910	26,593	1.91	64
1890	7	68	.....	21,809	12,311	29,116	2.37	56
1891	6	72	.....	27,181	14,174	33,296	2.35	52
1892	6	75	.....	15,437	9,132	19,906	2.18	59.2
1893	6	75	0	13,645	8,565	18,640	2.18	62.8
1894	6	61	0	13,288	8,439	15,660	1.855	63.5
1895	5	55	0	8,424	5,287	11,289	2.14	62.8
1896	6	55	0	8,940	4,785	8,676	1.813	53.5

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The character of the coal used in the manufacture of coke in Kansas since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Kansas since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	0	0	19,619	2,190	21,809
1891	0	0	27,181	0	27,181
1892	0	0	15,437	0	15,437
1893	0	0	12,445	1,200	13,645
1894	0	0	13,288	0	13,288
1895	0	0	8,424	0	8,424
1896	0	0	8,940	0	8,940

KENTUCKY.

The number of coke establishments in Kentucky was reduced from five in 1895 to four in 1896, one establishment of 29 ovens being abandoned and decreasing the number of ovens from 293 to 264. There was a slight increase, however, in the amount of coke made. In 1895 the product was 25,460 tons, while in 1896 it was 27,107 tons, an increase of 1,647 tons.

The statistics of the manufacture of coke in Kentucky from 1880 to 1896 are as follows:

Statistics of the manufacture of coke in Kentucky from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880	5	45	.....	7,206	4,250	$12,250	$2.88	60
1881	5	45	.....	7,406	4,370	12,630	2.89	60
1882	5	45	.....	6,906	4,070	11,530	2.83	59
1883	5	45	.....	8,437	5,025	14,425	2.87	60
1884	5	45	.....	3,451	2,223	8,760	3.94	64
1885	5	33	.....	5,075	2,704	8,489	3.14	53
1886	6	76	2	9,055	4,528	10,082	2.23	50
1887	6	98	.....	29,129	14,565	31,730	2.18	50
1888	10	132	2	42,642	23,150	47,244	2.04	54
1889	9	166	100	25,192	13,021	29,769	2.28	52
1890	9	175	302	24,372	12,343	22,191	1.80	51
1891	7	115	24	64,390	33,777	68,281	2.02	52
1892	5	287	100	70,783	36,123	72,563	2.01	51
1893	4	283	100	97,212	48,619	97,350	2.00	50
1894	6	293	0	66,418	29,748	51,566	1.73	44.8
1895	5	293	0	63,419	25,460	37,249	1.46	40.1
1896	4	264	0	55,719	27,107	42,062	1.55	48.6

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The increase in the output in 1896 was due to greater activity in the Pineville region, but as one of the companies has since gone into a receiver's hands it is probable that the product in 1897 will be materially less than in 1896, unless industrial conditions show substantial improvement. Coal coked by the Pineville Coal and Coke Company was unwashed run of mine; all the other coal was washed slack.

The character of the coal used in the manufacture of coke in Kentucky since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Kentucky since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons*	*Short tons.*	*Short tons.*
1890	0	3,000	2,100	19,272	24,372
1891	11,000	0	3,500	49,890	64,390
1892	0	5,955	7,883	56,945	70,783
1893	825	11,973	26,759	57,655	97,212
1894	0	2,980	7,900	55,538	66,418
1895	0	502	624	62,293	63,419
1896	16,271	0	0	39,448	55,719

MISSOURI.

There is little to add to what has been said of coke manufacture in Missouri. There are three establishments in the State, all of which consume their own coke in the smelting of zinc. The ovens are run in connection with the zinc works. Three ovens were abandoned, reducing the number from ten to seven. The production of coke increased nearly 25 per cent, from 2,028 tons in 1895 to 2,500 tons in 1896, indicating a slight improvement in the zinc-smelting industry in that State. The coal used in Missouri coke ovens is all unwashed slack.

The statistics of the production of coke in Missouri from 1887, when coking began in this State, to 1896 are as follows:

Statistics of the manufacture of coke in Missouri from 1887 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1887	1	4	.....	5,400	2,970	$10,395	$3.50	55
1888	1	4	.....	5,000	2,600	9,100	3.50	52
1889	3	9	.....	8,485	5,275	5,800	1.10	62
1890	3	10	.....	9,491	6,136	9,240	1.51	65
1891	3	10	.....	10,377	6,872	10,000	1.45	66
1892	3	10	.....	11,088	7,299	10,949	1.50	65.8
1893	3	10	0	8,875	5,905	9,735	1.65	66.5
1894	3	10	0	3,442	2,250	3,563	1.58	65.4
1895	3	10	0	3,120	2,028	2,442	1.20	65
1896	3	7	0	4,471	2,500	4,131	1.65	55.9

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The character of the coal used for coke in Missouri since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Missouri since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	0	0	9,491	0	9,491
1891	0	0	10,377	0	10,377
1892	0	0	11,088	0	11,088
1893	0	0	8,875	0	8,875
1894	0	0	3,442	0	3,442
1895	0	0	3,120	0	3,120
1896	0	0	4,471	0	4,471

MONTANA.

Montana's coke production in 1896 was the largest in the history of the State, being about two and one-third times the output in 1895. The largest production in any previous year was in 1892, when 34,557 tons were made. It decreased in 1893 and again in 1894, the product in the latter year being about one-half of that in 1892. There was a marked improvement in 1895, and a still greater improvement in 1896. The number of establishments in 1896 and the number of ovens were the same as in 1895.

The statistics of the manufacture of coke in Montana from 1883, when ovens were first reported, to 1896 are as follows:

Statistics of the manufacture of coke in Montana from 1883 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1883	1	2	0	0	0	0	0	0
1884	3	5	12	165	75	$900	$12.00	46
1885	2	2	0	300	175	2,063	11.72	58.5
1886	4	16	0	0	0	0	0	0
1887	2	27	0	10,800	7,200	72,000	10.00	66⅔
1888	1	40	0	20,000	12,000	96,000	8.00	60
1889	2	90	50	30,576	14,043	122,023	8.69	46
1890	2	140	0	32,148	14,427	125,655	8.71	45
1891	2	140	0	61,667	29,009	258,523	8.91	47
1892	2	153	0	64,412	34,557	311,013	9.00	53.6
1893	2	153	0	61,770	29,945	239,560	8.00	48.5
1894	2	153	0	33,313	17,388	165,187	9.50	52.2
1895	3	303	0	55,770	25,337	189,856	7.49	45.4
1896	3	303	0	113,165	60,078	425,483	7.08	53

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The character of the coal used in the manufacture of coke in Montana since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Montana since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	0	22,852	0	9,296	32,148
1891	0	34,000	0	27,667	61,667
1892	0	28,000	0	36,412	64,412
1893	0	44,000	0	17,770	61,770
1894	0	33,313	0	0	33,313
1895	0	0	0	55,770	55,770
1896	0	50,000	0	63,165	113,165

NEW MEXICO.

There is only one establishment making coke in New Mexico, located at Cerrillos. All of the coke made is used by silver smelters in the Territory. As in Montana, there was a decided increase in coke production in New Mexico, the product in 1896 being 65 per cent larger than in 1895.

The statistics of the production of coke in New Mexico from 1882, when coke ovens were first reported, until 1896 are as follows:

Statistics of the manufacture of coke in New Mexico from 1882 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built. (a)	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1882	2	0	12	1,500	1,000	$6,000	$6.00	66⅔
1883	2	12	28	6,941	3,905	21,478	5.50	57¼
1884	2	70	0	29,990	18,282	91,410	5.00	57¼
1885	2	70	0	31,889	17,940	89,700	5.00	56¼
1886	2	70	0	18,194	10,236	51,180	5.00	56
1887	1	70	0	22,549	13,710	82,260	6.00	61
1888	1	70	0	14,628	8,540	51,240	6.00	58
1889	2	70	0	7,162	3,460	18,408	5.32	48
1890	2	70	0	3,980	2,050	10,025	4.89	51.5
1891	1	70	0	4,000	2,300	10,925	4.75	57.5
1892	1	50	0	0	0	0	0	0
1893	1	50	0	14,698	5,803	18,476	3.18	39.5
1894	1	50	0	13,042	6,529	28,213	4.32	50
1895	1	50	0	22,385	14,663	29,491	2.01	65.5
1896	1	50	0	39,286	24,228	48,453	2.00	61.7

a At one works there are ten stone pits, with an average capacity of 10 tons each.

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The character of the coal used in the manufacture of coke in New Mexico since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in New Mexico since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	3,980	0	0	0	3,980
1891	4,000	0	0	0	4,000
1892	0	0	0	0	0
1893	14,698	0	0	0	14,698
1894	0	0	13,042	0	13,042
1895	.....	.....	.....	.....	22,385
1896	0	0	39,286	0	39,286

NEW YORK.

The authority to publish separately the figures of production at the Semet-Solvay works, near Syracuse, has been withheld for 1896, and the output for the past year is included in Pennsylvania's production. The 13 ovens reported as building in 1893, 1894, and 1895, were completed in 1896, increasing the total number to 25.

The statistics of the manufacture of coke in New York from 1893 to 1896 are as follows:

Statistics of the manufacture of coke in New York, 1893 to 1896.

	1893.	1894.	1895.	1896.
Number of establishments	1	1	1	1
Number of ovens built	12	12	12	25
Number of ovens building	13	13	13	0
Amount of coke produced ..tons..	12,850	16,500	18,521	.....
Amount of coal used .....do...	15,150	.....	22,207	.....
Yield of coal in coke....per cent..	84.8	.....	83.4	.....

OHIO.

Notwithstanding the large consumption of coke in Ohio and the large fields of coking coals in the State, the coking industry is of slight importance. This is doubtless due to the same cause that obtains in Indiana, the proximity of the Connellsville, New River, and Pocahontas fields, and the cheapness with which these cokes can be procured.

In the reports for 1894 and 1895 the State was divided into two districts, the Cincinnati and Ohio. This division is adhered to in this

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report. The Ohio district, however, includes in 1896 two establishments having 175 ovens which belong to the Federal Valley district. These ovens produced 11,326 tons in 1896.

Cincinnati district.—All the coke made in this district is from the dust and screenings of the coal yards at Cincinnati and from the coal boats and barges that bring coal from the upper Ohio, chiefly from the Pittsburg and the Kanawha regions of West Virginia. When the ovens are in operation some run of mine and slack from Pittsburg mines is used in the North Bend block of ovens, situated on the Ohio River a short distance below Cincinnati.

The statistics of the manufacture of coke in the Cincinnati district from 1880 to 1896 are as follows:

Statistics of the manufacture of coke in the Cincinnati district, Ohio, from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880	4	32	0	16,141	10,326	$42,255	$4.09	64
1881	4	32	0	20,607	13,237	54,439	4.11	64
1882	4	32	0	19,687	12,045	47,437	3.78	64
1883	5	57	0	33,978	20,106	65,990	3.28	59
1884	5	57	0	32,134	18,840	61,072	3.24	59
1885	5	82	0	17,480	10,962	35,873	3.27	63
1886	5	82	0	17,015	10,566	31,633	2.99	62.1
1887	5	150	20	56,723	32,894	95,754	2.91	56
1888	6	156	12	63,217	35,868	95,618	2.67	57
1889	5	146	0	75,892	45,108	120,899	2.68	59
1890	5	150	0	68,266	43,278	171,848	3.97	63
1891	3	130	0	13,403	9,080	31,529	3.47	67.6
1892	4	146	0	31,330	19,320	64,319	3.33	61.6
1893	3	142	0	13,700	9,000	27,000	3.00	65.7
1894	3	92	0	42,995	26,417	81,751	3.09	61
1895	3	92	0	9,628	5,657	16,971	3.00	58.8
1896	3	92	0	16,495	10,181	31,068	3.05	61.7

Ohio district.—This district, as noted above, includes all of the ovens coking Ohio coal, and the ovens at Leetonia, in Columbiana County, and in the vicinity of Steubenville and Bridgeport, which latter place is opposite Wheeling, West Virginia. It also includes 125 ovens of the Marietta Run Coal and Coke Company and 50 ovens of the Black Diamond Coal and Coke Company in the Federal Valley district.

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Statistics of the manufacture of coke in the Ohio district, Ohio, from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880	11	584	25	156,312	90,270	$213,650	$2.37	57
1881	11	609	0	180,438	106,232	243,289	2.39	59
1882	12	615	0	161,890	91,677	218,676	2.39	57
1883	13	625	0	118,524	67,728	159,670	2.36	57
1884	14	675	0	76,030	43,869	95,222	2.17	58
1885	8	560	0	51,316	28,454	73,850	2.60	55
1886	10	478	0	42,317	24,366	62,409	2.56	57½
1887	10	435	208	108,251	60,110	150,227	2.50	55½
1888	9	391	0	60,984	1,326	70,712	2.25	51
1889	8	316	0	56,936	30,016	67,323	2.24	52.7
1890	8	293	1	58,655	31,335	46,242	1.47	53.4.
1891	6	291	0	55,917	39,638	45,372	1.53	53
1892	6	290	0	63,906	32,498	48,588	1.50	50.9
1893	6	293	0	29,263	13,436	16,671	1.24	46
1894	5	271	0	12,329	6,223	9,124	1.466	50.5
1895	5	285	0	42,293	23,393	52,684	2.25	55.3
1896	6	339	0	112,428	70,687	177,721	2.51	62.8

TOTAL COKE PRODUCTION IN OHIO.

In the following table the statistics of the production of coke in the two districts of Ohio for the years 1880 to 1896 are consolidated:

Statistics of the manufacture of coke in Ohio from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880	15	616	25	172,453	100,596	$255,905	$2.54	58
1881	15	641	0	201,045	119,469	297,728	2.49	59
1882	16	647	0	181,577	103,722	266,113	2.57	57
1883	18	682	0	152,502	87,834	225,660	2.57	58
1884	19	732	0	108,164	62,709	156,294	2.49	58
1885	13	642	0	68,796	39,416	109,723	2.78	57
1886	15	560	0	59,332	34,932	94,042	2.69	59
1887	15	585	223	164,974	93,004	245,981	2.65	56
1888	15	547	12	124,201	67,194	166,330	2.48	54

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Statistics of the manufacture of coke in Ohio from 1880 to 1896—Continued.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1889	13	462	0	132,828	75,124	$188,222	$2.50	56
1890	13	443	1	126,921	74,633	218,090	2.92	59
1891	9	421	0	69,320	38,718	76,901	1.99	56
1892	10	436	0	95,236	51,818	112,907	2.18	54.4
1893	9	435	0	42,963	22,436	43,671	1.95	52
1894	8	363	0	55,324	32,640	90,875	2.78	59
1895	8	377	0	51,921	29,050	69,655	2.40	56
1896	9	431	0	128,923	80,868	208,789	2.58	62.7

The character of the coal used in the manufacture of coke in Ohio since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Ohio since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	34,729	0	54,473	37,719	126,921
1891	5,200	0	64,120	0	69,320
1892	35,334	0	32,402	27,500	95,236
1893	0	0	24,859	18,104	42,963
1894	0	0	14,845	40,479	55,324
1895	28,053	0	10,868	13,000	51,921
1896	88,616	0	24,325	15,982	128,923

PENNSYLVANIA.

The coking districts of Pennsylvania have been so frequently described in previous volumes of Mineral Resources that it is not necessary to enter into any details regarding them. As it is important, however, that the dividing line between these districts should be kept in mind in examining these statistics, the following brief statement as to the territory included in these districts is given:

The Allegheny Mountain district includes the ovens along the line of the Pennsylvania Railroad from Gallitzin eastward over the crest of the Alleghenies to beyond Altoona. The Allegheny Valley district includes the coke works of Armstrong and Butler counties and one of those in Clarion County, the other ovens in the latter county being included in

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the Reynoldsville-Walston district. The Beaver district includes the ovens in Beaver County; the Blossburg and Broad Top those in the Blossburg and Broad Top coal fields. The ovens of the Clearfield-Center district are chiefly in the two counties from which it derives it name. The Connellsville district is the well-known region in western Pennsylvania, in Westmoreland and Fayette counties, extending from just south of Latrobe to Fairchance. The Greensburg, Irwin, Pittsburg, and Reynoldsville-Walston districts include the ovens near the towns which have given the names to these districts. The Upper Connellsville district, sometimes called the Latrobe district, is near the town of Latrobe.

In the following table the statistics are given of the production of coke in Pennsylvania for the years 1880 to 1896:

Statistics of the manufacture of coke in Pennsylvania from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880...	124	9,501	836	4,347,558	2,821,384	$5,255,040	$1.86	65
1881...	132	10,881	761	5,393,503	3,437,708	5,898,579	1.70	64
1882...	137	12,424	642	6,149,179	3,945,034	6,133,698	1.55	64
1883...	140	13,610	211	6,823,275	4,438,464	5,410,387	1.22	65
1884...	145	14,285	232	6,204,604	3,822,128	4,783,230	1.25	62
1885...	133	14,553	317	6,178,500	3,991,805	4,981,656	1.25	64.6
1886...	108	16,314	2,558	8,290,849	5,406,597	7,664,023	1.42	65.2
1887...	151	18,294	802	8,938,438	5,832,849	10,746,352	1.84	65.3
1888...	120	20,381	1,565	9,673,097	6,545,779	8,230,759	1.26	68
1889...	109	22,143	567	11,581,292	7,659,055	10,743,492	1.40	66
1890...	106	23,430	74	13,046,143	8,560,245	16,333,674	1.91	65.6
1891...	109	25,324	11	10,588,544	6,954,846	12,679,826	1.82	66
1892...	109	25,366	269	12,591,345	8,327,612	15,015,336	1.80	66.1
1893...	102	25,744	19	9,386,702	6,229,051	9,468,036	1.52	66
1894...	101	25,824	118	9,059,118	6,063,777	6,585,489	1.086	66.9
1895...	99	26,042	170	14,211,567	9,404,215	11,908,162	1.266	66.2
1896*a*..	158	26,658	154	11,124,610	7,356,502	13,182,859	1.792	66.1

a Includes coal used, coke produced, and its value in New York.

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In the following tables will be found the statistics of the production of coke in Pennsylvania, by districts, for the years 1894, 1895, and 1896.

Coke production in Pennsylvania in 1896, by districts.

District.	Establishments.	Number of ovens.	Number of ovens building.	Coal used.	Coke produced.	Value of coke at ovens.	Average price per ton.	Yield of coal in coke.
				Short tons.	*Short tons.*			*Per ct.*
Allegheny Mountain	13	a 1,188	0	408,827	266,473	$349,373	$1.31	65
Allegheny Valley	2	116	0	12,445	7,467	14,934	2.00	60
Beaver	3	b 35	0	13,845	9,004	17,200	1.91	65
Broad Top	5	480	0	111,145	72,175	126,306	1.75	64.9
Clearfield-Center	7	666	0	183,056	118,155	164,266	1.39	64.5
Connellsville	88	c 18,347	0	8,107,536	5,462,490	10,018,946	1.834	67.4
Greensburg	3	178	0	36,963	24,642	30,928	1.255	66.7
Irwin	5	669	0	279,104	175,916	275,518	1.566	63
Pittsburg	11	1,264	d 120	583,984	368,070	941,076	2.56	63
Reynoldsville-Walston (e)	7	1,852	34	770,104	445,998	673,625	1.51	57.9
Upper Connellsville	14	f 1,863	0	617,601	406,112	570,687	1.405	65.7
Total	158	26,658	154	11,124,610	7,356,502	13,182,859	1.792	66.1

a Includes 60 Otto-Hoffman ovens.
b Includes 25 Semet-Solvay ovens in Mercer County.
c Includes 50 Semet-Solvay ovens.
d Otto-Hoffman ovens.
e Includes coal used, coke produced, and its value in New York.
f Includes 30 Newton-Chambers and 3 Slocum ovens.

Coke production in Pennsylvania in 1895, by districts.

District.	Establishments.	Number of ovens.	Number of ovens building.	Coal used.	Coke produced.	Value of coke at ovens.	Average price per ton.	Yield of coal in coke.
				Short tons.	*Short tons.*			*Per ct.*
Allegheny Mountain	13	a 1,233	0	271,096	173,965	$214,741	$1.23	64
Allegheny Valley	2	116	0	0	0	0	0	0
Beaver	2	8	0	2,888	1,584	3,940	2.49	54.8
Blossburg	1	200	0	976	488	1,220	2.50	50
Broad Top	5	460	0	133,276	85,842	150,224	1.75	64.4
Clearfield-Center	8	695	0	155,088	99,469	131,188	1.32	64
Connellsville	29	18,028	b 80	12,174,597	8,181,179	10,122,458	1.237	67.2
Greensburg	3	118	0	31,300	20,309	22,340	1.10	65
Irwin	5	725	0	166,124	103,872	105,609	1.017	62.5
Pittsburg	9	973	0	452,845	232,529	547,284	2.35	51.3
Reynoldsville-Walston	8	1,637	0	504,092	296,820	357,266	1.20	58.9
Upper Connellsville	14	1,849	c 30	319,285	208,158	251,892	1.21	65
Total	99	26,042	110	14,211,567	9,404,215	11,908,162	1.266	66.2

a Includes 60 Otto-Hoffman ovens.
b Includes 50 Semet Solvay ovens.
c By-product beehive ovens.

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Coke production in Pennsylvania in 1894, by districts.

District.	Establishments.	Number of ovens.	Number of ovens building.	Coal used.	Coke produced.	Value of coke at ovens.	Average price per ton.	Yield of coal in coke.
				Short tons.	*Short tons.*			*Per ct.*
Allegheny Mountain	15	1,253	0	92,965	58,823	$71,161	$1.21	63.3
Allegheny Valley	2	116	0	0	0	0	0	0
Beaver	2	8	0	2,968	1,624	4,251	2.62	54.7
Blossburg	1	250	0	670	332	896	2.70	49.6
Broad Top	5	454	14	53,216	34,089	51,815	1.52	64.1
Clearfield-Center	8	694	0	61,428	38,825	51,482	1.33	63.2
Connellsville	29	17,829	0	7,656,169	5,192,080	5,405,691	1.04	67.8
Greensburg	3	118	0	27,290	15,872	18,413	1.16	58.2
Irwin	5	725	0	176,318	110,995	119,764	1.08	63
Pittsburg	9	779	104	371,569	227,100	351,825	1.55	61.1
Reynoldsville-Walston	8	1,755	0	336,554	207,238	297,596	1.44	61.6
Upper Connellsville	14	1,843	0	279,971	176,799	212,595	1.20	63.1
Total	101	25,824	118	9,059,118	6,063,777	6,585,489	1.086	66.9

From the above tables it will be seen that the coke produced in Pennsylvania in 1895, the year previous to the one under review, was the largest in its history. The production in 1894, on the other hand, was the smallest in the nine years from 1888 to 1896, inclusive. The output in 1895 was 3,340,438 tons, or 55 per cent larger than in 1894. In 1896 the output was 2,047,713 tons, or 22 per cent less than in 1895, and 1,292,725, or 21 per cent, more than the product in 1894. The amount of coke made in the State in 1896 was 7,356,502 tons. This is 111,570 tons less than the average production for the eight years immediately preceding. In these eight years there were four in which the production was less than in 1896, and four in which the output was greater.

By referring to the table giving the production of coke in the United States in 1896, it will be seen that out of a total of 11,788,773 short tons Pennsylvania produced 7,356,502 tons, or 62.4 per cent. This was the smallest percentage made by the State in a number of years. In 1895 she produced 70.5 per cent of the total, and not for several years has her percentage fallen below 65.

While the amount of coke produced in 1896 was more than 2,000,000 tons less than in 1895, in the value of the product there was an increase of over $1,250,000. If the product in 1896 had realized the same price per ton as the average in 1895 ($1.266) the total value would have been $9,390,310 instead of $13,182,859, so that for the same amount of work done the producers were $3,792,549 better off. The decrease in the output and

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increase in value were due entirely to the determination of the larger coke-making concerns in the Connellsville region to maintain prices on a profitable basis. The price for foundry coke was put at $2.30 per ton, and maintained at that figure throughout the year. The highest price obtained in 1895 was $2 in October, November, and December. From April to December the price was $1.50, while in January, February, and March it was as low as $1.15. An increase of 100 per cent in price naturally resulted in a curtailment of production.

In the production of those 7,356,502 tons of coke in Pennsylvania in 1896, 11,124,610 tons of coal were used, or 1.51 tons of coal to a ton of coke. This ratio was the same in 1895. In 1895 the average value per ton of the coal charged into the ovens was 61.6 cents. In 1896 the average value per ton was 62.5 cents, so it may be readily seen that the advance in the price of coke was not due to any noticeable advance in the price of coal, but was due to the ability of producers to maintain prices.

As has previously been explained, the amount of coke reported as produced per ton of coal is probably in excess of the actual yield. The probability is that the actual product is somewhat less than 66 per cent. Much of the coal is not weighed before charging into the ovens, and consequently the yield is largely an estimate, and much of that which is charged is paid for by the measured bushel, while the coke is sold by the weighed ton.

The character of the coal used in the manufacture of coke in Pennsylvania since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Pennsylvania since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	11,788,625	303,591	630,195	323,732	13,046,143
1891	9,470,646	256,807	558,106	302,985	10,588,544
1892	11,237,253	159,698	1,059,994	134,400	12,591,345
1893	8,302,307	216,762	739,128	128,505	9,386,702
1894	8,671,534	118,279	204,811	64,494	9,059,118
1895	13,618,376	34,728	440,869	117,594	14,211,567
1896 (a)	9,289,089	273,082	1,463,047	99,392	11,124,610

(a) Includes coal used in New York.

The above table shows that of the 11,124,610 tons of coal made into coke 9,289,089 tons, or 83.5 per cent, was unwashed run of mine; 1,463,047 tons, or 13 per cent, was unwashed slack; 273,082 tons, or 2.5 per cent, was washed run of mine, and 99,392, or not quite 1 per cent, was washed slack. In 1895 unwashed run of mine was over 95 per

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cent of the total, and unwashed slack 3 per cent. The amount of washed coal, run of mine and slack combined, was less than 2 per cent. The amount of washed coal in 1896 was nearly two and one-half times as much as in 1895, and the amount of unwashed slack in 1896 used was more than three times that of 1895. The amount of run of mine coal used in 1896 was more than 4,000,000 tons less than in 1895. While the remarkable feature of coke production in 1895 was an increase in all of the important coke-producing regions, the notable feature in 1896 was the greatly reduced production in the Connellsville district and marked increases in all the other districts except two—the Blossburg, which produced 488 tons in 1895 and was abandoned in 1896, and the Broad Top, which produced 85,842 tons in 1895 and 72,175 in 1896. As an offset to the abandonment of the ovens in the Blossburg district, the 116 ovens in the Allegheny Valley district, which were idle in 1894 and 1895, resumed in 1896, with an output of 7,467 tons.

The Allegheny Mountain district increased its output from 58,823 tons in 1894 to 173,965 tons in 1895, and again to 266,473 tons in 1896. The Clearfield-Center district produced 38,825 tons in 1894, 99,469 tons in 1895, and 118,155 tons in 1896. In the Pittsburg district production increased from 227,100 tons in 1894 to 232,529 tons in 1895, and to 368,070 tons in 1896. The Reynoldsville-Walston district increased from 207,238 tons in 1894 to 296,820 tons in 1895, and to 445,998 tons in 1896. The Upper Connellsville district produced 176,799 tons in 1894, 208,158 tons in 1895, and 406,112 tons in 1896. Comparing the production of these districts in 1896 with that in 1894, it is seen that the Allegheny Mountain district increased its production to four and one-half times what it was in 1894, the Clearfield-Center district more than three times, the Pittsburg district about one and two-thirds, the Reynoldsville-Walston more than double, and the Upper Connellsville two and a half times. Compared with the production in 1895, the Allegheny Mountain district shows an increase in 1896 of 92,508 tons, or 53 per cent; the Clearfield-Center district 18,686 tons, or about 18 per cent; the Pittsburg district 135,541 tons, or 58 per cent; the Reynoldsville-Walston district 149,178 tons, or 50 per cent, and the Upper Connellsville 197,954 tons, or 95 per cent. The Irwin district, whose product in 1895 was a little less than in 1894, increased its output in 1896 72,044 tons, or about 70 per cent.

It was in the Connellsville region, therefore, that the decreased production occurred. The output in this district in 1895 increased 2,989,099 tons, or more than 57 per cent over that of 1894. The production in 1896 decreased 2,718,689, or 33 per cent below 1895, and was only 270,000 tons more than in 1894. This decreased production was due entirely to the determination on the part of producers to maintain prices at a profitable figure. Had the decrease in production been due to other causes, the value would have decreased in proportion. As it

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was, the amount received by Connellsville coke makers for the 5,462,490 tons of coke made in 1896 was within 1 per cent of that received for the 8,181,179 tons made in 1895, and nearly double the value of the 5,192,080 tons produced in 1894.

The producers in the other regions received additional benefit from the lessened product and higher prices of Connellsville coke in better prices for themselves. The average price per ton in the Allegheny Mountain district advanced from $1.23 to $1.31; in the Clearfield-Center from $1.32 to $1.39; in the Irwin district from $1.017 to $1.566; in the Pittsburg district from $2.35 to $2.56; in the Reynoldsville-Walston district from $1.20 to $1.51, and in the Upper Connellsville from $1.21 to $1.405. The price for Connellsville coke advanced from $1.237 in 1895 to $1.834 in 1896, and the average for the State advanced from $1.266 to $1.792.

During 1896 the by-product ovens mentioned in the report for 1895 became producers. These include 60 Otto-Hoffman ovens at the Cambria Iron Works, at Johnstown, 25 Semet-Solvay ovens in Mercer County, 50 Semet-Solvay ovens at Dunbar, 30 Newton-Chambers at Latrobe, and 3 Slocum ovens at Bolivar. The returns for 1896 show that 120 more of the Otto-Hoffman ovens were in course of construction in the Pittsburg district at the close of the year.

Connellsville district.—The decreased production of the Connellsville district in 1896 has not affected its standing as the most important coke-producing center in the United States. This region produced 87 per cent of the Pennsylvania product in 1895 and 61 per cent of the total output in the United States. In 1896 the Connellsville region produced 74 per cent of Pennsylvania's total and 46 per cent of the total product in the United States.

The following are the statistics of the manufacture of coke in the Connellsville region from 1880 to 1896:

Statistics of the manufacture of coke in the Connellsville region, Pennsylvania, from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880....	67	7,211	731	3,367,856	2,205,946	$3,948,643	$1.79	66.5
1881....	70	8,208	654	4,018,782	2,639,002	4,301,573	1.63	65.7
1882....	72	9,283	592	4,628,736	3,043,394	4,473,789	1.47	65.8
1883....	74	10,176	101	5,355,380	3,552,402	4,049,738	1.14	66.3
1884....	76	10,543	200	4,829,054	3,192,105	3,607,078	1.13	66.1
1885....	68	10,471	48	4,683,831	3,096,012	3,776,388	1.22	66.1
1886....	36	11,324	1,895	6,305,460	4,180,521	5,701,086	1.36	66.3
1887....	73	11,923	98	6,182,846	4,146,989	7,437,669	1.79	67

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Statistics of the manufacture of coke in the Connellsville region, Pennsylvania, from 1880 to 1896—Continued.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1888....	38	12,818	1,320	7,191,708	4,955,553	$5,884,081	$1.19	69
1889....	29	14,458	430	8,832,371	5,930,428	7,974,633	1.34	67
1890....	28	15,865	30	9,748,449	6,464,156	12,537,370	1.94	66
1891....	33	17,551	0	7,083,705	4,760,665	8,903,454	1.87	67
1892....	31	17,309	0	9,389,549	6,329,452	11,598,407	1.83	67.4
1893....	28	17,504	5	7,095,491	4,805,623	7,141,031	1.49	67.7
1894....	29	17,829	0	7,656,169	5,192,080	5,405,691	1.04	67.8
1895....	29	18,028	*a* 80	12,174,597	8,181,179	10,122,458	1.237	67.2
1896....	88	*a*18,347	0	8,107,536	5,462,490	10,018,946	1.834	67.4

a Includes 50 Semet-Solvay by-product ovens.

In the Connellsville region the old beehive oven still stands supreme, all but 50 of the 18,347 in the district being of this type. The exception consists of a bank of Semet-Solvay ovens, which were completed in 1895, and contributed to the product in 1896.

In the following table will be found a statement taken from the files of the American Manufacturer of Pittsburg, showing the number of cars shipped out of the region in 1894, 1895, and 1896. It is to be remembered that the great strike of 1894 was responsible for the small shipments in that year.

Monthly shipments of coke from the Connellsville region during 1894, 1895, and 1896.

Months.	Cars.		
	1894.	1895.	1896.
January	17,558	29,530	26,891
February	20,560	31,643	31,808
March	23,216	44,384	29,992
April	20,678	29,674	27,240
May	3,328	32,930	33,307
June	11,518	30,507	22,263
July	11,518	32,944	23,457
August	23,476	41,820	22,214
September	35,841	35,568	12,815
October	30,294	37,251	17,237
November	30,714	47,680	16,804
December	31,774	38,885	21,238
Total	260,475	432,816	285,266

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The correspondent of the American Manufacturer, in Connellsville, in reporting the industry for that paper, says:

The Connellsville coke trade during the year showed no special feature further than the great dullness which cut down production so greatly in the latter part of the summer. The largest output in the Connellsville region was during the month of February, and the smallest was in September. Prices during the year showed no material change. The larger companies, who practically control the market, have sustained one rate during the year, keeping furnace coke at $2, foundry at $2.30, and crushed at $2.35 per ton f. o. b. at ovens. It can not be said, however, that these were the only coke prices during the year. Several of the smaller companies continued to sell furnace coke at $1.75 for a great part of the year, and at times even lower figures were rumored.

The following table shows how prices were quoted throughout the year:

Average monthly prices of coke during 1896.

Month.	Furnace.	Foundry.	Crushed.
January	$1.75 to $2.00	$2.30	$2.35
February	1.75 2.00	2.30	2.35
March	1.75 2.00	2.30	2.35
April	1.75 2.00	2.30	2.35
May	1.75 2.00	2.30	2.35
June	1.75 2.00	2.30	2.35
July	1.75 2.00	2.30	2.35
August	1.75 2.00	2.30	2.35
September	1.75 2.00	2.30	2.35
October	1.75 2.00	2.30	2.35
November	1.75 2.00	2.30	2.35
December	1.75 2.00	2.30	2.35

How the above compares with the prices for the corresponding months in 1895 may be seen below:

Average monthly prices of coke during 1895.

Month.	Furnace.	Foundry.	Crushed.
January	$1.00	$1.15	$1.40
February	1.00	1.15	1.40
March	1.00	1.15	1.40
April	1.35	1.50	1.65
May	1.35	1.50	1.65
June	1.35	1.50	1.65
July	1.35	1.50	1.65
August	1.35	1.50	1.65
September	1.35	1.50	1.65
October	1.60	2.00	2.25
November	1.60	2.00	2.25
December	1.60	2.00	2.25

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The following table gives the ruling and circular prices of blast-furnace coke free on board at the ovens for the past sixteen years:

Monthly prices of Connellsville blast-furnace coke free on board at ovens.

Month.	1881.		1882.		1883.		1884.	1885.
January	$1.50 to	$1.75	$1.70 to	$1.80	$1.15 to	$1.20	$1.00	$1.10
February	1.50	1.75	1.70	1.80	1.10	1.20	1.00	1.10
March	1.50	1.75	1.70	1.75		1.05	1.00	1.10
April	1.60	1.75	1.70	1.75		1.05	1.10	1.20
May	1.60	1.65	1.65	1.70	.95	1.05	1.10	1.20
June	1.60	1.65	1.50	1.65		.90	1.10	1.20
July	1.50	1.60	1.35	1.50		.90	1.10	1.20
August.....		1.60		1.35		.90	1.10	1.20
September ...		1.60	1.25	1.35		1.00	1.10	1.20
October	1.60	1.65		1.25		1.00	1.10	1.20
November	1.60	1.65	1.25	1.35		1.00	1.10	1.20
December	1.60	1.70	1.15	1.35		1.00	1.10	1.20

Month.	1886.	1887.	1888.	1889.	1890.	1891.
January	$1.20	$1.50	$1.75	$1.25	$1.75	$1.90
February	1.20	2.00	1.75	1.25	1.75	1.90
March	1.35	2.00	$1.25 to 1.50	1.25	2.15	1.90
April	1.35	2.00	1.00	1.15	2.15	1.90
May	1.50	2.00	1.00	1.10	2.15	1.90
June	1.50	2.00	1.00	1.10	2.15	1.90
July	1.50	2.00	1.00	$1.00 to 1.10	2.15	1.90
August.....	1.50	2.00	1.00	1.10	2.15	1.90
September ...	1.50	2.00	1.00	1.25 1.50	2.15	1.85
October	1.50	2.00	1.00	1.50	2.15	1.85
November	1.50	2.00	1.25	1.75	2.15	1.80
December	1.50	2.00	1.25	1.75	2.15	1.80

Month.	1892.	1893.	1894.	1895.	1896.
January	$1.90	$1.90	$0.95 to $1.00	$1.00	$1.75 to $2.00
February	1.90	1.90	.95	1.00	1.75 2.00
March	1.90	1.90	1.00	1.00	1.75 2.00
April	1.90	1.70	.92	1.35	1.75 2.00
May	1.80	1.60	.92	1.35	1.75 2.00
June	1.80	1.50	1.00	1.35	1.75 2.00
July	1.75	1.45	1.00	1.35	1.75 2.00
August	1.75	1.25	1.15 2.00	1.35	1.75 2.00
September	1.75	1.20	1.30 1.40	1.35	1.75 2.00
October	1.75	1.20	1.00	1.60	1.75 2.00
November.....	1.75	1.10	1.01	1.60	1.75 2.00
December.....	1.75	1.05	1.00	1.60	1.75 2.00

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Upper Connellsville district.—This district includes that portion of the Connellsville coal trough or basin that is located northward from a point just below Latrobe. The coal differs somewhat from that found in the lower part of the basin.

The following are the statistics of the manufacture of coke in the Upper Connellsville region for the years 1880 to 1896:

Statistics of the manufacture of coke in the Upper Connellsville district from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880.....	8	757	0	319,927	229,433	$397,945	$1.73	59
1881.....	10	986	0	588,924	343,728	548,362	1.60	58
1882.....	11	1,118	0	650,174	375,918	536,503	1.43	58
1883.....	11	1,118	0	668,882	389,053	422,174	1.08	58
1884.....	11	1,118	0	496,894	294,477	311,665	1.06	59
1885.....	11	1,168	40	555,735	319,297	346,168	1.08	57
1886.....	12	1,337	29	691,331	442,968	572,073	1.29	64.1
1887.....	16	1,442	87	717,274	470,233	840,144	1.79	65.6
1888.....	16	1,977	0	657,966	441,966	617,189	1.40	68
1889.....	13	1,568	80	635,220	417,263	609,828	1.46	65.6
1890.....	14	1,569	28	889,277	577,246	1,008,102	1.75	64.9
1891.....	14	1,724	0	1,000,184	649,316	1,111,056	1.71	65
1892.....	14	1,843	0	706,171	451,975	691,323	1.53	64
1893.....	14	1,843	0	499,809	320,793	447,090	1.39	64
1894.....	14	1,843	0	279,971	176,799	212,595	1.20	63
1895.....	14	1,849	*a* 30	319,285	208,158	251,892	1.21	65
1896.....	14	*b* 1,863	0	617,601	406,112	570,687	1.405	65.7

a By-product beehive ovens. *b* Includes 33 by-product ovens.

It will be seen in the above table that the output in 1896 increased 197,954 tons, or 95 per cent over 1895, and that the district recovered some of its old-time importance, though it was still 45,000 tons short of the production in 1892, and 243,000 tons less than in 1891, when the largest yield was obtained. In 1894 and 1895 the production was less than in other years since statistics have been obtained.

Allegheny Mountain district.—In this district are included all the ovens along the line of the Pennsylvania Railroad east of Blairsville and those in Somerset County.

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The statistics of the manufacture of coke in the Allegheny Mountain district from 1880 to 1896 are as follows:

Statistics of the manufacture of coke in the Allegheny Mountain district of Pennsylvania from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880.....	8	291	0	201,345	127,525	$289,929	$2.27	63
1881.....	9	371	0	225,563	144,430	329,198	2.28	64
1882.....	10	481	0	284,544	179,580	377,286	2.10	63
1883.....	10	532	0	200,343	135,342	240,641	1.78	68
1884.....	12	614	0	241,459	156,290	203,213	1.30	65
1885.....	11	523	82	327,666	212,242	286,539	1.30	65
1886.....	10	579	14	351,070	227,369	374,013	1.64	64.8
1887.....	10	694	150	461,922	297,724	671,437	2.25	64.4
1888.....	12	950	145	521,047	335,689	479,845	1.43	64.4
1889.....	16	1,069	20	564,112	354,288	601,964	1.69	63.5
1890.....	16	1,171	0	633,974	402,514	730,048	1.81	63.5
1891.....	16	1,201	0	708,523	448,067	782,175	1.75	63
1892.....	16	1,260	0	724,903	448,522	775,927	1.73	61.9
1893.....	15	1,260	0	275,865	173,131	264,292	1.53	62.8
1894.....	15	1,253	0	92,965	58,823	71,161	1.21	63.3
1895.....	13	1,233	60	271,096	173,965	214,741	1.23	64
1896.....	13	[a]1,188	0	408,827	266,473	349,373	1.31	65

[a] Includes 60 Otto-Hoffman ovens.

This district, like the other important ones in the State, benefited by the higher prices of Connellsville coke, and the production increased 92,508 tons, or 53 per cent, over 1895, and was four and one-half times the output in 1894. Still it did not reach the amount made in 1892, and was less than in any year from 1887 to 1892, inclusive.

Clearfield-Center district.—This district includes the ovens in Clearfield and Center counties, including Snow Shoe, Moshannon, and other well-known coal districts. While it has great promises for the future, much of its coke is made from slack coal, and the prosperity of the coke industry in the district depends not only on the demand for coke, but also on the demand for coal and amount of slack available.

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The statistics of the manufacture of coke in the Clearfield-Center district for the years 1880 to 1896 are as follows:

Statistics of the manufacture of coke in the Clearfield-Center district, Pennsylvania, from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880.....	1	0	0	200	100	$200	$2.00	50
1881.....	2	50	0	20,025	13,350	22,695	1.70	67
1882.....	1	50	0	25,000	17,160	27,406	1.60	69
1883.....	1	60	0	26,500	18,696	28,844	1.50	71
1884.....	1	60	0	33,000	23,431	32,849	1.40	71
1885.....	2	245	0	69,720	48,103	70,331	1.46	69
1886.....	3	299	20	84,870	55,810	94,877	1.70	66
1887.....	6	523	10	154,566	97,852	198,095	2.02	63.3
1888.....	6	601	0	172,999	115,338	174,220	1.51	66.6
1889.....	6	671	0	195,473	120,734	215,112	1.78	61.7
1890.....	7	701	0	331,104	212,286	391,957	1.85	64
1891.....	7	666	0	293,542	183,911	339,082	1.84	63
1892.....	7	731	0	231,357	147,819	264,422	1.79	63.9
1893.....	8	695	0	155,119	98,650	171,482	1.74	63.6
1894.....	8	694	0	61,428	38,825	51,482	1.33	63
1895.....	8	695	0	155,088	99,469	131,188	1.32	64
1896.....	7	666	0	183,056	118,155	164,266	1.39	64.5

While the production in this district increased 18,686 tons, or 18 per cent, over the output of 1895, and was three times the product of 1894, it was still below the capacity of the district as shown in the production from 1888 to 1892. The better conditions in 1896, both in amount and value of the product, as compared with 1894 and 1895, were due to the high price of Connellsville coke.

Broad Top district.—The ovens situated in Bedford and Huntingdon counties, comprising what is known as the Broad Top coal field, are included in this district. This district was the one exception to the increased production outside of the Connellsville district in 1896, the output here decreasing 13,667 tons.

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The statistics of the manufacture of coke in the Broad Top region from 1880 to 1896 are shown in the following table:

Statistics of the manufacture of coke in the Broad Top region, Pennsylvania, from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880.....	5	188	105	92,894	51,130	$123,748	$2.40	55
1881.....	5	188	105	111,593	66,560	167,074	2.51	59
1882.....	5	293	50	170,637	105,111	215,079	2.05	62
1883.....	5	343	110	220,932	147,154	271,692	1.84	66
1884.....	5	453	0	227,954	151,959	264,569	1.74	66
1885.....	5	537	0	190,836	112,073	185,656	1.65	58
1886.....	5	562	100	171,137	108,294	187,321	1.73	63.3
1887.....	5	581	0	262,730	164,535	347,061	2.11	62.6
1888.....	5	591	0	196,015	119,469	286,655	2.40	61
1889.....	5	589	0	152,090	91,256	186,718	2.05	60
1890.....	5	482	16	247,823	157,208	314,416	2.00	63
1891.....	5	448	0	146,008	90,728	197,048	2.17	62
1892.....	5	448	8	185,600	117,554	216,090	1.84	63.3
1893.....	5	456	14	136,069	86,752	150,196	1.73	63.8
1894.....	5	454	14	53,216	34,089	51,815	1.52	64
1895.....	5	460	0	133,276	85,842	150,224	1.75	64.4
1896.....	5	480	0	111,145	72,175	126,306	1.75	64.9

Pittsburg district.—Much of the coal made into coke in the Pittsburg district is slack, usually obtained from the mines along the several pools of the Monongahela River and brought to Pittsburg by barges. Latterly also considerable coal has been brought from the fourth pool of the Monongahela River to Pittsburg for coking. The indications are that the Pittsburg district will, in the near future, assume much greater importance as a coke-producing center than it has heretofore enjoyed, in view of the fact that a large number of by-product ovens will be built in and near Pittsburg along the Monongahela River. In this district are included the ovens at and near Pittsburg, as well as the ovens in Washington County that use slack from the coal mines of that county.

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The statistics of the manufacture of coke in the Pittsburg district, Pennsylvania, for the years 1880 to 1896 are stated in the following table.

Statistics of the manufacture of coke in the Pittsburg district, Pennsylvania, from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880.....	21	534	0	194,393	105,974	$254,500	$2.40	55
1881.....	21	538	0	178,509	96,310	206,965	2.15	54
1882.....	21	557	0	114,956	64,779	134,378	2.07	61
1883.....	20	542	0	119,310	66,820	126,020	1.89	56
1884.....	20	535	0	97,367	53,857	99,911	1.87	55
1885.....	17	416	4	91,101	46,930	72,509	1.55	51.5
1886.....	18	730	0	228,874	138,646	221,617	1.88	60.6
1887.....	20	880	235	366,184	177,097	315,546	1.78	48.4
1888.....	22	980	0	428,899	264,156	350,818	1.33	62
1889.....	17	600	21	233,571	141,324	283,402	2.00	60.5
1890.....	14	541	0	149,230	93,984	171,465	1.82	63
1891.....	13	590	11	154,054	94,160	201,458	2.14	61
1892.....	15	725	261	292,357	176,365	376,613	2.14	60.3
1893.....	10	885	0	357,400	216,268	438,801	2.03	60.5
1894.....	9	779	104	371,569	227,100	351,825	1.55	61
1895.....	9	973	0	452,845	232,529	547,284	2.35	51.3
1896.....	11	1,264	*a* 120	583,984	368,070	941,076	2.56	63

a Otto-Hoffman by-product ovens.

The production of coke in the Pittsburg district was 135,541 tons, or 58 per cent larger than in 1895, and was the largest ever obtained in the district, being more than 100,000 tons ahead of the production in 1888, which was the largest in any previous year.

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Beaver district.—The output in the Beaver district in 1896 is increased by the inclusion of 25 Semet-Solvay ovens in Mercer County.

The following are the statistics of the manufacture of coke in the Beaver district, Pennsylvania, for the years 1880 to 1896:

Statistics of the manufacture of coke in the Beaver district, Pennsylvania, from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880.....	5	106	.....	8,013	4,880	$10,150	$2.08	61
1881.....	5	106	.....	6,887	4,333	9,013	2.08	63
1882.....	5	106	.....	11,699	7,960	15,124	1.90	68
1883.....	5	107	.....	19,510	12,395	21,062	1.70	64
1884.....	4	89	.....	2,250	1,390	2,168	1.56	62
1885.....	4	89	.....	686	438	696	1.59	63
1886.....	3	87	.....	698	411	646	1.57	59
1887.....	3	65	.....	25,207	13,818	24,137	1.75	55
1888.....	4	145	.....	262	175	260	1.48	66.6
1889.....	3	90	.....	3,100	1,853	3,848	2.07	60
1890.....	3	90	.....	4,010	2,148	4,564	2.12	53.5
1891.....	3	88	.....	4,224	2,332	6,663	2.86	55
1892.....	2	10	0	3,925	2,154	6,270	2.91	54.9
1893.....	2	10	0	2,998	1,644	4,446	2.70	54.8
1894.....	2	8	0	2,968	1,624	4,251	2.62	54.7
1895.....	2	8	0	2,888	1,584	3,940	2.49	54.8
1896.....	3	*a* 35	0	13,845	9,004	17,200	1.91	65

a Includes 25 Semet-Solvay ovens in Mercer County.

Allegheny Valley district.—This district includes the coke works of Armstrong and Butler counties, situated in the valley of the Allegheny River. There was no coke made in this district in 1894 or 1895, but the prediction made in this report for last year that production would be resumed in the near future has been verified by an output of 7,467 tons in 1896.

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The statistics of the manufacture of coke in the Allegheny Valley district for the years 1880 to 1896 are as follows:

Statistics of the manufacture of coke in the Allegheny Valley district, Pennsylvania, from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880.....	5	97	0	45,355	23,470	$49,068	$2.10	52
1881.....	5	109	0	55,676	29,650	64,664	2.18	53
1882.....	6	159	0	76,000	41,897	80,294	1.92	55
1883.....	6	159	0	64,810	34,868	62,982	1.81	54
1884.....	7	209	0	55,110	31,430	54,859	1.75	57
1885.....	5	208	0	28,630	15,326	30,151	1.97	53.5
1886.....	5	208	0	51,580	28,948	44,422	1.54	56
1887.....	5	288	88	77,666	44,621	84,913	1.90	57.1
1888.....	5	376	0	37,792	21,719	36,008	1.66	57.5
1889.....	4	198	0	13,105	6,569	10,538	1.62	50
1890.....	3	148	0	33,049	18,733	40,204	2.15	56.7
1891.....	3	148	0	21,833	11,314	25,909	2.29	52
1892.....	3	148	0	0	0	0	0	0
1893.....	2	116	0	10,927	6,557	11,147	1.70	60
1894.....	2	116	0	0	0	0	0	0
1895.....	2	116	0	0	0	0	0	0
1896.....	2	116	0	12,445	7,467	14,934	2.00	60

Reynoldsville-Walston district.—This district includes all the ovens on the Rochester and Pittsburg Railroad, as well as those on the Low Grade Division of the Allegheny Valley Railway, and the mines of the New York, Lake Erie and Western Railroad. It is at the present time one of the most important coking districts in Pennsylvania, and gives promise of great increase in production in the near future. The production of coke in this district in 1896 (including a small amount made in New York) was the largest, with one exception, in its history. Compared with 1895, the output in 1896 shows an increase of 149,178 tons, or 50 per cent.

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The following are the statistics of the manufacture of coke in the Reynoldsville-Walston district for the years 1880 to 1896:

Statistics of the manufacture of coke in the Reynoldsville-Walston district, Pennsylvania, from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880.....	3	117	0	45,055	28,090	$46,359	$1.65	62
1881.....	4	125	2	99,489	44,260	80,785	1.85	44
1882.....	5	177	0	87,314	44,709	80,339	1.80	51
1883.....	6	229	0	76,580	37,044	65,584	1.77	48
1884.....	7	321	0	159,151	78,646	113,155	1.44	49
1885.....	8	600	143	183,806	114,409	153,795	1.35	62
1886.....	9	783	500	271,037	161,828	217,834	1.35	59.7
1887.....	11	1,492	134	507,320	316,107	592,728	1.88	62.3
1888.....	9	1,636	100	404,346	253,662	320,203	1.26	62.7
1889.....	8	1,747	0	514,461	313,011	436,857	1.40	60.8
1890.....	8	1,737	0	652,966	406,184	771,996	1.90	62
1891.....	7	1,747	0	769,100	470,479	744,098	1.58	61
1892.....	8	1,734	0	683,539	425,250	743,227	1.75	62.2
1893.....	8	1,755	0	562,033	339,314	586,212	1.73	60.4
1894.....	8	1,755	0	336,554	207,238	297,596	1.44	61.6
1895.....	8	1,637	0	504,092	296,820	357,266	1.20	58.9
1896 *a*	7	1,852	34	770,104	445,998	673,625	1.51	57.9

a Includes coal used, coke produced, and its value in New York.

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Blossburg district.—This district, which was at one time of considerable importance as a coke-producing district, especially to central and western New York, produced very little coke in 1894 and 1895, and none in 1896. The ovens have been abandoned.

Statistics of the manufacture of coke in the Blossburg district, Pennsylvania, from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880	1	200	0	72,520	44,836	$134,500	$3.00	62
1881	1	200	0	88,055	56,085	168,250	3.00	64
1882	1	200	0	100,119	64,526	193,500	3.00	64
1883	2	344	0	71,028	44,690	122,450	2.74	63
1884	2	344	32	62,365	39,043	93,763	2.40	63
1885	2	296	0	46,489	26,975	59,423	2.17	58
1886	2	405	0	136,136	81,801	174,532	2.13	60
1887	2	406	0	182,623	103,873	234,622	2.26	56.9
1888	2	407	0	62,063	38,052	81,400	2.14	61
1889	2	407	0	31,806	18,422	47,765	2.59	58
1890	2	407	0	41,785	23,196	62,804	2.71	55.5
1891	2	407	0	46,084	24,351	66,195	2.72	53
1892	2	404	0	30,746	16,675	45,855	2.75	54.2
1893	2	407	0	22,176	11,463	31,427	2.74	50.7
1894	1	250	0	670	332	896	2.70	50
1895	1	200	0	976	488	1,220	2.50	50
1896	0	0	0	0	0	0	0	0

Greensburg district.—The Greensburg district includes a small number of ovens situated in the Greensburg coal basin, erected chiefly for the utilization of the slack coal. The coal is all from the Pittsburg vein.

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The following are the statistics of the manufacture of coke in the Greensburg district from 1889 to 1896:

Statistics of the manufacture of coke in the Greensburg district, Pennsylvania, from 1889 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1889.....	2	50	16	32,070	20,459	$21,523	$1.05	63.8
1890.....	2	58	0	44,000	30,261	44,290	1.46	68.7
1891.....	2	58	0	38,188	22,441	36,627	1.63	59
1892.....	2	58	0	15,005	9,037	13,173	1.46	60.2
1893.....	3	88	0	29,983	18,393	26,303	1.43	61
1894.....	3	118	0	27,290	15,872	18,413	1.16	58.2
1895.....	3	118	0	31,300	20,309	22,340	1.10	65
1896.....	3	178	0	36,963	24,642	30,928	1.255	66

Irwin district.—The Irwin district comprises the ovens situated near the town of that name; also those located in what may be termed the Irwin basin, on the Youghiogheny River. It will be noted that this district is of considerable importance as a coke producer. Most of the coke made in the district is produced by the Carnegie Steel Company, Limited, at Larimer, where slack from the gas coal mined in the imme. diate vicinity is made into coke.

The following are the statistics of the manufacture of coke in the Irwin district for the years 1889 to 1896:

Statistics of the manufacture of coke in the Irwin district, Pennsylvania, from 1889 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1889.....	4	696	0	373,913	243,448	$351,304	$1.44	65
1890.....	4	661	0	270,476	172,329	256,458	1.49	63.7
1891.....	4	696	0	323,099	197,082	266,061	1.35	61
1892.....	4	696	0	328,193	202,809	284,029	1.40	61.8
1893.....	5	725	0	238,832	150,463	195,609	1.30	63
1894.....	5	725	0	176,318	110,995	119,764	1.08	63
1895.....	5	725	0	166,124	103,872	105,609	1.017	62.5
1896.....	5	669	0	279,104	175,916	275,518	1.566	63

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TENNESSEE.

Owing to a decreased production in 1896 of 57,588 tons as compared with 1895, and an increase in Colorado's production of about 15,500 tons, Tennessee drops from fourth to fifth place in the rank of coke-producing States. Colorado, which was fifth in 1895, advanced to fourth in 1896. Tennessee was one of the three Appalachian States whose product decreased in 1896. The other two were Pennsylvania and Georgia.

The following are the statistics of the manufacture of coke in Tennessee for the years 1880 to 1896:

Statistics of manufacture of coke in Tennessee from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880.....	6	656	68	217,656	130,609	$316,607	$2.42	60
1881.....	6	724	84	241,644	143,853	342,585	2.38	60
1882.....	8	861	14	313,537	187,695	472,505	2.52	60
1883.....	11	992	10	330,961	203,691	459,126	2.25	62
1884.....	*a* 13	1,105	175	348,295	219,723	428,870	1.95	63
1885.....	12	1,387	36	412,538	218,842	398,459	1.82	53
1886.....	12	1,485	126	621,669	368,139	687,865	1.87	59
1887.....	11	1,560	165	655,857	396,979	870,900	2.19	61
1888.....	11	1,634	84	630,099	385,693	490,491	1.27	61
1889.....	12	1,639	40	626,016	359,710	731,496	2.03	57
1890.....	11	1,664	292	600,387	348,728	684,116	1.96	58
1891.....	11	1,995	0	623,177	364,318	701,803	1.93	58
1892.....	11	1,941	0	600,126	354,096	724,106	2.05	59
1893.....	11	1,942	0	449,511	265,777	491,523	1.85	59
1894.....	11	1,860	0	516,802	292,646	480,124	1.64	56.6
1895.....	12	1,903	0	684,655	396,790	754,926	1.90	57.9
1896.....	15	1,861	100	600,379	339,202	624,011	1.84	56.5

a One establishment made coke in pits.

As will be seen in the above table, that while the production in 1896 was less than in 1895, it was larger than that of either 1893 or 1894. The average annual production from 1887 to 1896 (ten years) was 350,394 tons, while the variation was from 265,777 tons in 1893 to 396,979 tons in 1887. This shows that the output in 1896 was about 11,000 tons less than the average for the last ten years.

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The character of the coal used in the manufacture of coke in Tennessee since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Tennessee since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	255,359	0	273,028	72,000	600,387
1891	184,556	0	377,914	60,707	623,177
1892	176,453	15,000	367,827	40,846	600,126
1893	179,126	0	137,483	132,902	449,511
1894	166,990	61,841	149,958	138,013	516,802
1895	96,744	59,284	285,906	242,721	684,655
1896	0	206,319	219,231	174,829	600,379

The most notable feature of the coke industry in this State during the past year is the increased attention given to the treatment of coal used in coking. The reports show that 64 per cent of the coal used in the manufacture of coke in Tennessee during 1896 was washed, whereas only 12 per cent of the coal used in the manufacture of coke in 1890 was washed. The washing of coal in this State has now become a necessity, and every large plant in the State, except one, that produces furnace coke is equipped with a washing plant.

TEXAS.

No coke has yet been produced in this State upon a commercial scale. The Texas and Pacific Coal Company is still experimenting, and hopes to be able to report successful operations before the close of the year. Considerable trouble has been experienced in washing the coal. In the early part of 1897 the company was contemplating the erection of a new washer, which was guaranteed to do the work in a satisfactory manner.

UTAH.

As there is but one establishment making coke in Utah, detailed statistics of production have been included with that of Colorado, as the coals in this State are practically identical in character with those of western Colorado.

The following is the amount of coke produced in Utah from 1889 to 1896:

Production of coke in Utah from 1889 to 1896.

Year.	Tons.	Year.	Tons.
1889	761	1893	16,005
1890	8,528	1894	16,056
1891	7,949	1895	22,519
1892	7,309	1896	20,447

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VIRGINIA.

In 1895, for the first time since the publication of these reports began, Virginia showed a production of coke that could properly be called a Virginia product. Previous to 1895 only two establishments were reported in Virginia. One of these is at Pocahontas, in the Flat Top region, and its mining is done on both sides of the boundary line between Virginia and West Virginia, much of the coal coming from the latter State. The other ovens are at Low Moor, just east of the West Virginia line, and all of the coal used is drawn from the New River coal fields, in West Virginia. During 1895 three establishments, all in Wise County, on the Clinch Valley division of the Norfolk and Western Railroad, began operations. These are the Wise County Coke Company, the Big Stone Gap Colliery Company (since succeeded by the Dorchester Coal and Coke Company), and the Virginia Coal and Iron Company. All of these draw their coal from Virginia mines. Two more establishments were added in 1896, one, the Toms Creek Coal and Coke Company, also in Wise County, the other at Gayton, Henrico County, in what is known as the Richmond Basin. This last is of special interest, as it is the first systematic attempt to coke the Triassic coals of the Richmond field.

The following are the statistics of the manufacture of coke in Virginia from 1883 to 1896:

Statistics of the manufacture of coke in Virginia from 1883 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1883.....	1	200	0	39,000	25,340	$44,345	$1.75	65
1884.....	1	200	0	99,000	63,600	111,300	1.75	64 25
1885.....	1	200	0	81,899	40,139	85,993	1.75	60
1886.....	2	350	100	200,018	122,352	305,880	2.50	61.2
1887.....	2	350	300	235,841	166,947	417,368	2.50	70.8
1888.....	2	550	0	230,529	140,199	260,000	1.74	64.7
1889.....	2	550	250	238,793	146,528	325,861	2.22	61
1890.....	2	550	250	251,683	165,847	278,724	1.68	66
1891.....	2	550	250	285,113	167,516	265,107	1.58	58.8
1892.....	2	594	206	226,517	147,912	322,486	2.18	65.3
1893.....	2	594	206	194,059	125,092	282,898	2.26	64.5
1894.....	2	736	100	280,524	180,091	295,747	1.64	64.2
1895.....	5	832	350	410,737	244,738	322,564	1.32	59.6
1896.....	7	1,138	101	454,964	268,081	404,573	1.509	58.9

It will be seen by the above table that the coke production in Virginia increased nearly 10 per cent in 1896 over 1895, and was the largest

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product ever obtained. The output of 244,738 tons in 1895 was the largest up to that time, as was in turn the 180,091 tons made in 1894. It will also be noticed that there were 306 more ovens in 1896 than in 1895.

The character of the coal used in the manufacture of coke in Virginia since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Virginia since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	98,215	0	153,468	0	251,683
1891	107,498	0	177,615	0	285,113
1892	106,010	0	120,507	0	226,517
1893	107,498	0	86,561	0	194,059
1894	103,874	0	176,650	0	280,524
1895	114,802	0	295,935	0	410,737
1896	70,756	0	370,624	13,584	454,964

WASHINGTON.

In Washington there are but three coke works, two of which were in operation in 1895 and 1896, both making coke from washed slack, one from the coal of the Wilkeson coal field near Tacoma, the other at Cokedale, near Fairhaven, in Skagit County. These coals, like those of Colorado and Montana, are Cretaceous, and still preserve at many places their lignite characteristics. At some localities, however, these lignitic coals have been locally altered in character and are true coking coals.

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In the following table will be found the statistics of the manufacture of coke in Washington for the years 1884 to 1896, the only years in which coke has been made.

Statistics of the production of coke in Washington from 1884 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens per ton.	Yield of coal in coke.
		Built	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1884.....	1	0	0	700	400	$1,900	$4.75	57.5
1885.....	1	2	0	544	311	1,477	4.75	57
1886.....	1	11	21	1,400	825	4,125	5.00	58.9
1887.....	1	30	0	22,500	14,625	102,375	7.00	65
1888.....	3	30	100	0	0	0	0	0
1889.....	1	30	0	6,983	3,841	30,728	8.00	55
1890.....	2	30	80	9,120	5,837	46,696	8.00	64
1891.....	2	80	0	10,000	6,000	42,000	7.00	60
1892.....	3	84	30	12,372	7,177	50,446	7.03	58
1893.....	3	84	0	11,374	6,731	34,207	5.08	59
1894.....	3	84	0	8,563	5,245	18,249	3.48	61.2
1895.....	3	110	0	22,973	15,129	64,632	4.27	65.9
1896.....	3	120	0	38,685	25,949	104,894	4.04	67

The amount of coke made in Washington during 1896, as shown in the above table, was 70 per cent more than in 1895, which was in turn nearly three times as large as the product in 1894, and the largest in any year up to that time. In 1894 Washington held sixteenth place in the list of coke-producing States, advancing to thirteenth in 1895 and to the eleventh in 1896.

All of the coal charged into the ovens is washed. Of the total of 38,685 tons charged into the ovens in 1896, 20,967 tons were washed run of mine and 17,718 tons washed slack.

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The character of the coal used in the manufacture of coke in Washington since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Washington since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	0	9,120	0	0	9,120
1891	0	0	10,000	0	10,000
1892	0	0	0	12,372	12,372
1893	0	10,974	0	405	11,379
1894	0	0	0	8,563	8,563
1895	0	0	0	22,973	22,973
1896	0	20,967	0	17,718	38,685

WEST VIRGINIA.

In West Virginia five coking districts are recognized, viz, the Kanawha, the New River, the Flat Top, the Upper Monongahela, and the Upper Potomac. The first two are compact and continuous. They include the ovens along the line of the Chesapeake and Ohio Railroad from west of Low Moor, in Virginia, to the Kanawha Valley. The Flat Top region includes the ovens in what is sometimes called the Pocahontas district. The fourth district, the Upper Monongahela or Northern, is a scattered one, including the ovens in Preston, Taylor, Harrison, and Marion counties, on the upper waters of the Monongahela. The district which has been termed the Upper Potomac includes the coke ovens in the Elk Garden and Upper Potomac fields. These districts have been so frequently described that it is not necessary to repeat the description at this point, but refer those interested to previous volumes of Mineral Resources.

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PRODUCTION OF COKE IN WEST VIRGINIA, BY DISTRICTS.

In the following table will be found consolidated the statistics of the production of coke in West Virginia in the three years especially covered by this report, viz, 1894, 1895, and 1896, by districts:

Production of coke in West Virginia in 1896, by districts.

District.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke produced.	Average price of coke, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per ct.*
Kanawha	7	576	10	259,715	157,741	$263,210	$1.67	60.7
New River ...	17	1,259	0	425,219	269,372	443,072	1.64	63.3
Flat Top	36	4,648	18	1,400,369	852,120	1,100,312	1.291	60.8
Upper Monongahela	22	1,386	0	331,526	206,429	211,272	1.023	62.3
Upper Potomac.....	2	482	0	270,275	164,093	242,133	1.476	60.7
Total ..	84	8,351	28	2,687,104	1,649,755	2,259,999	1.37	61.4

Production of coke in West Virginia in 1895, by districts.

District.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke produced.	Average price of coke per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent*
Kanawha	6	506	0	267,520	164,729	$270,879	$1.64	61.6
New River....	14	978	0	385,899	244,815	404,978	1.65	63.4
Flat Top	36	4,648	18	858,913	524,252	656,494	1.25	61
Upper Monongahela..	20	1,260	37	392,297	240,657	265,293	1.10	61.3
Upper Potomac.....	2	442	0	183,187	110,753	126,595	1.14	60.5
Total ..	78	7,834	55	2.087,816	1,285,206	1,724,239	1.34	61.6

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Production of coke in West Virginia in 1894, by districts.

District.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke produced.	Average price of coke per ton.	Yield of coal in coke.
		Built.	Building.	*Short tons.*	*Short tons.*			*Per cent.*
Kanawha	6	506	0	176,746	104,160	$181,586	$1.74	58.9
New River....	14	1,089	0	222,900	140,842	245,154	1.74	63.2
Flat Top.....	36	4,648	18	1,229,136	746,762	989,876	1.33	60.7
Upper Monongahela..	20	1,221	42	280,748	158,623	179,525	1.13	56.5
Upper Potomac.....	2	394	0	66,598	43,546	43,546	1.00	65.4
Total ..	78	7,858	60	1,976,128	1,193,933	1,639,687	1.373	60.4

From the above tables it will be seen that the production of coke in West Virginia increased from 1,285,206 tons in 1895 to 1,649,755 tons in 1896, a gain of 364,549 tons, or 28.37 per cent. In fact, the history of coke making in West Virginia has been a phenomenal one. The output has shown an uninterrupted annual increase since 1884, and there was only one year (1884) since the statistics have been collected that the output showed a decrease from the year preceding. Considering the production by districts, it is seen that in 1895 all the districts except the Flat Top showed increased production. The Flat Top miners were on strike a good part of 1895, and the production in the region fell off from 746,762 tons in 1894 to 524,252 tons in 1895, a loss of 222,510 tons, or about 30 per cent. Rival districts, particularly the New River, benefited by the trouble in the Flat Top. The New River region increased its output 75 per cent in 1895, and was able to hold its own in 1896, the product from the region showing an increase over 1895 of 24,557 tons, or about 10 per cent. This was in spite of the fact that the Flat Top field not only regained its supremacy in the State by an increase of 327,868 tons, or 60 per cent over its decreased production in 1895, but exceeded by more than 100,000 tons the output in 1894, which, up to that time, was the largest on record. The Kanawha district lost ground in 1896, the product being about 7,000 tons less than in 1895. The Upper Monongahela region also shows a decrease from 240,657 tons to 206,429 tons. The Upper Potomac region increased its output about 50 per cent—from 110,753 tons in 1895 to 164,093 tons in 1896.

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Statistics of the manufacture of coke in West Virginia from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880....	18	631	40	230,758	138,755	$318,797	$2.30	60
1881....	19	689	0	304,823	187,126	429,571	2.30	61
1882....	22	878	0	366,653	230,398	520,437	2.26	63
1883....	24	962	9	411,159	257,519	563,490	2.19	63
1884....	27	1,005	127	385,588	223,472	425,952	1.91	62
1885....	27	978	63	415,533	260,571	485,588	1.86	63
1886....	29	1,100	317	425,002	264,158	513,843	1.94	62
1887....	39	2,080	742	698,327	442,031	976,732	2.21	63.3
1888....	51	2,764	318	854,531	525,927	896,797	1.71	61.5
1889....	53	3,438	631	1,001,372	607,880	1,074,177	1.76	60
1890....	55	4,060	334	1,395,266	833,377	1,524,746	1.83	60
1891....	55	4,621	555	1,716,976	1,009,051	1,845,043	1.83	58.8
1892....	72	5,843	978	1,709,183	1,034,750	1,821,965	1.76	60.5
1893....	75	7,354	132	1,745,757	1,062,076	1,716,907	1.62	60.8
1894....	78	7,858	60	1,976,128	1,193,933	1,639,687	1.373	60.4
1895....	78	7,834	55	2,087,816	1,285,206	1,724,239	1.34	61.6
1896....	84	8,351	28	2,687,104	1,649,755	2,259,999	1.37	61.4

The character of the coal used in the manufacture of coke in West Virginia since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in West Virginia since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890.....	324,847	0	930,989	139,430	1,395,266
1891.....	276,259	0	1,116,060	324,657	1,716,976
1892.....	298,824	115,397	1,108,353	186,609	1,709,183
1893.....	324,932	15,240	1,176,656	228,929	1,745,757
1894.....	162,270	14,901	1,607,735	191,222	1,976,128
1895.....	405,725	24,054	1,476,003	182,034	2,087,816
1896.....	407,378	33,096	2,079,237	167,393	2,687,104

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Very little of the coke in West Virginia is washed. Most of the washing is done in the Northern or Upper Monongahela district. About 8 per cent of the coal made into coke in this State in 1896 was washed coal.

Pocahontas-Flat Top district.—This is one of the most important coking districts of the country and shares with the Connellsville in producing a typical blast-furnace coke. Indeed, it is chemically a better fuel than the Connellsville, being lower in ash. By some ironmasters it is also regarded as a blast-furnace fuel physically the equal of the Connellsville. The strike among the Flat Top miners in 1895 caused a decrease of 222,510 tons, or 30 per cent, in the output for that year as compared with 1894. The production in 1896 indicates an increase of 327,868 tons, or 60 per cent, over the product of 1895.

Statistics of the manufacture of coke in the Flat Top district of West Virginia from 1886 to 1896.

Year.	Establishments	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1886	2	10	38	1,075	658	$1,316	$2.00	61.2
1887	5	348	642	76,274	51,071	100,738	1.97	67
1888	13	882	200	164,818	103,947	183,938	1.77	63
1889	16	1,433	431	387,533	240,386	405,635	1.69	64
1890	17	1,584	252	566,118	325,576	571,239	1.75	57.5
1891	19	1,889	358	537,847	312,421	545,367	1.70	58
1892	30	2,848	933	595,734	353,696	596,911	1.69	59.3
1893	34	4,349	80	746,051	451,503	713,261	1.58	60.5
1894	36	4,648	18	1,229,136	746,762	989,876	1.325	60.7
1895	36	4,648	18	858,913	524,252	656,494	1.25	61
1896	36	4,648	18	1,400,369	852,120	1,100,312	1.291	60.8

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New River district.—This district includes the ovens along the Chesapeake and Ohio Railroad from Quinnimont to Nuttallburg. The coal makes an excellent coke and is in great demand, its market being chiefly east of the mountains. The statistics of the manufacture of coke in the New River district from 1880 to 1896 are as follows:

Statistics of the manufacture of coke in the New River district, West Virginia, from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880.....	6	468	40	159,032	98,427	$239,977	$2.14	62
1881.....	6	499	0	219,446	136,423	334,652	2.45	62
1882.....	6	518	0	233,361	148,373	352,415	2.38	64
1883.....	6	546	0	264,171	167,795	384,552	2.29	64
1884.....	8	547	12	219,839	135,335	274,988	2.03	62
1885.....	8	519	0	244,769	156,007	325,001	2.08	63¼
1886.....	8	513	5	203,621	127,006	281,778	2.22	62
1887.....	11	518	50	253,373	159,836	401,164	2.51	63
1888.....	12	743	0	334,695	199,831	390,182	1.95	60
1889.....	12	773	0	268,185	157,186	351,132	2.23	58.6
1890.....	12	773	4	275,458	174,295	377,847	2.17	63
1891.....	13	787	102	309,073	193,711	426,630	2.20	63
1892.....	14	965	0	315,511	196,359	429,376	2.19	62
1893.....	13	947	10	281,600	178,049	355,965	2.00	63
1894.....	14	1,089	0	222,900	140,842	245,154	1.74	63.2
1895.....	14	978	0	385,899	244,815	404,978	1.65	63.4
1896.....	17	1,259	0	425,219	269,372	443,072	1.64	63.3

Kanawha district.—This region includes all the ovens from the junction of the New and Gauley rivers to the western limit of the coal fields on the Kanawha River. The production of coke in this region reached its highest figure in 1895, when, by reason of the strike in the Flat Top district, the product amounted to 164,729 tons. There was a decrease of about 7,000 tons in the output for 1896.

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The statistics of the manufacture of coke in the Kanawha district from 1880 to 1896 are as follows:

Statistics of the manufacture of coke in the Kanawha district, West Virginia, from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880.....	4	18	0	6,789	4,300	$9,890	$2.30	63.3
1881.....	4	18	0	11,516	6,900	16,905	2.45	60
1882.....	5	*a* 138	0	40,782	26,170	62,808	2.40	64
1883.....	5	*a* 147	0	58,735	37,970	88,090	2.32	64.6
1884.....	6	*a* 177	15	60,281	39,000	76,070	1.95	64.6
1885.....	7	*b* 181	63	65,348	37,551	63,082	1.68	57
1886.....	7	302	170	89,410	54,329	117,649	2.17	60.7
1887.....	7	548	0	153,784	96,721	201,418	2.08	63
1888.....	9	572	8	141,641	84,052	146,837	1.75	59
1889.....	6	474	0	109,466	63,678	117,340	1.84	58
1890.....	6	474	0	182,340	104,076	196,583	1.89	57
1891.....	6	474	0	241,427	134,715	276,420	2.05	56
1892.....	6	506	0	242,627	140,641	284,174	2.02	58
1893.....	6	506	0	215,108	122,241	237,308	1.94	56.8
1894.....	6	506	0	176,746	104,160	181,586	1.74	58.9
1895.....	6	506	0	267,520	164,729	270,879	1.64	61.6
1896.....	7	576	10	259,715	157,741	263,210	1.67	60.7

a Eighty of these ovens are Coppée, the balance beehive.
b Sixty of these ovens are Coppée, the balance beehive.

Upper Monongahela district.—The Upper Monongahela district includes the ovens in the group of counties lying along the line of the Baltimore and Ohio Railroad, near the head waters of the Monongahela River—Preston, Taylor, Harrison, and Marion counties. This is becoming an important coking district, and though the coke is made largely from washed slack it is a good fuel and finds a ready sale in the markets of the country. As in the Kanawha district, the production in this region increased in 1895, but decreased in 1896.

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The statistics of the production of coke in the Upper Monongahela district of West Virginia from 1880 to 1896 are as follows:

Statistics of the manufacture of coke in the Upper Monongahela district, West Virginia, from 1880 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1880.....	8	145	0	64,937	36,028	$68,930	$1.91	55
1881.....	9	172	0	73,863	43,803	78,014	1.78	59
1882.....	11	222	0	92,510	55,855	105,214	1.88	60
1883.....	13	269	0	88,253	51,754	90,848	1.76	59
1884.....	13	281	100	78,468	49,139	74,894	1.52	63
1885.....	12	278	0	105,416	67,013	97,505	1.45	63.5
1886.....	12	275	104	131,896	82,165	113,100	1.38	62.3
1887.....	15	646	0	211,330	132,192	268,990	2.03	62.5
1888.....	17	567	110	213,377	138,097	175,840	1.27	64.7
1889.....	17	674	200	210,083	128,685	171,511	1.33	62.5
1890.....	18	1,051	50	276,367	167,459	260,574	1.56	60
1891.....	15	1,081	56	517,615	291,605	462,677	1.58	56
1892.....	19	1,129	45	441,266	265,363	390,296	1.47	60.1
1893.....	19	1,158	42	379,506	225,676	295,123	1.31	59
1894.....	20	1,221	42	280,748	158,323	179,525	1.13	56.5
1895.....	20	1,260	37	392,297	240,657	265,293	1.10	61.3
1896.....	22	1,386	0	331,526	206,429	211,272	1.023	62.3

Upper Potomac district.—In the Upper Potomac district are included the ovens along the line of the West Virginia Central and Pittsburg Railway, running south from near Cumberland, Md. This district has been thoroughly described, not only in previous volumes of Mineral Resources, but also in a separate publication by the Survey.

With the exception of 1894, the production of coke in this region has shown a steadily increasing business since operations began in 1887. In this way it has rivaled the record of the State.

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Statistics of the production of coke in the Upper Potomac district of West Virginia are as follows:

Statistics of the manufacture of coke in the Upper Potomac district of West Virginia from 1887 to 1896.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1887.....	1	20	50	3,565	2,211	$4,422	$2.00	62
1888.....	1	28	0	9,176	5,835	8,752	1.50	64
1889.....	2	84	0	26,105	17,945	28,559	1.58	69
1890.....	2	178	28	94,983	61,971	118,503	1.91	65
1891.....	2	390	39	111,014	76,599	133,549	1.75	69
1892.....	3	395	0	114,045	78,691	121,208	1.54	69
1893.....	3	394	0	123,492	84,607	115,250	1.36	68.5
1894.....	2	394	0	66,598	43,546	43,546	1.00	65.4
1895.....	2	442	0	183,187	110,753	126,595	1.14	60.5
1896.....	2	482	0	270,275	164,093	242,133	1.476	60.7

WISCONSIN.

All the coke made in Wisconsin is from Connellsville (Pennsylvania) coal, and the coke is standard Connellsville. Its production, therefore, is not of so much interest as the production of coke for developing certain regions. It is an interesting product, however, as showing that coal can be carried to a distance and successfully made into coke.

The statistics of the manufacture of coke in Wisconsin from 1888 to 1896, inclusive, are as follows:

Statistics of the manufacture of coke in Wisconsin.

Year.	Establishments.	Ovens.		Coal used.	Coke produced.	Total value of coke at ovens.	Value of coke at ovens, per ton.	Yield of coal in coke.
		Built.	Building.					
				Short tons.	*Short tons.*			*Per cent.*
1888.....	1	50	.....	1,000	500	$1,500	$3.00	50
1889.....	1	50	.....	25,616	16,016	92,092	5.75	62.5
1890.....	1	70	.....	38,425	24,976	143,612	5.75	65
1891.....	1	120	0	52,904	34,387	192,804	5.61	65
1892.....	1	120	0	54,300	33,800	185,900	5.50	62.2
1893.....	1	120	0	24,085	14,958	95,851	6.41	62
1894.....	1	120	0	6,343	4,250	19,465	4.58	67
1895.....	1	120	0	8,287	4,972	26,103	5.25	60
1896.....	1	120	0	8,648	5,332	21,000	3.94	62

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The character of the coal used in the manufacture of coke in Wisconsin since 1890 is shown in the following table:

Character of coal used in the manufacture of coke in Wisconsin since 1890.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1890	38,425	0	0	0	38,425
1891	52,904	0	0	0	52,904
1892	54,300	0	0	0	54,300
1893	20,474	0	3,611	0	24,085
1894	6,343	0	0	0	6,343
1895	8,287	0	0	0	8,287
1896	0	0	5,183	3,465	8,648

WYOMING.

There is but one establishment making coke in Wyoming—that of the Cambria Mining Company, located at Cambria, Weston County. This establishment began the manufacture of coke in 1891, but produced no coke in 1892, resuming the manufacture again in 1893, and producing coke in 1894, 1895, and 1896. The coal occurs probably in the lowest portion of the Dakota measures of the Colorado Cretaceous and almost upon the topmost rocks of the Jurassic. The vein is 6½ to 7½ feet in thickness, with good roof and floor. Regarding the character of the coal, it has been classed all the way from lignite to a high-grade coking bituminous coal. This difference in classification may be due to the fact that the samples upon which judgment was based were taken from different parts of the vein, in which there may have been actual variations caused by partial metamorphism by heat.

All of the coal used in coking was unwashed slack, which does not give as good a result as washed slack. When the latter is used the coke is of fine texture and very strong. It is dense and capable of sustaining any weight ordinarily required of coke used, as this is, in silver smelting. As at present produced, however, the coke is very high in ash.

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The statistics of the production of coke in Wyoming from 1891 to 1896, inclusive, are as follows:

Statistics of the production of coke in Wyoming from 1891 to 1896.

	1891.	1892.	1893.	1894.	1895.	1896.
Number of establishments.	1	1	1	1	1	1
Number of ovens built....	24	24	24	24	74	74
Number of ovens building.	0	0	0	0	0	0
Amount of coal used, short tons.....	4,470	0	5,400	8,685	10,240	41,038
Coke produced, short tons.	2,682	0	2,916	4,352	4,895	19,542
Total value of coke at ovens	$8,046	0	$10,206	$15,232	$17,133	$58,626
Value of coke at ovens, per ton.....	$3.00	0	$3.50	a$3.50	$3.50	$3.00
Yield of coal in coke, per cent.....	60	0	54	50	47.8	47.6

a Value estimated.

The character of the coal used in the manufacture of coke in Wyoming is shown in the following table:

Character of coal used in the manufacture of coke in Wyoming since 1891.

Year.	Run of mine.		Slack.		Total.
	Unwashed.	Washed.	Unwashed.	Washed.	
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*
1891.....	0	0	4,470	0	4,470
1892.....	0	0	0	0	0
1893.....	0	0	5,400	0	5,400
1894.....	0	0	8,685	0	8,685
1895.....	0	0	10,240	0	10,240
1896.....	0	0	41,038	0	41,038

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PETROLEUM.[1]

By F. H. OLIPHANT.

[The barrel used in this report, unless otherwise specified, is of 42 Winchester gallons.]

IMPORTANT FEATURES OF THE YEAR.

By a comparison of the tables in this report with preceding years, it will be found that the following features are conspicuous:

First. An increase in the production of crude petroleum in the United States, the total for 1896 exceeding that of any former year in the history of the industry.

Second. A general increase in the Appalachian oil field, especially in the State of West Virginia.

Third. A large increase in the production of Lima crude oil, in the State of Ohio.

Fourth. An increase in stocks.

Fifth. A decrease in price.

TOTAL PRODUCTION IN THE UNITED STATES.

The entire production of petroleum in the United States for the year 1896 is placed at 60,960,361 barrels, as compared with 52,892,276 barrels in 1895, an increase of 8,068,085 barrels, or 15.254 per cent.

The production for 1896 was the largest of any year, being 60,960,361 barrels, as compared with 54,291,980 barrels in 1891, the largest production heretofore on record, showing an increase of 6,668,381 barrels.

The total production in 1896 has been subdivided as follows:

Percentage of crude petroleum produced in the several fields in 1896.

	Per cent.
Amount produced in the Appalachian field	55.7
Amount produced in the Lima-Indiana field	41.4
Amount produced in all other fields	2.9
Total	100.0

[1] For much of the statistical information in this report credit should be given to the Oil City Derrick. Other special acknowledgments are given in the body of the report.

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INCREASE IN APPALACHIAN OIL FIELD.

Stimulated by the rise in the price of petroleum in the spring of 1895, a large amount of new work was started, but it was not until the year 1896 that its effects were fully shown in the increased production.

New York increased from 912,948 barrels in 1895 to 1,205,220 barrels in 1896, a gain of 292,272 barrels, or 32 per cent.

Pennsylvania increased from 18,231,442 barrels in 1895 to 19,379,201 barrels in 1896, an increase of 1,147,759 barrels, or 6.29 per cent.

Southern Ohio decreased from 3,694,624 barrels in 1895 to 3,366,031 barrels in 1896, a falling off in 1896 of 328,593 barrels, or 8.9 per cent.

West Virginia increased from 8,120,125 barrels in 1895 to 10,019,770 barrels in 1896, an increase of 1,899,645 barrels, or 23.39 per cent. A large amount of profitable territory was opened up.

Kentucky and Tennessee showed a very slight increase, but nothing in comparison to the large amount of money expended in testing almost barren territory. The extension of the Appalachian field in these States has been a disappointment.

The total production of crude petroleum in this field for 1895 was 30,959,139 barrels, as compared with 33,970,222 barrels for 1896, a gain of 3,011,083 barrels, or 9.73 per cent, as compared to an increase of only one-half of 1 per cent in 1895.

INCREASE IN LIMA OIL FIELD, OHIO.

The great increase in the State of Ohio did not come from the opening up of any new pools, but from the extension of the old ones into more than ordinarily rich territory. The number of wells drilled in 1896 did not quite reach the number drilled in 1895.

The increase coming from Indiana was very slight.

The total production of crude petroleum in the Ohio Lima field in 1895 was 15,850,609 barrels, as compared with 20,575,138 barrels in 1896, a gain of 4,724,529 barrels, or 29.8 per cent. The increase of 1895 as compared with 1894 was 17 per cent.

COMPARISON OF OTHER STATES.

Indiana increased from 4,386,132 barrels in 1895 to 4,680,732 barrels in 1896, or a fraction less than 6¾ per cent.

Kansas increased from 44,430 barrels in 1895 to 113,571 barrels in 1896, or 155.62 per cent.

California has increased from 1,208,482 barrels in 1895 to 1,252,777 barrels in 1896—only 44,295 barrels over 1895.

Colorado has decreased 17.52 per cent in 1896 as compared with 1895.

Wyoming has decreased 16.7 per cent in 1896 as compared with 1895.

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The tables in the body of this report, showing production, value, and percentages of increase and decrease, give much additional information in detail.

INCREASE IN STOCKS.

The stocks in the Appalachian field at the close of 1895 were 5,344,784 barrels, and at the close of 1896, 9,745,722 barrels. This was an increase of 4,400,938 barrels, or 82⅓ per cent.

The stocks in northwestern Ohio and Indiana, generally known as the Lima field, were 20,596,439 barrels at the close of 1895 and 22,573,768 barrels at the close of 1896, an increase for the year of 1,977,329 barrels, or 9⅗ per cent.

The total stocks of the two fields at the close of 1895 were 25,941,223 barrels, as compared with 32,319;490 barrels at the close of 1896, an increase of 6,378,267 barrels, or 24½ per cent.

DECREASE IN PRICE.

The average value of what has been called certificate oil in the Pennsylvania field in 1896 was $1.18 per barrel, as compared with $1.36 in 1895, showing a decline of 18 cents per barrel.

The highest average price during any one month in 1896 was $1.45¾, in January. The lowest average price for the same period was 97⅞ cents, in December.

In the Lima field the price fell from an average of 71¾ cents in 1895 to an average of 66¾ cents in 1896, a decline of 5 cents per barrel. The total value of the 52,892,276 barrels of merchantable crude oil produced in the United States in 1895 was $57,632,296, or an average of about $1.09 per barrel, while the total value of the 60,960,361 barrels produced in 1896 was $58,518,709, or an average of about 96 cents per barrel, a decline of 13 cents per barrel. There was a total increase in value of $886,413, however. Kansas oil decreased from 60 cents in 1895 to 45 cents in 1896. California oil increased from 70 cents in 1895 to 99 cents in 1896. Colorado oil increased from 77 cents in 1895 to 88 cents in 1896. The price ranged from 45 cents per barrel for Kansas oil to $8 per barrel for Wyoming oil in 1896.

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PRODUCTION AND VALUE.

TOTAL PRODUCTION AND VALUE.

In the following table is given a statement of the total amount and the total value of all crude petroleum produced in the United States in 1895 and 1896, by States and important districts:

Total amount and value of crude petroleum produced in the United States in 1895 and 1896.

State and district.	1895.		Average value per barrel.	1896.		Average value per barrel.
	Barrels.	Value.		Barrels.	Value.	
New York	912,948	$1,240,468	$1.35⅞	1,205,220	$1,420,653	$1.17⅞
Pennsylvania:						
Pennsylvania	18,180,331	24,702,525	1.35⅞	19,327,168	22,781,899	1.17⅞
Franklin	48,711	194,844	4.00	49,329	197,316	4.00
Smith's Ferry	2,400	3,261	1.35⅞	2,704	3,187	1.17⅞
Total	18,231,442	24,900,630	1.366	19,379,201	22,982,402	1.186
West Virginia:						
West Virginia, Burning Springs	8,105,341	11,013,132	1.35⅞	10,005,966	11,794,532	1.17⅞
Volcano	10,170	20,158	1.98	*a* 13,228	33,070	2.50
Petroleum	4,614	5,480	1.19	*b* 576	2,016	3.50
Total	8,120,125	11,038,770	1.36	10,019,770	11,829,618	1.18
Ohio:						
Eastern or southern	3,693,248	5,018,201	1.35⅞	3,365,365	3,966,924	1.17⅞
Lima	15,850,609	11,372,812	.71¾	20,575,138	13,723,617	.667
Mecca-Belden	1,376	8,229	5.98	666	2,897	4.35
Total	19,545,233	16,399,242	.839	23,941,169	17,693,438	.739
Indiana	4,386,132	2,811,444	.64	4,680,732	2,954,411	.63
Kentucky	1,500	600	.40	1,680	924	.55
Missouri	10	50	5.00	43	185	4.30
Colorado	438,232	336,010	.767	361,450	318,977	.88¼
California	1,208,482	849,082	.70	1,252,777	1,240,990	.99
Texas	50	250	5.00	1,450	1,050	.72
Indian Territory	37	252	6.81	170	680	4.00
Illinois	200	1,200	6.00	250	1,250	5.00
Wyoming	3,455	27,640	8.00	2,878	23,024	8.00
Kansas	44,430	26,658	.60	113,571	51,107	.45
Grand total	52,892,276	57,632,296	1.0896	*c* 60,960,361	58,518,709	.96

a Production of light oil in Volcano included with West Virginia's product.

b Production of light oil in Petroleum included with West Virginia's product.

c In addition to this product, 4,325 barrels of crude were produced in Kentucky and Tennessee, for which no value could be given, none being sold or used.

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The increase or decrease of the production of crude petroleum in the several States in 1896 as compared with that in 1895 is shown in the following table:

Increase or decrease in amount and percentage of crude petroleum produced in the several States in 1896 as compared with 1895.

State.	Production.		Percentage.	
	Increase.	Decrease.	Increase.	Decrease.
	Barrels.	*Barrels.*		
New York	292,272		32.00	
Pennsylvania	1,147,759		6.29	
West Virginia	1,899,645		23.39	
Ohio	4,395,936		22.49	
Indiana	294,600		6.72	
Kentucky	180		12.00	
Missouri	33		330.00	
Colorado		76,782		17.52
California	44,295		3.665	
Texas	1,400		2,800.00	
Indian Territory	133		359.5	
Illinois	50		25.00	
Wyoming		577		16.70
Kansas	69,141		155.62	
Total	8,068,085		15.254	

PRODUCTION BY FIELDS.

The production of petroleum in the principal fields of the United States in 1894, 1895, and 1896 was as follows:

Production of petroleum in the United States in 1894, 1895, and 1896, by fields.

[Barrels of 42 gallons.]

Field.	Production.		
	1894.	1895.	1896.
Appalachian	30,781,924	30,959,139	33,970,222
Lima-Indiana	17,296,510	20,236,741	25,255,870
Florence, Colorado	515,746	438,232	361,450
Southern California	705,969	1,208,482	1,252,777
Kansas	40,000	44,430	113,571
Wyoming	2,369	3,455	2,878
Other	1,998	1,797	3,593
Total	49,344,516	52,892,276	*a* 60,960,361

a In addition to this total 4,325 barrels of crude oil were produced in Kentucky and Tennessee, for which no value could be given, none being sold or used.

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From the above table it will be noticed that the only fields that do not show an increased production are Colorado and Wyoming. The latter State, which showed a gain of nearly 50 per cent in 1895 over 1894, now shows a loss of 16.7 per cent. Colorado showed a decrease of 15 per cent in 1895, and a decrease of 17.52 per cent in 1896.

PRODUCTION OF CRUDE PETROLEUM IN THE UNITED STATES, 1859 TO 1896.

In the following table will be found a statement of the production of crude petroleum in the United States from the beginning of production, marked by the drilling of the Colonel Drake well in 1859, up to and including the production of 1896, the tables being by years and States:

Product of crude petroleum in the United States from 1859 to 1896.

[Barrels.]

Year.	Pennsylvania and New York.	Ohio.	West Virginia.	Colorado.	California.	Indiana.
1859...	2,000	.....	.....	.....	.....	.....
1860...	500,000	.....	.....	.....	.....	.....
1861...	2,113,609	.....	.....	.....	.....	.....
1862...	3,056,690	.....	.....	.....	.....	.....
1863...	2,611,309	.....	.....	.....	.....	.....
1864...	2,116,109	.....	.....	.....	.....	.....
1865...	2,497,700	.....	.....	.....	.....	.....
1866...	3,597,700	.....	.....	.....	.....	.....
1867...	3,347,300	.....	.....	.....	.....	.....
1868...	3,646,117	.....	.....	.....	.....	.....
1869...	4,215,000	.....	.....	.....	.....	.....
1870...	5,260,745	.....	.....	.....	.....	.....
1871...	5,205,234	.....	.....	.....	.....	.....
1872...	6,293,194	.....	.....	.....	.....	.....
1873...	9,893,786	.....	.....	.....	.....	.....
1874...	10,926,945	.....	.....	.....	.....	.....
1875...	8,787,514	*a* 200,000	*a*3,000,000	.....	*a* 175,000	.....
1876...	8,968,906	31,763	120,000	.....	12,000	.....
1877...	13,135,475	29,888	172,000	.....	13,000	.....
1878...	15,163,462	38,179	180,000	.....	15,227	.....
1879...	19,685,176	29,112	180,000	.....	19,858	.....
1880...	26,027,631	38,940	179,000	.....	40,552	.....
1881...	27,376,509	33,867	151,000	.....	99,862	.....
1882...	30,053,500	39,761	128,000	.....	128,636	.....
1883...	23,128,389	47,632	126,000	.....	142,857	.....
1884...	23,772,209	90,081	90,000	.....	262,000	.....

a Including all production prior to 1876.

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Product of crude petroleum in the United States from 1859 to 1896—Continued.

[Barrels.]

Year.	Pennsylvania and New York.	Ohio.	West Virginia.	Colorado.	California.	Indiana.
1885...	20,776,041	661,580	91,000	.....	325,000	.....
1886...	25,798,000	1,782,970	102,000	.....	377,145	.....
1887...	22,356,193	5,022,632	145,000	76,295	678,572	.....
1888...	16,488,668	10,010,868	119,448	297,612	690,333	.....
1889...	21,487,435	12,471,466	544,113	316,476	303,220	33,375
1890...	28,458,208	16,124,656	492,578	368,842	307,360	63,496
1891...	33,009,236	17,740,301	2,406,218	665,482	323,600	136,634
1892...	28,422,377	16,362,921	3,810,086	824,000	385,049	698,068
1893...	20,314,513	16,249,769	8,445,412	594,390	470,179	2,335,293
1894...	19,019,990	16,792,154	8,577,624	515,746	705,969	3,688,666
1895...	19,144,390	19,545,233	8,120,125	438,232	1,208,482	4,386,132
1896...	20,584,421	23,941,169	10,019,770	361,450	1,252,777	4,680,732
Total.	537,241,681	157,284,942	47,199,374	4,458,525	7,936,678	16,022,396

Year.	Kentucky and Tennessee.	Illinois.	Kansas.	Texas.	Missouri.	Indian Territory.	Wyoming.	United States.
1859....	.....	.....	.....	.....	.....	.....	.....	2,000
1860....	.....	.....	.....	.....	.....	.....	.....	500,000
1861....	.....	.....	.....	.....	.....	.....	.....	2,113,609
1862....	.....	.....	.....	.....	.....	.....	.....	*a* 3,056,690
1863....	.....	.....	.....	.....	.....	.....	.....	2,611,309
1864....	.....	.....	.....	.....	.....	.....	.....	2,116,109
1865....	.....	.....	.....	.....	.....	.....	.....	2,497,700
1866....	.....	.....	.....	.....	.....	.....	.....	3,597,700
1867....	.....	.....	.....	.....	.....	.....	.....	3,347,300
1868....	.....	.....	.....	.....	.....	.....	.....	3,646,117
1869....	.....	.....	.....	.....	.....	.....	.....	4,215,000
1870....	.....	.....	.....	.....	.....	.....	.....	5,260,745
1871....	.....	.....	.....	.....	.....	.....	.....	5,205,234
1872....	.....	.....	.....	.....	.....	.....	.....	6,293,194
1873....	.....	.....	.....	.....	.....	.....	.....	9,893,786
1874....	.....	.....	.....	.....	.....	.....	.....	10,926,945
1875....	.....	.....	.....	.....	.....	.....	.....	*b* 12,162,514
1876....	.....	.....	.....	.....	.....	.....	.....	9,132,669
1877....	.....	.....	.....	.....	.....	.....	.....	13,350,363

a In addition to this amount, it is estimated that for want of a market some 10,000,000 barrels ran to waste in and prior to 1862 from the Pennsylvania fields; also a large amount from West Virginia and Tennessee.

b Including all production prior to 1876 in Ohio, West Virginia, and California.

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Product of crude petroleum in the United States from 1859 to 1896—Continued.

[Barrels.]

Year.	Kentucky and Tennessee.	Illinois.	Kansas.	Texas.	Missouri.	Indian Territory.	Wyoming.	United States.
1878	.....	.....	.....	.....	.....	.....	.....	15,396,868
1879	.....	.....	.....	.....	.....	.....	.....	19,914,146
1880	.....	.....	.....	.....	.....	.....	.....	26,286,123
1881	.....	.....	.....	.....	.....	.....	.....	27,661,238
1882	*a* 160,933	.....	.....	.....	.....	.....	.....	30,510,830
1883	4,755	.....	.....	.....	.....	.....	.....	23,449,633
1884	4,148	.....	.....	.....	.....	.....	.....	24,218,438
1885	5,164	.....	.....	.....	.....	.....	.....	21,858,785
1886	4,726	.....	.....	.....	.....	.....	.....	28,064,841
1887	4,791	.....	.....	.....	.....	.....	.....	28,283,483
1888	5,096	.....	.....	.....	.....	.....	.....	27,612,025
1889	5,400	1,460	500	48	20	.....	.....	35,163,513
1890	6,000	.....	1,200	54	278	.....	.....	45,822,672
1891	9,000	.....	1,400	54	25	30	.....	54,291,980
1892	6,500	.....	.....	45	10	80	.....	50,509,136
1893	3,000	.....	.....	50	50	10	.....	48,412,666
1894	1,500	300	40,000	60	8	130	2,369	49,344,516
1895	1,500	200	44,430	50	10	37	3,455	52,892,276
1896	*b* 1,680	250	113,571	1,450	43	170	2,878	*b* 60,960,361
Total.	224,193	2,210	201,101	1,811	444	457	8,702	770,582,514

a This includes all the petroleum produced in Kentucky and Tennessee prior to 1883.

b In addition to this amount 4,325 barrels of crude oil were produced in Kentucky and Tennessee, for which, as none was sold or used, no value could be given.

From the above table it appears that the enormous total of 770,582,514 barrels of crude petroleum has been produced in the United States since the beginning of operations near Titusville, Pennsylvania, in 1859. If we allow 5.6 cubic feet as the capacity of a barrel, we have 4,315,262,078 cubic feet, which would require a cube whose sides would be about 1,628 feet long to contain this amount.

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For convenience of reference, a statement is given below of the production of petroleum in the United States from 1891 to 1896, by States:

Production of petroleum in the United States from 1891 to 1896.

[Barrels of 42 gallons.]

State.	1891.	1892.	1893.
Pennsylvania and New York	33,009,236	28,422,377	20,314,513
Ohio	17,740,301	16,362,921	16,249,769
West Virginia	2,406,218	3,810,086	8,445,412
Colorado	665,482	824,000	594,390
California	323,600	385,049	470,179
Indiana	136,634	698,068	2,335,293
Kentucky	9,000	6,500	3,000
Illinois	.....	.....	.....
Kansas	1,400	.....	.....
Texas	54	45	50
Missouri	25	10	50
Indian Territory	30	80	10
Wyoming	.....	.....	.....
Total	54,291,980	50,509,136	48,412,666

State.	1894.	1895.	1896.
Pennsylvania and New York	19,019,990	19,144,390	20,584,421
Ohio	16,792,154	19,545,233	23,941,169
West Virginia	8,577,624	8,120,125	10,019,770
Colorado	515,746	438,232	361,450
California	705,969	1,20[illegible]482	1,252,777
Indiana	3,688,666	4,386,132	4,680,732
Kentucky	1,500	1,500	1,680
Illinois	300	200	250
Kansas	40,000	44,430	113,571
Texas	60	50	1,450
Missouri	8	10	43
Indian Territory	130	37	170
Wyoming	2,369	3,455	2,878
Total	49,344,516	52,892,276	*a* 60,960,361

a In addition to this amount 4,325 barrels of crude oil were produced in Kentucky and Tennessee, for which, as none was sold or used, no value could be given.

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EXPORTS.

In the following table are given the exports of crude petroleum and its products from the United States from 1871 to 1896, together with a statement of the production of the United States in the years named. The figures of exports are from the Statistical Abstract of the United States, published by the Bureau of Statistics, Treasury Department. The figures of production were collected by the writer.

Quantity of crude petroleum produced in, and the quantities and values of petroleum products exported from, the United States during each of the calendar years from 1871 to 1896, inclusive.

Year ending December 31—	Production.		Exports.			
	Barrels (of 42 gallons).	Gallons.	Mineral, crude (including all natural oils, without regard to gravity).		Mineral, refined or manufactured. Naphthas, benzine, gasoline, etc.	
			Gallons.	*Dollars.*	*Gallons.*	*Dollars.*
1871	5,205,234	218,619,828	11,278,589	2,171,706	8,396,905	895,910
1872	6,293,194	264,314,148	16,363,975	2,761,094	8,688,257	1,307,058
1873	9,893,786	415,539,012	19,643,740	2,665,171	10,250,497	1,266,962
1874	10,926.945	458,931,690	14,430,851	1,428,494	10,616,644	997,355
1875	12,162,514	510,825,588	16,536,830	1,738,589	14,048,726	1,392,192
1876	9,132,669	383,572,098	25,343,271	3,343,763	13,252,751	1,502,498
1877	13,350,363	560,715,246	28,773,233	3,267,309	19,565,909	1,938,672
1878	15,396,868	646,668,456	24,049,604	2,169,790	13,431,782	1,077,402
1879	19,914,146	836,394,132	28,601,650	2,069,458	19,524,582	1,367,996
1880	26,286,123	1,104,017,166	36,748,116	2,772,400	15,115,131	1,344,529
1881	27,661,238	1,161,771,996	40,430,108	3,089,297	20,655,116	1,981,197
1882	30,510,830	1,281,454,860	45,011,154	3,373,302	16,969,839	1,304,041
1883	23,449,633	984,884,586	59,018,537	4,439,097	17,365,314	1,195,035
1884	24,218,438	1,017,174,396	79,679,395	6,102,810	13,676,421	1,132,528
1885	21,858,785	918,068,970	81,435,609	6,040,685	14,739,469	1,160,999
1886	28,064,841	1,178,723,322	76,346,480	5,068,409	14,474,951	1,264,736
1887	28,283,483	1,187,906,286	80,650,286	5,141,833	12,382,213	1,049,043
1888	27,612,025	1,159,705,050	77,549,452	5,454,705	13,481,706	1,083,429
1889	35,163,513	1,476,867,546	85,189,658	6,134,002	13,984,407	1,208,116
1890	45,822,672	1,924,552,224	96,572,625	6,535,499	12,462,636	1,050,613
1891	54,291,980	2,280,263,160	96,722,807	5,365,579	11,424,993	868,137
1892	50,509,136	2,121,383,712	104,397,107	4,696,191	16,393,284	1,037,558
1893	48,412,666	2,033,331,972	111,703,508	4,567,391	17,304,005	1,074,710
1894	49,344,516	2,072,469,672	121,926,349	4,415,915	15,555,754	943,970
1895	52,892,276	2,221,475,592	111,285,264	5,161,710	14,801,224	910,988
1896	[a]60,960,361	2,560,335,162	110,923,620	6,121,836	12,349,319	1,059,542

[a] In addition to this amount 4,325 barrels of crude oil were produced in Kentucky and Tennessee, for which, as none was sold or used, no value could be given.

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Quantity of crude petroleum produced in, and the quantities and values of petroleum products exported from, the United States, etc.—Continued. .

Year ending December 31—	Exports.			
	Mineral, refined or manufactured.			
	Illuminating.		Lubricating (heavy paraffin, etc.).	
	Gallons.	*Dollars.*	*Gallons.*	*Dollars.*
1871	132, 178, 843	33, 493, 351	240, 228	92, 408
1872	118, 259, 832	29, 456, 453	438, 425	180, 462
1873	207, 595, 988	41, 357, 686	1, 502, 503	517, 466
1874	206, 562, 977	30, 168, 747	993, 068	269, 886
1875	203, 678, 748	28, 168, 572	938, 052	265, 837
1876	220, 831, 608	44, 089, 066	1, 157, 929	370, 431
1877	307, 373, 842	51, 366, 205	1, 914, 129	577, 610
1878	306, 212, 506	36, 855, 798	2, 525, 545	698, 182
1879	365, 597, 467	32, 811, 755	3, 168, 561	713, 208
1880	286, 131, 557	29, 047, 908	5, 607, 009	1, 141, 825
1881	444, 666, 615	42, 122, 683	5, 053, 862	1, 165, 605
1882	428, 424, 581	37, 635, 981	8, 821, 536	2, 034, 487
1883	440, 150, 660	39, 470, 352	10, 108, 394	2, 193, 245
1884	433, 851, 275	39, 450, 794	11, 985, 219	2, 443, 385
1885	445, 880, 518	39, 476, 082	12, 978, 955	2, 659, 210
1886	485, 120, 680	39, 012, 922	13, 948, 367	2, 689, 464
1887	485, 242, 107	37, 007, 336	20, 582, 613	3, 559, 280
1888	455, 045, 784	37, 236, 111	24, 510, 437	4, 215, 449
1889	551, 769, 666	41, 215, 192	27, 903, 267	4, 638, 724
1890	550, 873, 438	39, 826, 086	32, 090, 537	4, 766, 850
1891	531, 445, 099	34, 879, 759	33, 310, 264	4, 999, 978
1892	589, 418, 185	31, 826, 545	34, 026, 855	5, 130, 643
1893	642, 239, 816	31, 719, 404	32, 432, 857	4, 738, 892
1894	730, 368, 626	30, 676, 217	40, 190, 577	5, 449, 000
1895	714, 859, 144	34, 706, 844	43, 418, 942	5, 867, 477
1896	716, 455, 565	48, 630, 920	50, 525, 530	6, 556, 775

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Quantity of crude petroleum produced in, and the quantities and values of petroleum products exported from, the United States, etc.—Continued.

Year ending December 31—	Exports.			
	Residuum (tar, pitch, and all other, from which the light bodies have been distilled).		Total.	
	Gallons.	*Dollars.*	*Gallons.*	*Dollars.*
1871	101,052	10,450	152,195,617	36,663,825
1872	568,218	56,618	144,318,707	33,761,685
1873	1,377,180	117,595	240,369,908	45,924,880
1874	2,504,628	177,794	235,108,168	33,042,276
1875	2,323,986	169,671	237,526,312	31,734,861
1876	2,863,896	239,461	263,449,455	49,545,219
1877	4,256,112	390,077	361,883,225	57,539,873
1878	3,126,816	220,835	349,346,253	41,022,007
1879	4,827,522	273,050	421,719,782	37,235,467
1880	3,177,630	198,983	346,779,443	34,505,645
1881	3,756,018	197,321	514,561,719	48,556,103
1882	4,265,352	275,263	503,492,462	44,623,074
1883	6,502,524	465,350	533,145,429	47,763,079
1884	5,303,298	327,599	544,495,608	49,457,116
1885	5,713,908	334,767	560,784,459	49,671,743
1886	1,993,824	109,673	591,884,302	48,145,204
1887	2,989,098	141,350	601,846,317	46,898,842
1888	1,870,596	116,009	572,457,975	48,105,703
1889	1,858,458	97,265	680,705,456	53,293,299
1890	1,830,612	91,905	693,829,848	52,270,953
1891	1,002,414	61,382	673,905,577	46,174,835
1892	403,032	38,220	744,638,463	42,729,157
1893	541,044	41,661	804,221,230	42,142,058
1894	211,008	14,704	908,252,314	41,499,806
1895	137,508	13,063	884,502,082	46,660,082
1896	204,960	14,330	890,458,994	62,383,403

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FOREIGN MARKETS.

In the following table is given a statement showing the foreign markets for our oil in the past seven years. As will be seen from this table, the total exports of illuminating oils have increased.

Exports of petroleum in its various forms from the United States from 1890 to 1896, by countries.

Countries.	1890.	1891.	1892.	1893.
CRUDE.				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
France	68,947,436	61,663,973	69,100,657	69,424,609
Germany	1,188,266	3,107,137	5,247,209	4,182,963
Spain	13,934,088	17,103,416	17,064,929	21,112,042
United Kingdom	.....	.....	.....	.....
Other Europe	3,680,631	2,380,600	1,935,014	3,948,842
Total	87,750,421	84,255,126	93,347,809	98,668,456
North America:				
Mexico	2,217,846	3,854,176	3,499,514	5,508,769
Cuba	4,913,390	3,300,455	6,316,406	6,955,315
Other North America	36,806	4,338	425,348	548,068
Total	7,167,982	7,158,969	10,241,268	13,012,152
All other countries	532,250	1,000	3,690	22,900
Total crude	95,450,653	91,415,095	103,592,767	111,703,508
REFINED.				
Naphthas.				
Europe:				
France	4,195,704	2,831,929	1,561,284	4,080,839
Germany	2,015,298	3,227,106	3,471,652	4,127,354
United Kingdom	5,603,994	5,058,325	6,813,416	8,209,526
Other Europe	928,616	824,537	686,398	658,270
Total	12,743,612	11,941,897	12,532,750	17,076,989
North America	59,563	86,910	35,762	122,237
South America	78,180	71,192	89,609	55,940
Asia and Oceanica	45,214	55,005	57,787	39,625
Africa	10,864	16,143	12,070	9,214
Total	193,821	229,250	195,228	227,016
Total naphthas	12,937,433	12,171,147	12,727,978	17,304,005

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Exports of petroleum in its various forms from the United States from 1890 to 1896, by countries—Continued.

Countries.	1890.	1891.	1892.	1893.
REFINED—continued.				
Illuminating.				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Belgium	41,391,323	32,397,015	31,471,121	33,541,439
Denmark	7,147,115	9,135,043	7,019,575	12,262,308
France	2,088,291	3,764,974	3,005,535	8,161,023
Germany	140,264,082	162,187,071	133,417,314	119,277,484
Italy	19,747,758	20,955,728	22,324,113	22,815,279
Netherlands	47,315,526	54,879,032	76,607,780	51,298,480
Sweden and Norway	11,772,106	8,957,350	11,159,824	16,312,922
United Kingdom	66,393,246	81,028,529	94,901,777	180,996,321
Other Europe	7,464,013	8,759,531	6,450,040	8,054,660
Total	343,583,460	382,064,273	386,357,079	453,319,916
North America:				
British North America	5,104,864	5,230,259	5,735,411	6,311,042
West Indies	4,404,548	3,303,506	4,262,935	4,439,118
Other North America	2,520,131	3,303,608	2,250,162	2,204,602
Total	12,029,543	11,837,373	12,248,508	12,984,762
South America:				
Argentina	3,113,750	3,476,192	4,825,196	4,070,719
Brazil	8,695,291	10,470,656	14,028,476	15,556,685
Uruguay	3,492,158	3,165,880	4,293,400	2,882,105
Other South America	6,236,596	4,792,161	6,827,814	6,041,571
Total	21,537,795	21,904,889	29,974,886	28,551,080
Asia and Oceanica:				
China	13,072,000	27,160,660	17,370,600	27,874,230
Hongkong	11,150,220	10,814,630	16,529,790	12,758,820
East Indies	63,456,071	63,285,770	55,907,410	57,404,175
Japan	37,892,930	31,000,629	23,761,930	26,869,510
British Australasia	7,976,572	10,276,095	10,376,260	11,053,991
Other Asia and Oceanica	3,982,465	4,630,690	3,095,516	2,637,250
Total	137,530,258	147,168,474	127,041,536	138,597,976
Africa	8,426,714	8,058,806	8,865,999	8,206,932
All other countries	187,320	85,990	408,650	579,150
Total illuminating	523,295,090	571,119,805	564,896,658	642,239,816

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Exports of petroleum in its various forms from the United States from 1890 to 1896, by countries—Continued.

Countries.	1890.	1891.	1892.	1893.
REFINED—continued.				
Lubricating.				
Europe:	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Belgium	1,955,145	2,337,030	2,632,954	2,426,926
France	3,088,183	3,948,257	2,461,722	2,426,659
Germany	3,670,937	4,186,225	4,512,639	3,798,953
Italy	510,622	591,996	404,971	788,805
Netherlands	2,037,437	1,504,623	2,229,116	1,842,608
United Kingdom	17,035,447	18,767,573	18,779,806	17,683,132
Other Europe	146,557	111,165	209,713	249,474
Total	28,444,328	31,446,869	31,240,921	29,216,557
North America	524,898	570,380	656,991	1,043,770
South America	721,669	889,610	798,194	1,207,232
Asia and Oceanica	457,363	582,392	813,618	888,032
Africa	14,264	25,479	81,352	77,266
Total	1,718,194	2,067,861	2,350,155	3,216,300
Total lubricating	30,162,522	33,514,730	33,591,076	32,432,857
Residuum (barrels).				
Europe	10,017	9,058	6,361	10,404
North America	42,141	28,833	6,622	2,202
All other countries	758	175	287	276
Total residuum	52,916	38,066	13,270	12,882

Countries.	1894.	1895.	1896.
CRUDE.			
Europe:	*Gallons.*	*Gallons.*	*Gallons.*
France	84,434,953	72,802,459	79,242,152
Germany	4,877,593	3,966,870	817,212
Netherlands	.....	.....	4,455,469
Spain	15,176,034	15,188,547	12,869,235
United Kingdom	.....	3,997,013	.....
Other Europe	2,009,727	2,590,441	1,212,528
Total	106,498,307	98,545,330	98,596,596
North America:			
Mexico	8,026,189	5,229,983	6,779,059
Cuba	6,865,549	6,980,372	4,838,657
Other North America	534,304	523,579	708,008
Total	15,426,042	12,733,934	12,325,724
All other countries	2,000	6,000	1,300
Total crude	121,926,349	111,285,264	110,923,620

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Exports of petroleum in its various forms from the United States from 1890 to 1896, by countries—Continued.

Countries.	1894.	1895.	1896.
REFINED.			
Naphthas.			
Europe:	*Gallons.*	*Gallons.*	*Gallons.*
France	3,764,569	1,564,360	1,672,056
Germany	4,278,757	4,900,028	2,814,217
United Kingdom	6,834,760	7,343,355	7,236,285
Other Europe	364,135	577,378	160,658
Total	15,242,221	14,385,121	11,883,216
North America	173,649	230,269	294,949
South America	79,777	135,752	113,382
Asia and Oceanica	57,057	45,217	49,927
Africa	3,050	4,865	7,845
Total	313,533	416,103	466,103
Total naphthas	15,555,754	14,801,224	12,349,319
Illuminating.			
Europe:			
Belgium	36,312,974	35,385,765	35,413,132
Denmark	9,290,251	14,626,436	12,693,927
France	11,812,001	6,204,663	5,338,501
Germany	86,388,785	100,829,413	121,841,266
Italy	22,945,037	28,017,572	22,648,184
Netherlands	31,868,189	45,900,640	122,510,644
Sweden and Norway	9,848,074	24,623,246	10,582,677
United Kingdom	274,555,010	279,064,424	181,883,052
Other Europe	7,232,024	6,586,826	8,149,109
Total	490,252,345	541,238,985	521,060,492
North America:			
British North America	8,218,417	7,621,352	9,534,590
West Indies	4,174,856	4,109,358	4,689,128
Other North America	1,759,565	1,501,157	1,493,040
Total	14,182,838	13,231,867	15,716,758
South America:			
Argentina	3,162,846	5,876,742	7,803,218
Brazil	12,154,709	15,315,196	18,490,043
Chile	.....	.....	4,325,915
Uruguay	2,520,571	3,898,514	3,622,810
Other South America	5,503,680	7,245,123	4,267,282
Total	23,341,806	32,335,575	38,509,268

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Exports of petroleum in its various forms from the United States from 1890 to 1896, by countries—Continued.

Countries.	1894.	1895.	1896.
REFINED—continued.			
Illuminating—Continued.			
Asia and Oceanica:	*Gallons.*	*Gallons.*	*Gallons.*
China	40,377,296	18,022,800	25,694,890
Hongkong	16,888,820	10,595,610	10,499,000
East Indies	85,907,557	46,680,054	43,706,780
Japan	37,272,450	24,298,170	33,701,038
British Australasia	11,821,881	14,686,752	13,721,827
Other Asia and Oceanica	2,944,958	3,636,230	3,131,405
Total	195,212,962	117,919,616	130,454,940
Africa	7,049,455	9,676,741	10,280,607
All other countries	329,220	456,360	433,500
Total illuminating	730,368,626	714,859,144	716,455,565
Lubricating.			
Europe:			
Belgium	2,931,204	2,679,832	4,078,951
France	3,050,547	3,271,804	5,165,586
Germany	5,637,471	5,378,398	5,990,561
Italy	1,356,340	1,381,587	1,324,994
Netherlands	2,346,896	2,641,209	2,724,546
United Kingdom	19,668,767	21,209,497	23,436,081
Other Europe	415,385	520,025	815,017
Total	35,406,610	37,082,352	43,535,736
North America	1,725,709	1,565,025	1,457,842
South America	1,509,708	2,159,844	2,221,780
Asia and Oceanica	1,433,191	2,498,975	3,000,471
Africa	115,359	172,746	309,701
Total	4,783,967	6,336,590	6,989,794
Total lubricating	40,190,577	43,418,942	50,525,530
Residuum (barrels).			
Europe	2,056	2,099	4,248
North America	2,460	1,045	438
All other countries	513	130	194
Total residuum	5,029	3,274	4,880

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PRODUCTION BY STATES AND FOREIGN COUNTRIES.

APPALACHIAN OIL FIELD.

The Appalachian oil field includes the productive territory within the limits of the well-defined Appalachian region in the eastern part of the United States, and extends for many miles northeast and southwest, following the western flank of the Appalachian Mountains. The production of this field comes from the States of New York, Pennsylvania, West Virginia, the southeastern part of Ohio, and those portions of Kentucky, Tennessee, Alabama, and Georgia that are within the limits of the Appalachian region.

The production of oil at the present time, however, is confined chiefly to New York, Pennsylvania, West Virginia, and eastern Ohio. The older districts are well known and have been frequently described, and therefore no detailed accounts of them are given.

EXTENSION OF THE APPALACHIAN OIL FIELD.

The results of the drill in the Appalachian districts for 1896, in New York, Pennsylvania, West Virginia, southern and eastern Ohio, Kentucky, and Tennessee, are noted in the following statements:

NEW YORK.

Toward the close of 1896 a number of large wells were developed in what is known as the Chipmunk and Rice Brook fields, in southern-central Cattaraugus County, and these gave a considerable increase in the production. In the extreme northern portion of the Allegany field, also, some new production helped to swell the total.

PENNSYLVANIA.

McKean County.—In the fall of 1896 a number of large wells were opened up in the Ormsby Junction pools in this county.

Forest County.—In the northeastern corner of this county there was a considerable extension of the Watsonville pool to the south. A number of the wells were vigorous and put a large amount of oil to their credit in a short time.

Butler County.—This county also contributed its usual quota of new production, although no new pools were developed.

Allegheny County.—In June and July, 1896, a number of large wells were drilled at Wildwood, in Allegheny County, in what was formerly considered developed territory.

Washington County.—In March, 1896, there was a sudden development of several vigorous wells at and near the town of Cecil, on the northern border of Washington County. They lacked the staying qualities, however, and the production soon ran down.

Greene County.—This county, during the year, produced some small wells in the deep territory of the Gordon fourth and fifth sand, near the extreme southwestern corner of the State, and a few moderate gas wells,

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but nothing that would seem to justify the expense of such deep drilling. Some of the wells are over 3,000 feet in depth. A number of dry holes seem to cut off the further extension of the Mount Morris field to the north, with the single exception of a good paying well in the Big Injun sand, on the Berkshire farm, on Whiteley Creek north of Mapletown. This well has been surrounded by dry holes.

The increased production in Pennsylvania comes from the extensions of pools already developed, rather than from any new pools discovered.

SOUTHERN OHIO.

Monroe County.—This county has continued to be of special interest owing to the development of the Benwood pool, about 10 miles north of Sistersville. The first well on the Price farm came in in August, and produced quite an excitement. The oil comes from the Big Injun sand. At the end of the year there were a number of good producers in the field.

WEST VIRGINIA.

The probabilities of this State becoming a large producer seem to be assured.

Tyler County.—The Kyle pool, on Indian Creek, was opened up near the first of the year, and a number of powerful gas wells, and also a large number of oil wells, were drilled in. The production is from the Big Injun sand. The immense gas pressure near to and among the oil wells made their life as large producers short but active.

A few miles east of the Kyle pool, during the year, several good, deep sand wells were brought in, the oil coming from the Gordon sand. Indications seem to point to a large pool in this locality.

The Wick, Hebron, and Sancho Creek pools were also developed. The Wick and Sancho Creek pools get their production from the Big Injun sand; the Hebron pool from the Big Injun and Cow Run sands; it is located in the extreme southwest corner of the county, lapping over into Pleasants County. A number of vigorous wells have been opened up, although there is a considerable showing of dry holes. In the northern central part of this county, at Conaway post-office, a large gas well was brought in, in the Big Injun, in July; two months after, by deeper drilling, it developed into an oil well. Before the end of the year another well was producing oil, at 60 barrels per day.

The main Big Injun development borders along the eastern line of this county and of Doddridge County.

Pleasants County.—As before stated, a part of the Hebron pool is located in this county. There has also been considerable development some 3 miles west of St. Marys, in the Cow Run sand.

Ritchie County.—In the vicinity of Cairo a number of fair wells have been secured, the oil coming from the Big Injun and salt sand. The number of dry holes thus far credited to this county is large.

Wood County.—There has been considerable work done near Waverly, in the Cow Run sand. The Ogdin pool, which at first produced some fine gas wells, in 1896 began to be worked actively for oil, in the Berea

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sand, with good success. To the south of the Ogdin pool the Hendershott pool was developed, also in the Berea sand.

Early production.—The oldest production in this State was in Wirt, Ritchie, and Pleasants counties, and dates back to 1861. Burning Springs, in Wirt County, marks the spot which was among the earliest to produce oil in this State. This point is near the southern extremity of a very violent upheaval, known generally as "The Breaks," which extends from Burning Springs to Eureka, on the Ohio River, almost due north 25 miles. It is from 2 to 2½ miles wide. In the central part, for most of this width, the measures are nearly level, and are elevated from 800 to 1,200 feet. The flanks of this upheaval in the last quarter of a mile on both sides pitch from 30 to 80 degrees, and then gradually assume the general level of the surrounding strata. This particular uplift has been fully described by Prof. F. W. Minshall.[1]

On the flanks of this uplift many shallow wells produced large quantities of oil from 1864 to about 1874. The best natural lubricating oil comes from this section. This is one of the most remarkable disturbances found anywhere in the coal measures. On its eastern flank, in Ritchie County, the celebrated dike of grahamite, or Ritchie mineral, is found.

Doddridge County.—The northwestern part of this county is very rich in production from the Big Injun sand, and has been steadily producing for the past five years; although nothing new has been opened up, some very good wells have been drilled inside of proven territory.

Wetzel County.—This county has probably added more oil to the production of West Virginia than any other. The watersheds of Ten Mile, Prices Fork, and Buck Run have produced some of the largest wells among the Big Injun producers.

The territory along the waters of Pine Fork and Buffalo has also produced largely from the Gordon sand, over a large area, the wells being widely separated, and it looks as if this county would be a very large producer in the near future.

Marion County.—This county has many miles of developed territory in the Big Injun sand northeast and southwest of Mannington, also a Gordon and fifth-sand production following parallel, but to the west of the Big Injun production. This section was the first to produce oil from the Big Injun sand south of Mount Morris. The most important event in the way of new production was the extension of the Flat Run pool in the Gordon sand to the northeast, to the summit, 6 miles nearly due north of Mannington. Here several wells were drilled to a depth of from 3,540 to 3,580 feet into the Gordon sand. They are large flowing wells, and the deepest producing wells in the world. In round numbers it is estimated that 2.7 feet of oil in a column will give 1 pound pressure to the square inch. Dividing 3,545 by 2.7 we get 1,322 pounds, to which, if 178 pounds be added for friction in pipes, the total can not be less than 1,500 pounds pressure to the square inch at the bottom of these deep wells. The producing sand is 1,940 feet below sea level.

[1] Tenth Census Reports, Vol. X, p. 49 et seq.

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Monongalia County.—Nothing new in the Big Injun pool has been developed. A few good wells have been brought in inside of developed territory. A deep well with small production from one of the lower sands was drilled in on Dunkard Creek, near Browns Mills, during the year.

Marshall County.—In the summer of 1896 a small pool was found 3 miles north of Moundsville, in the Cow Run sand.

Lewis County.—There have been one or two deep wells drilled farther south, in the extreme northeastern corner of Lewis County, that developed oil in the 50-foot sand. At this date this is the southern limit of profitable production in West Virginia.

KENTUCKY.

Eastern Kentucky.—In eastern Kentucky there has been considerable drilling done on the waters of the Levisa Fork of Big Sandy River, in Pike and Floyd counties. Some of these wells have shown oil and gas in very moderate quantities in the Big Injun and salt sands.

Following is a list of the wells completed in this region in 1896:

List of wells in eastern Kentucky completed in 1896.

County.	Farms.	Company.	Location.	Result.
Pike ...	Bowles, No. 1 ..	Old Dominion Oil and Gas Co.	Head of Hurricane Creek.	Dry.
Do...	Cedar tract, No. 2.	.....do	Head of Cedar Creek.	Do.
Floyd ..	George Allen, No. 2.	.....do	Near mouth of Salt Lick Creek.	Very small well.
Do...	Newton Allen, No. 1.	.....do	3 miles NE. of Salt Lick.	Gas.
Do...	Daniel Howard, No. 3.	.....do	¼ mile NE. of Salt Lick.	Very small producer.
Do...	Daniel Howard, No. 4.	.....do	⅛ mile NE. of Salt Lick.	Do.
Do...	Tucker Allen, No. 1.	.....do	2 miles NE. of Salt Lick.	Dry.
Do...	John Burchett, No. 1.	.....do	Head of Cow Creek	Do.
Do...	Corning, No. 1 .	Corning Oil Co..	2 miles NE. of Salt Creek.	Small producer.
Do...	Corning, No. 2 .	.....do	Mouth of Wilson Creek.	Dry.
Do...	Corning, No. 3 .	.....do	2½ miles NE. of Salt Lick.	Small producer.
Do...	Corning, No. 4 .	.....do	3 miles NE. of Salt Lick.	Dry.

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Still farther south, near the border of Tennessee, there are some producers, from the siliceous lime at the bottom of the sub-Carboniferous limestone group, which is the probable equivalent of the Big Injun and Berea sands. Others get their oil from the Corniferous limestone at the bottom of the Devonian black, or Huron, shale. The Niagara and Clinton may also furnish some of the oil. The great development of the sub-Carboniferous and other compact limestones, and the exclusion of sandstone and shale, that furnish the oil in West Virginia and Pennsylvania, has been the source of considerable disappointment in southern Kentucky and Tennessee. Nearly all of the wells drilled in this section show some oil or gas. There are numerous springs and surface shows of oil that have proved to be deceptive. Where oil has been found it seems generally to come from pockets, some large and some small. There seems to be no horizontal bed of a porous nature forming a large reservoir, as is found in the Trenton limestone in Ohio and Indiana, or the open pebble sand of Pennsylvania and West Virginia.

Southern-central Kentucky.—In the following table will be found a list of the deep wells completed in this region in 1896:

List of deep wells completed in 1896.

County.	Farms.	Company.	Location.	Depth, in feet.	Result.
Bell.....	Log Mountain Coal Co.	Guffey & Galey.	Left fork of Bear Creek.	1,816	Dry.
Knox	Smith.....	.....do	Stinking Creek.	1,325	Oil show.
Do.....	Williams....	.....do	.....	600	Small producer.
Do.....	Hammond...	Logan	.....	850	Oil show.
Whitley ...	.....	Cumberland Basin Oil Co.	7 miles SW. of Pine Knot.	1,518	Dry.
Do.....	.....	Home Oil Co.	9 miles N. of Williamsburg.	700	Do.
Laurel.....	.....	Sistersville Oil Co.	13 miles SW. of London.	1,649	Do.
Perry	.....	Corning Oil Co.	NW. of Hazard.	1,000	Not finished.
Cumberland	Smith.....	South Penn Oil Co.	Bear Creek...	1,755	Dry; oil show at 155.
Do.....	E. P. Hutchinson.	.....do	Leslie.....	1,305	Dry.
Clinton	T. H. Shickels.	.....do	Ill-Will Creek	950	Dry; gas at 368, 582 and 940.
Wayne.....	Fairchild ...	.....do	SW. corner of county.	1,450	Dry.

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TENNESSEE.

During the year a number of wells were drilled in Fentress, Pickett, Overton, Scott, Putnam, Smith, Cannon, and Morgan counties, Tennessee. The depth ranged from 300 to 2,800 feet. Only one produced oil in paying quantities, and some of these wells must have gone through the Trenton formation into the Blue Lick waters of the silicious limestone of the Calciferous formation.

The Bobs Bar well was drilled in 1896, and commenced to flow at the rate of 50 barrels per hour. After flowing twelve hours it caught fire and burned down. After it was put in shape it flowed at the rate of 200 barrels per day for some time. It was pumping at the rate of 25 barrels per day at the close of the year, and was the only well producing in Tennessee. The elevation of this well is 675 feet above tide. Black or Huron shale was found at 81 feet; oil at 275 feet; total depth, 277 feet.

This well is surrounded by dry holes. The present outlook is not encouraging, as the following list will show. Out of 48 wells drilled of recent date, only one producer was found.

The following table of deep wells will give some clew to the large amount of prospecting done in this State in 1895 and 1896, and only one producing well had been developed up to the close of 1896:

Descriptive list of Tennessee oil wells.

[Those marked * drilled in 1896.]

County.	Owners of lands.	Present owner of wells.	Approximate altitude.	Depth of black shale.	Thickness of black shale.	Total depth.	Oil show at—	Gas at—
			Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Pickett	J. L. Lacy	Stone, Percy & Filer	620	61	29	1,085	268–297 357	.....
Do	N. Wright	.....do	675	131	29	510	435	.....
Do	J. Bowles	.....do	690	88	29	450	425	.....
Do	J. Sims	Cumberland Oil Co.	600	18	24	676	210–455	120–676–360
Do	Dr. Snodgras	.....do	600	7	24	787	30	12 seams.
Do	Mary Potts	Adams, Janes & Co.	850	247	24	745	.....	745
Do	S. Hinds*	Percy & Filer	630	80	29	500	180	.....
Do	Jas. Gillentine*	Wile Block Co	1,075	490	30	806	.....	.....
Do	J. Robbins*	Henry Oil Co	700	120	28	1,667	350–1640	240
Do	J. Gunter*	South Penn Oil Co.	660	80	30	1,200	343	380–600
Do	.....do	Stone, Percy & Filer	650	.....	.....	.....	.....	.....
Do	Nath. Halbert	Halbert Oil Co	.....	.....	.....	.....	.....	.....
Fentress	J. C. Wright	Collins Oil Co	850	360	36	1,000	155	.....
Do	Joe Woods (Bobs Bar).*	Southern Oil Co	650	80	28	275	270–275	.....
Do	S. H. Pile*	Shaver & Hall	900	.....	.....	.....	.....	.....
Do	John Hill*	Duke and Applebee	900	315	30	667	.....	.....
Do	Thos. Runnells*	Forest Oil Co	825	243	28	2,200	310–1781	110–345–470
Do	John Turner*	.....do	900	315	30	693	540	.....

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Descriptive list of Tennessee oil wells—Continued.

[Those marked * drilled in 1896.]

County.	Owners of lands.	Present owner of wells.	Approximate altitude.	Depth of black shale.	Thickness of black shale.	Total depth.	Oil show at—	Gas at—
			Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Fentress	Jacob Cooper*	Wile Block Co	900	310	30	900	540-900	.....
Do	David Beaty *	Azoic Oil Co	700	135	28	515	297-347	300-400-500
Do	Geo. T. Linder*	John Hauk	800	347	27	1,192	.....	135-150
Do	Rugby Co.*	Forest Oil Co	1,181	1,243	42	1,779	1,603	.....
Do	J. Reagan *	Southern Oil Co	650	.....	.....	.....	.....	.....
Do	Abe Beaty *	G. R. Wright, et al.	650	.....	.....	.....	.....	.....
Overton	J. A. McDonald	Norton & Clelland	900	295	33	700	.....	.....
Do	S. S. Davis	Wright, Gernt, Fry, et al.	650	52	26	624	.....	6 shows.
Do	Levi Phillips	Interstate Co	1,300	705	45	650	.....	.....
Do	Thos. Looper	Geo. Cusack	1,000	.....	.....	.....	.....	.....
Do	L. T. Bohannan*	South Penn Oil Co.	1,000	310	30	2,100	.....	.....
Do	Wisdom Oil Co	Burt Oil Co	900	230	29	1,540	.....	.....
Do	do	do	900	230	29	600	.....	.....
Do	do	do	900	230	29	600	.....	.....
Do	C. Eldridge	do	990	335	29	600	.....	.....
Smith	T. J. Fisher*	South Penn Oil Co.	.....	.....	.....	900	.....	.....
White	Diamond Oil Co	do	.....	.....	.....	.....	.....	.....
Scott	Rugby Co.*	Forest Oil Co	1,297	1,683	45	2,401	500-1340	.....
Do	Sta. Camp Creek	Cudahy Bros	950	.....	.....	1,020	.....	.....
Do	do	do	.....	.....	.....	1,236	1,236	.....
Do	Rugby Co	W. G. Strubbe	1,250	.....	.....	1,236	1,236	.....
Do	do	do	1,300	.....	.....	.....	430	.....
Morgan	Rugby Co.*	Forest Oil Co	1,267	1,455	40	2,793	1,235	.....
Putnam	Near Cookeville	Napoleon Oil Co	.....	.....	.....	150	.....	.....
Do	M. V. Lewis*	South Penn Oil Co.	.....	.....	30	2,100	.....	.....
Do	Spring Creek No. 1.*	Burt Oil Co	.....	.....	.....	.....	.....	.....
Do	Spring Creek No. 2.*	do	.....	.....	.....	.....	.....	.....
Do	Spring Creek No. 3.*	do	.....	.....	.....	.....	.....	.....
Do	M. V. Lewis*	South Penn Oil Co.	.....	246	.....	1,990	.....	280
Cannon	Near Woodbury*	do	.....	.....	.....	1,350	.....	.....

PRODUCTION OF THE APPALACHIAN OIL FIELD FROM 1889 TO 1896.

The difficulty in completely separating the New York and Pennsylvania production, owing to several of the pools overlapping from one State to the other, has made it necessary to give the combined figures for these States.

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Production of petroleum in the Appalachian oil field from 1889 to 1896.

[Barrels of 42 gallons.]

Year.	Pennsylvania and New York.	West Virginia.	Southern Ohio.	Total.
1889	21,487,435	544,113	318,277	32,349,825
1890	28,458,208	492,578	1,116,521	30,067,307
1891	33,009,236	2,406,218	424,323	35,839,777
1892	28,422,377	3,810,086	1,193,414	33,425,877
1893	20,314,513	8,445,412	2,602,965	31,362,890
1894	19,019,990	8,577,624	3,184,310	30,781,924
1895	19,144,390	8,120,125	3,694,624	30,959,139
1896	20,584,421	10,019,770	3,366,031	33,970,222

From the above table it appears that the production for the year 1896 is the largest of any, excepting the year 1891. The production in 1896 was 3,011,083 barrels greater than that in the year 1895 and 1,869,555 barrels less than that in the year 1891.

PRODUCTION IN THE APPALACHIAN OIL FIELD, BY MONTHS.

In the following table is given the production of crude petroleum in the Appalachian oil field from 1891 to 1896, by months:

Production of crude petroleum in the Appalachian oil field from 1891 to 1896, by months.

[Barrels.]

Month.	1891.	1892.	1893.	1894.	1895.	1896.
January	2,968,164	3,016,062	2,491,853	2,627,123	2,469,941	2,727,891
February	2,451,901	2,923,272	2,350,490	2,330,582	2,083,087	2,528,867
March	2,618,394	2,885,531	2,769,501	2,671,051	2,504,645	2,711,088
April	2,592,998	2,802,221	2,493,590	2,494,772	2,588,727	2,933,487
May	2,549,787	2,741,848	2,673,648	2,654,299	2,586,710	2,888,502
June	2,565,856	2,757,436	2,669,110	2,637,416	2,488,551	2,916,018
July	2,540,907	2,759,309	2,658,141	2,659,718	2,673,621	2,972,601
August	2,740,797	2,851,348	2,757,351	2,605,494	2,753,417	2,871,118
September	3,088,801	2,698,196	2,682,296	2,465,689	2,685,766	2,831,507
October	3,823,643	2,729,444	2,651,591	2,638,689	2,717,958	2,901,781
November	4,070,287	2,606,646	2,513,281	2,460,880	2,661,700	2,745,756
December	3,828,242	2,654,564	2,652,038	2,536,211	2,745,016	2,942,206
Total	35,839,777	33,425,877	31,362,890	30,781,924	30,959,139	33,970,222

From the above table it appears that the average monthly production in 1896, considering the difference in the number of days, is remarkably regular, with the exception of April and October. The average monthly production was 2,830,852 barrels. The fall of 1891, owing to the opening up of the McDonald field in Allegheny County, Pennsylvania, shows large variations.

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AVERAGE DAILY PRODUCTION OF THE APPALACHIAN OIL FIELD FROM 1891 TO 1896.

The average daily production is usually in the mind of the oil operator, producer, refiner, or dealer when production is mentioned. The averages are obtained by dividing the product of each month by the number of days in the month, and the average for the year is obtained by dividing the total production by the number of days in the year—365 or 366, as the case may be.

Average daily product of crude petroleum in the Appalachian oil field each month for the years 1891 to 1896, by months and years.

[Barrels.]

Month.	1891.	1892.	1893.	1894.	1895.	1896.
January	95,747	97,292	80,382	84,746	79,676	87,996
February	87,568	100,802	83,946	83,235	74,396	87,202
March	84,464	93,082	89,339	86,163	80,795	87,454
April	86,433	93,407	83,120	83,159	86,291	97,783
May	82,251	88,447	86,247	85,622	83,443	93,177
June	85,529	91,915	88,970	87,914	82,952	97,201
July	81,965	89,010	85,746	85,797	86,246	95,871
August	88,412	91,979	88,947	84,048	88,820	92,617
September	102,960	89,940	89,410	82,190	89,526	94,384
October	123,343	88,047	85,535	85,119	87,676	93,606
November	135,676	86,888	83,776	82,030	88,723	91,525
December	123,492	85,631	85,550	81,813	88,549	94,910
Average	98,191	91,328	85,926	84,334	84,820	92,815

In the above table the averages are meant to include all the oil produced, and includes some oil not reported in the runs of the pipe lines. In 1896 the month of April shows a large gain as compared with March and May, and was the largest of the year. February had the least production of any month. The average daily production shows an increase of 7,995 barrels per day during 1896.

PIPE-LINE RUNS IN THE APPALACHIAN OIL FIELD IN 1896.

Usually the terms "production" and "pipe-line runs" are regarded as synonymous, but production is somewhat in excess of runs. The expression "pipe-line runs" means the amounts of oil which the several pipe lines receive from the wells. If all oil were sent from the wells by pipe lines, these runs would indicate the total production of petroleum in a given year less the oil remaining in tanks at the wells. In other words, on the basis that all oil was shipped from the wells by pipe lines, the total production of a year would be the total runs plus the stocks of oil on hand at the wells at the close of the year minus the well stocks at the beginning of the year. However, as some oil is not

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sent to the pipe lines, the table of production of the Appalachian oil field, as given elsewhere, will be greater than the pipe-line runs. The production of the Appalachian field in 1896 was 33,970,222 barrels; the pipe-line runs are 33,505,197, making a difference between pipe-line runs and the production of 465,025 barrels.

In the following table will be found the pipe-line runs in the Appalachian oil field in 1896, by lines and by months:

Pipe-line runs in the Appalachian oil field in 1896, by lines and months.

[Barrels.]

Month.	National Transit.	Tide Water.	Southwest.	Franklin.	Eureka.	Elk.
January	752,478	161,464	503,307	3,731	757,684	26,440
February	684,239	146,251	480,872	4,115	721,290	25,144
March	731,188	150,093	532,605	3,730	782,609	25,239
April	790,217	162,225	650,262	4,634	793,244	25,185
May	759,834	155,403	621,825	4,280	848,003	24,224
June	770,423	160,422	632,919	4,308	851,518	23,558
July	807,559	177,307	644,823	4,719	837,488	23,196
August	797,479	175,489	570,881	3,852	899,128	22,412
September	816,639	174,475	524,529	3,751	856,293	22,441
October	850,427	180,938	524,007	4,246	884,171	22,804
November	825,802	165,394	477,675	4,301	837,192	21,347
December	889,827	183,988	502,629	3,662	914,581	21,751
Total	9,476,112	1,993,449	6,666,334	49,329	9,983,201	283,741

Month.	Emery.	Mellon. [a]	Producers and Refiners' Pipe Line Company, Limited.	Buckeye-Macksburg.	Total.
January	28,117	.....	125,238	321,468	2,679,927
February	23,929	.....	118,631	272,933	2,477,404
March	28,238	.....	129,727	296,565	2,679,994
April	28,113	.....	135,759	294,603	2,884,242
May	28,345	.....	122,660	279,317	2,843,891
June	26,362	.....	133,127	283,385	2,886,022
July	28,290	.....	122,921	267,797	2,914,100
August	26,015	.....	109,230	270,280	2,874,766
September	25,879	.....	99,605	252,351	2,775,963
October	26,091	.....	102,769	267,337	2,862,790
November	26,280	.....	94,088	253,909	2,705,988
December	27,026	.....	98,415	278,231	2,920,110
Total	322,685	.....	1,392,170	3,338,176	33,505,197

[a] January 1, 1896, the Mellon Pipe Line Company was absorbed by the Eureka Pipe Line Company.

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SHIPMENTS OF OIL FROM THE APPALACHIAN OIL FIELD.

In the following table are given the total deliveries of petroleum by the pipe lines of the Appalachian oil field from 1889 to 1896, by years and months. These figures must not be regarded as showing the actual consumption of the petroleum produced in this field. To them must be added, in order to ascertain what becomes of the oil produced in this region, all of the sediment, dump oil, or oil that does not pass through the pipe lines, as well as the oil that is destroyed by fire or accident, or disposed of in other ways than by refining and direct consumption. There is also a certain amount of loss by evaporation and otherwise. This is provided for by pipe lines in receiving oil from the producers, a certain number of gallons per barrel being allowed for such loss. Forty-three gallons are usually delivered to the pipe line as a barrel, but certificates are issued for 42 gallons only.

The table given below shows only the deliveries of oil to customers in the regular way of business. The total consumption of oil during the year can be ascertained only by adding to the production of a year the stocks at the beginning of the year and subtracting from this total the stocks at the close of the year. This will in no case be the same as deliveries.

Shipments of petroleum from the Appalachian oil field in 1896.

	Barrels.
Total stocks at the close of 1895 in the Appalachian field	5,344,784
Total production in 1896 in the Appalachian field	33,970,222
Total stocks at beginning and production during 1896	39,315,006
Less total stocks at the close of 1896	9,745,722
Apparent total shipments for 1896	29,569,284
Actual shipments for 1896 deducted	29,340,195
Amount in excess of stocks and deliveries at close of 1896	229,089

This excess is made up of "dump oil" (oil that was delivered by wagons), direct deliveries, waste, and the amounts which were from time to time credited by the pipe-line companies for increase in "B. S." and sediment.

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Total shipments of petroleum in the Appalachian oil field from 1889 to 1896, by months.

[Barrels.]

Month.	1889.	1890.	1891.	1892.
January	2,400,456	2,681,646	2,475,783	2,420,825
February	2,288,229	2,185,007	2,170,172	2,443,546
March	2,286,948	2,184,018	2,430,705	2,586,075
April	2,244,615	2,348,385	2,157,605	2,338,421
May	2,265,150	2,488,036	2,073,199	2,278,027
June	2,277,214	2,509,056	2,163,811	2,108,386
July	2,964,866	2,687,061	2,260,996	2,314,405
August	2,640,433	2,645,399	2,498,573	2,626,043
September	2,590,127	2,711,887	2,704,645	2,770,472
October	2,797,732	2,783,121	2,802,254	2,824,508
November	2,441,055	2,717,439	2,604,135	2,916,265
December	2,718,608	2,743,225	2,783,766	2,978,921
Average	2,492,953	2,557,023	2,427,137	2,550,491
Total	29,915,433	30,684,280	29,125,644	30,605,894

Month.	1893.	1894.	1895.	1896.
January	2,957,358	3,141,722	3,140,864	2,543,518
February	2,584,742	2,656,026	2,808,801	2,252,417
March	2,843,938	2,912,594	2,608,232	2,438,900
April	2,666,199	2,846,805	2,781,379	2,227,514
May	3,033,700	2,819,413	2,845,334	2,418,590
June	3,074,443	2,914,400	2,816,698	2,249,062
July	3,319,658	2,927,036	2,634,880	2,540,332
August	3,248,873	3,256,397	2,424,843	2,404,298
September	3,000,740	2,966,864	2,332,271	2,542,963
October	3,316,914	3,271,371	2,573,915	2,606,494
November	3,096,578	3,208,560	2,655,325	2,502,035
December	3,152,238	3,286,087	2,410,084	2,614,072
Average	3,024,615	3,017,273	2,669,386	2,445,016
Total	36,295,381	36,207,275	32,032,626	29,340,195

From the above tables it will be seen that the total shipments of petroleum for 1896 in the Appalachian field were 2,692,431 barrels less than in 1895. The table shows the average consumption to be 2,445,016 barrels per month, while the average production was 2,830,852 barrels, so that stocks must have accumulated at the rate of 366,745 barrels per month during 1896, after allowing for loss and sediment, amounting to 4,400,938 barrels during the year.

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STOCKS OF PETROLEUM IN THE APPALACHIAN OIL FIELD.

In the following table will be found a statement of the stocks of petroleum in the tanks of the pipe-line companies in the Appalachian oil field at the close of each month from 1889 to 1896:

Total stocks of petroleum in the Appalachian oil field at the close of each month from 1889 to 1896.

[Barrels of 42 gallons.]

Month.	1889.	1890.	1891.	1892.
January	18,529,228	11,356,634	11,068,179	16,973,225
February	17,597,956	11,282,453	11,340,147	17,416,399
March	16,994,558	11,472,854	11,419,782	17,587,512
April	16,441,298	11,503,776	11,793,604	18,028,753
May	16,044,384	11,445,975	12,138,347	18,464,378
June	15,656,582	11,318,438	12,455,630	19,056,902
July	14,928,784	11,170,539	12,640,790	19,446,441
August	14,248,456	11,057,828	12,791,156	19,563,635
September	13,581,845	10,942,934	13,039,230	19,394,242
October	12,823,467	10,923,831	13,936,108	19,039,149
November	12,353,863	10,783,567	15,413,864	18,529,914
December	11,873,442	10,691,729	16,457,089	18,037,385
Average	15,089,489	11,162,547	12,874,494	18,461,495

Month.	1893.	1894.	1895.	1896.
January	17,305,206	11,755,219	5,859,348	5,499,477
February	17,042,245	11,384,776	5,087,498	5,741,797
March	16,834,533	11,295,959	4,942,643	6,005,732
April	16,641,773	10,751,983	4,730,819	6,697,481
May	16,285,855	10,639,454	4,506,874	7,153,922
June	15,845,548	10,381,209	4,275,506	7,791,359
July	15,182,551	9,869,915	4,306,287	8,182,582
August	14,730,600	9,210,959	4,592,906	8,672,385
September	14,261,432	8,730,456	4,908,593	8,924,639
October	13,559,543	8,038,376	5,013,941	9,178,509
November	12,904,344	7,283,988	4,988,092	9,409,098
December	12,316,611	6,499,880	5,344,784	9,745,722
Average	15,242,520	9,653,515	4,879,775	7,750,225

The stocks in the above table do not include all of the stocks of the oil held in the Appalachian region, but only those held by the pipe lines, stocks at the wells, as a rule, not being included unless the tanks at the wells are in the custody of the pipe-line companies and the oil has been measured as it runs into them.

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A notable feature in this table is the steady gain in stocks throughout 1896.

The average stocks held at the close of each month in 1895 were 4,879,775 barrels, while the average stocks for 1896 were 7,750,225 barrels.

PRICES OF CRUDE PETROLEUM IN THE APPALACHIAN OIL FIELD.

The prices of crude petroleum in the Appalachian oil field given in the following table show the monthly and yearly average prices of pipe-line certificates or of crude petroleum at the primary markets from 1860 to 1896. In the earlier years covered by the table there were no pipe lines, and the price given for oil is the price per barrel either at the wells or at some delivery point in the oil region, usually the price at the wells. In the later years the price given is that of pipe-line certificates, which, until recently, have been issued by the pipe-line companies, usually for 1,000 barrels each, to the owners of the oil in their tanks, these certificates being to bearer and transferable. The price quoted for these certificates is the price at the wells or at the tanks of the pipe lines near the wells into which the oil is received from the wells. As a rule, the holder of the certificate desiring to receive the oil represented by the certificate could secure it from any of the tanks of the company wherever situated—that is, on a certificate (except in unusual cases calling for a given amount of oil of a certain grade) there was no statement as to where the oil covered by the certificate was to be delivered. In such cases, however, the pipe-line company is entitled to make a charge for storage and pipage, the storage charged per month, as well as the pipage, being regulated somewhat by the selling price of the oil. In the selling price of the oil, therefore, no charges for storage in the tanks nor for transportation are included. Practically, therefore, the prices given are the prices for the oil at or near the wells.

The average prices cover only the ordinary grades of oil. They do not include the prices of special oils, such as that from the Franklin district in Pennsylvania, or the lubricating oils from Petroleum or Volcano in West Virginia, nor the oil from the Mecca-Belden district in Ohio, but only that grade of oil which is known as Pennsylvania oil and is used chiefly for the production of illuminants. It is also true that at certain times oils from different districts in the Appalachian field have been worth an advance on certificate oil, and frequently old oil or tank oil—that is, oil that has stood for some time in tanks—is worth less than fresh oil, or oil that has been recently produced. This is especially the case when there is a large demand for the lighter oils, fresh oils producing a larger percentage of the lighter products than old oil. These averages, it should be understood, are not true averages—that is, averages which consider the price and the quantity sold at that price, but they are averages of the prices obtained for certificates or for oil at the primary markets from day to day. It is probable that the

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true average prices would be slightly under the averages obtained by averaging the prices. The figures given in the following table are, under the circumstances, the only ones that can be ascertained, and do not vary much from the true average:

Monthly and yearly average prices of pipe-line certificates of crude petroleum at wells from 1860 to 1896.

[Per barrel.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1860....	$19.25	$18.00	$12.62½	$11.00	$10.00	$9.50	$8.62½
1861....	1.00	1.00	1.00	.62½	.50	.50	.50
1862....	.10	.15	.22½	.50	.85	1.00	1.25
1863....	2.25	2.50	2.62½	2.87½	2.87½	3.00	3.25
1864....	4.00	4.37½	5.50	6.56	6.87½	9.50	12.12½
1865....	8.25	7.50	6.00	6.00	7.37½	5.62½	5.12½
1866....	4.50	4.40	3.75	3.95	4.50	3.87½	3.00
1867....	1.87½	1.85	1.75	2.07½	2.35	1.90	2.62½
1868....	1.95	2.00	2.55	2.82⅛	3.75	4.50	5.12½
1869....	5.75	6.95	6.00	5.70	5.35	4.95	5.37½
1870....	4.52½	4.52½	4.45	4.22½	4.40	4.17½	3.77½
1871....	3.82½	4.38	4.25	4.01	4.60	3.85½	4.79
1872....	4.02½	3.80	3.72½	3.52½	3.80	3.85	3.80
1873....	2.60	2.20	2.12½	2.30	2.47½	2.22½	2.00
1874....	1.20	1.40	1.60	1.90	1.62½	1.32½	1.02½
1875....	1.03	1.52½	1.75	1.36½	1.40	1.26½	1.09
1876....	1.80	2.60	2.01	2.02½	1.90½	2.01⅛	2.24½
1877....	3.53½	2.70	2.67½	2.58	2.24	1.94⅜	2.07½
1878....	1.43	1.65½	1.59	1.37½	1.35½	1.14	.98⅛
1879....	1.03	.98	.86½	.78½	.76	.68⅜	.69⅞
1880....	1.10½	1.03½	.88⅛	.78	.80	1.00	1.06¼
1881....	.95½	.90⅜	.83⅜	.86¼	.81⅞	.81¼	.76⅞
1882....	.83½	.84½	.81⅜	.78⅜	.71½	.54⅜	.57⅜
1883....	.93⅛	1.01	.97⅛	.94⅜	1.00⅛	1.16⅜	1.05⅞
1884....	1.11	1.04⅜	.98½	.94	.85⅝	.68⅜	.63½
1885....	.70⅞	.72⅜	.80⅜	.78½	.79	.82	.92½
1886....	.88⅜	.79⅞	.77¼	.74½	.70	.66½	.66
1887....	.70	.64⅜	.63⅜	.64⅞	.64½	.62⅜	.59¼
1888....	.91½	.91⅛	.98⅜	.82⅜	.86⅛	.75⅞	.80⅜
1889....	.86⅝	.89¼	.90⅞	.88	.83⅛	.83⅞	.95⅛
1890....	1.05¼	1.05½	.90	.82⅜	.88⅞	.89¼	.89⅛
1891....	.74¼	.78⅜	.74¼	.71½	.69¼	.68⅛	.66½
1892....	.62⅜	.60¼	.57⅛	.57⅞	.57⅜	.54⅛	.52½
1893....	.53½	.57⅜	.65¼	.68¼	.58¼	.60¼	.57⅜
1894....	.79¼	.80⅝	.82	.84¼	.86	.89⅜	.83⅛
1895....	.99	1.04⅜	1.09¼	1.79	1.74¼	1.53⅜	1.46⅜
1896....	1.42⅝	1.36⅝	1.28½	1.22½	1.15⅜	1.14¼	1.08¼

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Monthly and yearly average price of pipe-line certificates of crude petroleum at wells from 1860 to 1896—Continued.

[Per barrel.]

Year.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
1860.....	$7.50	$6.62½	$5.50	$3.75	$2.75	$9.59
1861.....	.25	.20	.10	.10	.10	.49
1862.....	1.25	1.25	1.75	2.00	2.25	1.05
1863.....	3.37½	3.50	3.75	3.85	3.95	3.15
1864.....	10.12½	8.87½	7.75	10.00	11.00	8.06
1865.....	4.62½	6.75	8.12½	7.25	6.50	6.59
1866.....	3.75	4.50	3.39	3.10	2.12½	3.74
1867.....	3.15	3.40	3.55	2.50	1.87½	2.41
1868.....	4.57½	4.00	4.12½	3.75	4.35	3.62½
1869.....	5.57½	5.50	5.50	5.80	5.12½	5.63¾
1870.....	3.15	3.25	3.27½	3.22½	3.40	3.86
1871.....	4.66	4.65	4.82½	4.25	4.00	4.34
1872.....	3.58½	3.25	3.15	3.83½	3.32½	3.64
1873.....	1.42½	1.15	1.20	1.25	1.00	1.83
1874.....	.95	.95	.85	.55	.61½	1.17
1875.....	1.13	1.33	1.32½	1.44	1.55	1.35
1876.....	2.71⅝	3.81	3.37½	3.11	3.73	2.56½
1877.....	2.51	2.38	2.56¼	1.91	1.80	2.42
1878.....	1.01	.86⅜	.82½	.89⅜	1.16	1.19
1879.....	.67⅛	.69⅜	.88⅛	1.05⅜	1.18⅛	.85⅞
1880.....	.91	.96	.96⅞	.91⅞	.91⅜	.94½
1881.....	.78⅛	.97⅛	.91¼	.85¼	.84⅜	.85⅝
1882.....	.58⅜	.72⅛	.93¾	1.14	.96	.78⅛
1883.....	1.08	1.12½	1.11⅛	1.14½	1.14¾	1.05⅜
1884.....	.81⅞	.78	.71⅛	.72½	.74⅜	.83½
1885	1.00¼	1.00¾	1.05½	1.04⅜	.89⅜	.87⅞
1886.....	.62⅛	.63⅜	.65⅛	.71⅜	.70⅜	.71¼
1887.....	.60⅛	.67	.70⅞	.73⅞	.80¾	.66¾
1888.....	.90⅛	.93⅝	.90⅜	.85⅜	.89½	.87⅜
1889.....	.99⅛	.99⅛	1.01⅜	1.08½	1.04⅛	.94⅛
1890.....	.89½	.81⅞	.80⅛	.72⅜	.67½	.86¾
1891.....	.64	.58½	.60½	.58¾	.59⅝	.67
1892.....	.55	.54⅜	.51⅜	.52	.53½	.55⅝
1893.....	.58⅞	.64⅜	.70¾	.73⅞	.78½	.64
1894.....	.81	.83	.83	.83	.91½	.83⅞
1895.....	1.26⅛	1.22⅜	1.24¼	1.48⅜	1.42	1.35⅞
1896.....	1.05	1.12	1.15	1.16	.98	1.17⅜

The above table shows a steady decline in 1896 for the first eight months, a slight increase in September, October, and November, and a very heavy drop in December.

For many years the price of certificates, by which was meant the cer-

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tificates issued by the pipe lines representing certain amounts of oil, was taken as the price of the oil. These certificates were bought and sold on the floor of the oil exchange. On January 23, 1895, the following notice was posted at the various offices of what was known as the Seep Purchasing Agency, Mr. Joseph Seep being the purchasing agent for the Standard Oil Company: "From this date the prices quoted are not those of certificate oil, but the price paid by the Seep Purchasing Agency." In the following table is given the range of prices paid producers in the Pennsylvania region in 1896, prices being given only for those dates on which changes were made:

Range of prices paid for petroleum in the Pennsylvania oil regions by the Seep Purchasing Agency in 1896.

Date.	Pennsylvania.	Tiona.	Corning.	New Castle.	Barnesville.
January 1	$1.50	$1.60	$1.35	$1.25	$1.40
January 17	1.47	1.57	1.32	1.22	1.37
January 18	1.45	1.55	1.30	1.20	1.35
January 20	1.45	1.53	1.28	1.18	1.33
January 22	1.40	1.50	1.25	1.15	1.30
January 31	1.43	1.53	1.28	1.18	1.33
February 18	1.40	1.50	1.25	1.15	1.30
February 20	1.35	1.45	1.20	1.10	1.25
February 24	1.33	1.43	1.18	1.08	1.23
February 26	1.30	1.40	1.15	1.05	1.20
March 4	1.28	1.38	1.13	1.03	1.18
March 9	1.30	1.40	1.15	1.05	1.20
March 10	1.33	1.43	1.18	1.08	1.23
March 12	1.35	1.45	1.20	1.10	1.25
March 14	1.38	1.48	1.23	1.13	1.28
March 17	1.40	1.50	1.25	1.15	1.30
March 23	1.37	1.47	1.22	1.12	1.27
March 25	1.35	1.45	1.20	1.10	1.25
March 26	1.32	1.42	1.17	1.07	1.22
March 27	1.29	1.39	1.14	1.04	1.19
April 2	1.25	1.35	1.12	1.02	1.17
April 7	1.22	1.32	1.07	.97	1.12
April 9	1.20	1.30	1.05	.95	1.10
April 24	1.25	1.35	1.10	1.00	1.15
April 30	1.25	1.35	1.15	1.00	1.15
May 11	1.22	1.32	1.12	.97	1.12
May 14	1.20	1.30	1.10	.95	1.10
May 18	1.17	1.27	1.07	.92	1.07
May 19	1.15	1.25	1.05	.90	1.05
May 22	1.13	1.23	1.03	.88	1.03

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Range of prices paid for petroleum in the Pennsylvania oil regions by the Seep Purchasing Agency in 1896—Continued.

Date.	Pennsylvania.	Tiona.	Corning.	New Castle.	Barnesville.
May 25	1.10	1.20	1.00	.85	1.00
May 26	1.09	1.19	.99	.84	.99
June 5	1.10	1.20	1.00	.85	1.00
June 10	1.14	1.24	1.04	.89	1.04
June 12	1.16	1.26	1.06	.91	1.06
June 15	1.18	1.28	1.08	.93	1.08
June 16	1.20	1.30	1.10	.95	1.10
June 23	1.18	1.28	1.08	.93	1.08
June 24	1.16	1.26	1.06	.91	1.06
June 25	1.15	1.25	1.05	.90	1.05
July 13	1.13	1.23	1.03	.88	1.03
July 14	1.10	1.20	1.00	.85	1.00
July 15	1.07	1.17	.97	.82	.97
July 16	1.03	1.13	.93	.78	.93
July 23	1.06	1.16	.96	.81	.96
July 27	1.08	1.18	.98	.83	.98
July 31	1.06	1.16	.96	.81	.96
August 12	1.04	1.14	.94	.79	.94
August 27	1.06	1.16	.96	.81	.96
August 31	1.08	1.18	.98	.83	.98
September 4	1.10	1.20	1.00	.85	1.00
September 10	1.12	1.22	1.02	.87	1.02
September 23	1.15	1.25	1.05	.90	1.05
September 25	1.18	1.28	1.08	.93	1.08
October 1	1.16	1.26	1.06	.91	1.06
October 13	1.14	1.24	1.04	.89	1.04
October 27	1.17	1.27	1.07	.92	1.07
November 10	1.20	1.30	1.10	.95	1.10
November 18	1.17	1.27	1.07	.92	1.07
November 19	1.15	1.25	1.05	.90	1.05
November 23	1.13	1.23	1.03	.88	1.03
November 24	1.10	1.20	1.00	.85	1.00
November 27	1.08	1.18	.98	.83	.98
November 30	1.05	1.15	.95	.80	.95
December 7	1.03	1.13	.93	.78	.93
December 9	1.01	1.11	.91	.76	.91
December 14	.99	1.09	.89	.74	.89
December 16	.97	1.07	.87	.72	.87
December 16	.95	1.05	.85	.70	.85
December 23	.93	1.03	.83	.68	.83
December 28	.90	1.00	.80	.65	.80

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WELL RECORDS IN THE APPALACHIAN OIL FIELD.

In the following table will be found statements showing the well records in the Appalachian field—that is, the number of wells completed in the Appalachian field during each month of 1896, by months and districts, and the wells completed in each year from 1891 to 1896, by months, as well as the initial daily production of new wells by months and districts for 1896, and by months from 1891 to 1896:

Total number of wells completed in the Appalachian oil field in 1896.

Month.	Bradford.	Allegany.	Middle field.	Venango and Clarion.	Butler and Armstrong.	Southwest district.	Macksburg.	Total.
January	38	29	37	120	98	215	43	580
February	48	23	29	112	79	223	41	555
March	31	29	34	100	87	218	43	542
April	44	31	45	131	93	225	45	614
May	70	36	55	138	115	244	71	729
June	74	25	68	160	101	316	49	793
July	72	32	57	155	103	254	66	739
August	81	20	43	151	84	210	51	640
September	74	27	43	133	102	215	50	644
October	91	16	61	150	89	174	43	624
November	74	27	60	126	102	233	60	682
December	72	36	62	138	100	217	57	682
Total	769	331	594	1,614	1,153	2,744	619	7,824

The above table shows a large monthly gain in the number of wells completed in all fields, excepting in the Venango and Clarion field and the Butler and Armstrong field; in these fields there was a slight falling off. The total for 1896 exceeds the very large number in 1895 by 688 wells.

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In order that the comparative work done in this field in 1895 and 1896 may be observed, we give the following table:

Total number of wells completed in the Appalachian oil field in 1895 and 1896.

District.	Wells completed.	
	1895.	1896.
Bradford	578	769
Allegany	258	331
Middle field	401	594
Venango and Clarion	1,783	1,614
Butler and Armstrong	1,292	1,153
Southwest	2,364	2,744
Macksburg	460	619
Total	7,136	7,824

The following table gives a statement of the number of wells completed in the Appalachian oil field for each month during the years 1891 to 1896:

Number of wells completed in the Appalachian oil field each month from 1891 to 1896, by months and years.

Month.	1891.	1892.	1893.	1894.	1895.	1896.
January	310	182	135	189	296	580
February	243	180	99	176	212	555
March	275	149	143	217	355	542
April	288	174	146	278	462	614
May	314	174	196	324	658	729
June	304	162	228	370	810	793
July	334	179	219	342	822	739
August	333	143	163	359	814	640
September	281	146	179	381	775	644
October	246	160	154	394	727	624
November	255	174	144	390	638	682
December	205	145	174	343	567	682
Total	3,388	1,968	1,980	3,763	7,136	7,824

The above tables do not include any wells drilled in the Franklin lubricating-oil district of Pennsylvania, nor the wells drilled in the Volcano and Burning Springs districts in West Virginia that produce lubricating oil.

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In the following table is given the initial daily production of new wells in the Appalachian oil field in 1896, by districts and months. By initial daily production is meant the production of the well when it is first drilled into the sand and begins producing. The figures do not include any of the production of the lubricating-oil districts of Pennsylvania or West Virginia.

Initial daily production of new wells in the Appalachian oil field in 1896.

[Barrels of 42 gallons.]

Month.	Bradford.	Allegany.	Middle field.	Venango and Clarion.	Butler and Armstrong.	Southwest district.	Macksburg.	Total entire field.
January	254	165	244	414	1,395	4,573	338	7,383
February	203	160	163	403	921	5,620	359	7,829
March	142	192	231	334	1,066	6,090	787	8,842
April	273	198	301	334	942	8,792	413	11,253
May	662	141	360	406	1,142	8,085	554	11,350
June	1,010	141	422	458	1,171	8,197	426	11,825
July	1,124	174	315	449	1,127	6,814	473	10,476
August	1,142	91	419	698	899	3,922	300	7,471
September	1,010	110	880	702	1,074	4,006	434	8,216
October	1,242	63	976	555	953	4,880	594	9,263
November	1,077	137	790	499	1,413	5,786	592	10,294
December	1,323	170	867	400	1,622	7,316	498	12,196
Average	788	145	497	471	1,144	6,174	481	9,700

For comparison we give below a statement showing the initial daily production of all the producing wells drilled in the Appalachian oil field in 1895 and 1896:

Initial daily production of new wells in the Appalachian oil field in 1895 and 1896.

[Barrels.]

District.	1895.	1896.
Bradford	3,431	9,462
Allegany	1,277	1,742
Middle field	2,691	5,968
Venango and Clarion	6,511	5,652
Butler and Armstrong	18,073	13,725
Southwest	65,684	74,081
Macksburg	5,336	5,768
Total	103,003	116,398
Average	14,715	16,628

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Average daily production of new wells in the Appalachian oil field in 1895 and 1896, by districts.

[Barrels.]

District.	1895.	1896.
Bradford	6.8	13.7
Allegany	5.8	6.1
Middle field	7.8	12.2
Venango and Clarion	4.3	4.2
Butler and Armstrong	19.3	17
Southwest	38.4	39.4
Macksburg	15.9	13.8

The above table is remarkable from the fact that there is a very large increase in the daily production of new wells in the old Bradford field—just double what it was in 1895. The others that show an increase are Allegany, Middle field, and the Southwest.

The total daily initial production of new wells completed in the Appalachian oil field from 1891 to 1896, as far as it could be ascertained, is as follows:

Total daily initial production of new wells in the Appalachian oil field from 1891 to 1896, by months.

[Barrels.]

Month.	1891.	1892.	1893.	1894.	1895.	1896.
January	13,364	12,249	5,910	8,667	5,938	7,383
February	6,618	9,992	6,982	5,914	3,662	7,829
March	7,751	8,661	7,650	6,100	6,150	8,842
April	7,710	6,751	6,962	7,584	6,388	11,253
May	7,875	7,793	8,176	7,430	7,859	11,350
June	5,263	9,585	10,815	11,443	9,909	11,825
July	6,543	10,669	7,662	9,009	8,786	10,476
August	13,536	7,861	8,733	7,691	12,204	7,471
September	18,118	6,347	6,640	6,912	14,728	8,216
October	46,748	8,833	4,510	7,838	9,916	9,263
November	33,660	6,932	6,495	7,507	10,374	10,294
December	15,538	7,580	7,840	5,949	7,089	12,196
Average	15,227	8,604	7,365	7,670	8,584	9,700

In the following table will be found a statement of the number of dry holes drilled in the Appalachian oil field in 1896, by months and districts. By "dry holes" is meant wells drilled that produce no petroleum.

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Total number of dry holes drilled in the Appalachian oil field in 1896.

Month.	Bradford.	Allegany.	Middle field.	Venango and Clarion.	Butler and Armstrong.	Southwest district.	Macksburg.	Total.
January	1	6	9	23	23	72	11	145
February	11	3	3	17	23	75	15	147
March	4	5	3	21	27	73	9	142
April	6	4	6	25	31	67	16	155
May	4	6	11	24	24	75	31	175
June	7	1	19	21	32	99	11	190
July	4	3	11	28	30	89	23	188
August	10	3	6	26	27	60	19	151
September	8	4	7	15	33	69	12	148
October	8	5	10	28	30	39	13	133
November	7	1	10	10	34	74	24	160
December	8	5	9	23	33	73	16	167
Total	78	46	104	261	347	865	200	1,901

A comparison of the number of dry holes drilled in the Appalachian oil field in the years 1895 and 1896 is of considerable interest. It is as follows:

Number of dry holes drilled in the Appalachian oil field in 1895 and 1896.

District.	1895.	1896.
Bradford	76	78
Allegany	39	46
Middle field	58	104
Venango and Clarion	283	261
Butler and Armstrong	354	347
Southwest	653	865
Macksburg	125	200
Total	1,588	1,901

It will be noted that in 1895 and 1896 there were 7,136 and 7,824 wells drilled, respectively. The number of paying wells to one dry hole in 1896 was 4.1, or 22 per cent. The number of paying wells to one dry hole in 1895 was 4.5, or 24 per cent; that is, operations were attended with less loss from the discovery of dry holes in 1895 than in 1896. There were 313 more dry holes drilled in 1896 than in 1895.

In the Bradford field in 1896, out of 769 wells 78 were dry, amounting to 10 per cent, as compared to 14 per cent in 1895. In the Southwest district the percentage of dry holes was 31.5, as compared to 28 per cent in 1895.

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In the following table will be found a statement of the number of dry holes drilled in each month from 1891 to 1896:

Dry holes drilled from 1891 to 1896.

Month.	1891.	1892.	1893.	1894.	1895.	1896.
January	46	37	39	36	76	145
February	61	36	24	41	55	147
March	52	38	36	54	87	142
April	59	40	28	68	110	155
May	48	48	41	67	119	175
June	72	33	48	84	170	190
July	67	43	40	67	181	188
August	66	31	40	80	185	151
September	41	40	43	102	169	148
October	50	37	35	91	176	133
November	59	40	28	100	139	160
December	43	39	41	85	121	167
Total	664	462	443	875	1,588	1,901

In the following table will be found a statement of the number of rigs or derricks in course of construction at the close of each month of 1896 for each of the districts of the appalachian field, the average for each month during the year being 414.

Rigs building in the Appalachian oil field in 1896.

Month.	Bradford.	Allegany.	Middle field.	Venango and Clarion.	Butler and Armstrong.	Southwest district.	Macksburg.	Total.
January	32	12	20	63	87	189	38	441
February	56	13	28	75	76	178	24	450
March	40	17	35	73	84	176	24	449
April	53	15	31	82	82	165	30	458
May	48	10	48	79	60	172	22	439
June	49	7	39	75	88	157	21	436
July	50	12	25	65	65	139	23	379
August	51	21	25	55	60	122	26	360
September	48	15	39	72	64	118	22	378
October	52	27	32	52	66	130	30	389
November	71	26	31	67	56	146	22	419
December	72	20	28	48	43	132	22	365
Average	52	16	32	67	69	152	26	414

In the following table will be found a statement of the number of rigs building in the entire Appalachian oil field, together with the monthly average, at the close of each month from 1891 to 1896.

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Rigs building in the Appalachian oil field from 1891 to 1896.

Month.	1891.	1892.	1893.	1894.	1895.	1896.
January	233	110	108	166	270	441
February	195	132	107	180	353	450
March	218	111	132	187	380	449
April	186	100	159	233	457	458
May	208	108	144	237	599	439
June	234	89	135	238	564	436
July	182	96	116	245	576	379
August	188	74	114	292	490	360
September	131	98	91	254	486	378
October	156	108	110	269	464	389
November	142	130	143	248	472	419
December	112	122	193	248	476	365
Average	182	107	129	233	466	414

The foregoing table shows a decrease of 52 in the monthly average in the number of rigs built in 1896 as compared to 1895. When the price went up in 1895 a large amount of new work was commenced, but the full benefit in production did not develop until 1896.

In the following tables will be found statements regarding the number of wells drilling but not completed at the close of each month of 1896, by districts, and also in the entire Appalachian oil field for each month from 1891 to 1896. At the close of the year there were 595 wells drilling, as compared with 716 drilling in December, 1895.

Wells in process of drilling in the Appalachian oil field in 1896.

Month.	Bradford.	Allegany.	Middle field.	Venango and Clarion.	Butler and Armstrong.	Southwest district.	Macksburg.	Total.
January	45	37	29	105	135	317	33	701
February	34	31	29	60	131	314	22	621
March	45	27	27	78	131	321	38	667
April	61	37	40	77	131	369	42	757
May	70	29	33	95	103	370	27	727
June	66	30	32	83	100	335	36	682
July	56	15	36	95	101	302	35	640
August	58	19	33	72	113	304	26	625
September	39	17	37	81	93	256	33	556
October	42	16	38	80	92	287	35	590
November	41	30	50	79	102	285	40	627
December	53	32	36	62	107	269	36	595
Average	51	27	35	80	112	311	33	649

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Number of wells drilling in the Appalachian oil field from 1891 to 1896 and the average by months.

Month.	1891.	1892.	1893.	1894.	1895.	1896.
January	407	264	188	269	418	701
February	410	273	214	282	440	621
March	401	251	206	330	467	667
April	387	230	269	345	635	757
May	380	233	291	410	824	727
June	407	258	305	430	941	682
July	420	204	266	498	902	640
August	406	244	248	484	866	625
September	397	236	233	489	819	556
October	386	246	219	469	794	590
November	351	228	277	451	760	627
December	286	238	233	456	716	595
Average	386	242	246	409	715	649

The following table shows the wells completed, the initial production, the dry holes, wells drilling, and rigs building in the Appalachian field in 1896:

Well record in the Appalachian oil field in 1896.

Month.	Wells completed.	Initial production.	Dry holes.	Wells drilling.	Rigs building.
		Barrels.			
January	580	7,383	145	701	441
February	555	7,829	147	621	450
March	542	8,842	142	667	449
April	614	11,253	155	757	458
May	729	11,350	175	727	439
June	793	11,825	190	682	436
July	739	10,476	188	640	379
August	640	7,471	151	625	360
September	644	8,216	148	556	378
October	624	9,263	133	590	389
November	682	10,294	160	627	419
December	682	12,196	167	595	365
Total	7,824	*a* 9,700	*a* 158	*a* 649	*a* 414

a Average.

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PENNSYLVANIA–NEW YORK OIL FIELD.

PRODUCTION.

In the statistics of production, shipments, stocks, etc., of the Appalachian oil field previously given are included the statistics of Pennsylvania and New York, as well as West Virginia and eastern Ohio, these four localities making up the Appalachian field. It is both interesting and important, so far as it can be done, to give the statistics of production for each of these States. This is especially necessary regarding Pennsylvania and New York, as for many years the statistics of petroleum in the United States were practically those of the production in these two States. Therefore a comparison of the increase or decrease in production should be made on the basis of the ascertained statistics of production in these two States. What has been stated already regarding the difficulty of ascertaining the exact figures for the several States separately for certain items should be recalled. There is but little difficulty in ascertaining the production of the several States, but it has been found impossible in some cases to separate the stocks, shipments, etc., of the four States comprising this field.

In the following table is given a statement of the production of crude petroleum in New York and Pennsylvania in 1896, by districts and months:

Production of crude petroleum in Pennsylvania and New York in 1896, by districts and months.

[Barrels of 42 gallons.]

District.	January.	February.	March.	April.	May.
Allegany, N. Y	56, 259	52, 162	57, 442	69, 561	68, 668
Bradford, Pa	282, 004	254, 636	270, 469	289, 005	283, 694
Clarendon and Warren	34, 231	28, 533	29, 584	34, 969	33. 167
Middle district	70, 009	64, 934	65, 910	69, 543	69, 771
Tiona	28, 670	24, 858	24, 872	28, 638	27, 554
Lower district	638, 126	584, 784	626, 963	660, 919	623, 351
Washington County	158, 011	148, 537	137, 760	239, 457	179, 811
Allegheny County	320, 271	311, 855	352, 708	390, 178	393, 308
Beaver County	46, 821	34, 133	55, 496	47, 559	55, 750
Greene County	9, 984	9, 052	7, 150	7. 801	6, 420
Total	1, 644, 386	1, 513, 484	1, 628, 354	1, 837, 630	1, 741, 494
Franklin district	3, 731	4, 115	3, 730	4, 634	4, 280
Smiths Ferry district	250	207	150	300	305
Grand total	1, 648, 367	1, 517, 806	1, 632, 234	1, 842, 564	1, 746. 079

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Production of crude petroleum in Pennsylvania and New York in 1896, etc.—Continued.

[Barrels of 42 gallons.]

District.	June.	July.	August.	September.
Allegany, N. Y	62,187	66,319	59,794	61,266
Bradford, Pa	287,608	316,059	313,862	318,028
Clarendon and Warren	33,469	33,084	33,011	28,347
Middle district	71,235	74,212	76,440	84,049
Tiona	25,871	25,707	24,905	24,541
Lower district	627,749	637,282	623,019	620,345
Washington County	183,971	169,998	159,842	157,841
Allegheny County	431,671	471,459	383,418	348,734
Beaver County	47,187	46,683	41,749	44,222
Greene County	8,618	8,085	6,170	8,537
Total	1,779,596	1,848,888	1,722,210	1,695,910
Franklin district	4,308	4,719	3,852	3,751
Smiths Ferry district	200	150	270	157
Grand total	1,784,104	1,853,757	1,726,332	1,699,818

District.	October.	November.	December.	Total.
Allegany, N. Y	63,730	57,460	61,758	736,606
Bradford, Pa	330,582	310,006	348,818	3,604,771
Clarendon and Warren	34,231	29,955	32,713	385,294
Middle district	91,459	104,999	113,829	956,390
Tiona	27,276	22,843	23,517	309,252
Lower district	637,384	612,796	647,089	7,539,807
Washington County	159,299	136,207	144,435	1,975,169
Allegheny County	349,082	314,012	313,311	4,380,007
Beaver County	41,683	42,521	46,492	550,296
Greene County	7,035	7,481	8,433	94,796
Total	1,741,761	1,638,280	1,740,395	20,532,388
Franklin district	4,246	4,301	3,662	49,329
Smiths Ferry district	250	265	200	*a* 2,704
Grand total	1,746,257	1,642,846	1,744,257	20,584,421

a This production only represents dump oil, the pipe-line runs of this district being included in runs of Beaver County.

The production in the Allegany (New York) district does not include all the production of that State. About 13 per cent of the production credited to the Bradford district in Pennsylvania comes from Cattaraugus County, New York. On this basis the total production of crude petroleum in the State of New York would be 1,205,220 barrels. The remainder of the 20,584,421 barrels, amounting to 19,379,201 barrels,

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should be credited to Pennsylvania, which includes the Smiths Ferry dump oil and the Franklin district lubricating oil.

This table shows a very remarkable increase over 1895 in all the districts excepting the Middle, Tiona, and Greene County districts. The increase in the Allegheny district was 13⅝ per cent; that in the Lower district was 9⅛ per cent, these two districts producing more than one-half the oil in Pennsylvania.

There was a slight decrease in the Middle and Tiona districts, while the Greene County district decreased 19 per cent. The total increase in New York and Pennsylvania in 1896 was 7½ per cent over 1895, as before stated.

In the following tables is given the total production of crude petroleum in the Pennsylvania and New York oil fields for the twenty-six years from 1871 to 1896, inclusive, by months, showing the production for 1896 to be the greatest since the year 1892.

Total product of crude petroleum in the Pennsylvania and New York oil fields from 1871 to 1896, by months and years.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1871.....	418,407	372,568	400,334	385,980	408,797
1872.....	583,575	462,985	461,590	462,090	537,106
1873.....	632,617	608,300	665,291	641,520	776,364
1874.....	1,167,243	835,492	883,438	778,740	895,745
1875.....	852,159	719,824	789,539	675,060	696,508
1876.....	712,225	668,885	718,177	701,490	735,351
1877.....	842,890	783,216	901,697	972,810	1,127,594
1878.....	1,203,296	1,094,856	1,208,380	1,195,890	1,264,862
1879.....	1,369,921	1,261,935	1,499,315	1,530,450	1,644,922
1880.....	1,904,113	1,870,008	2,015,992	2,015,700	2,228,931
1881.....	2,244,090	1,913,128	2,274,532	2,205,780	2,393,293
1882.....	2,353,551	2,131,332	2,482,170	2,402,790	2,486,572
1883.....	1,948,319	1,756,188	1,830,674	1,816,530	1,962,052
1884.....	1,825,838	1,880,650	2,052,262	2,065,860	2,381,854
1885.....	1,652,176	1,437,884	1,638,133	1,780,290	1,771,371
1886.....	1,748,958	1,604,848	1,928,448	1,938,360	2,178,373
1887.....	1,990,851	1,827,924	2,007,196	1,960,860	1,993,517
1888.....	1,155,937	1,290,718	1,338,877	1,349,403	1,473,362
1889.....	1,542,806	1,332,482	1,628,661	1,635,933	1,821,776
1890.....	2,108,248	2,055,424	2,313,189	2,328,870	2,378,382
1891.....	2,830,081	2,287,320	2,360,011	2,337,498	2,288,656
1892.....	2,786,528	2,703,663	2,657,432	2,574,814	2,485,040
1893.....	1,723,918	1,671,620	1,900,363	1,682,271	1,763,655
1894.....	1,579,420	1,432,251	1,662,595	1,537,500	1,628,149
1895.....	1,570,742	1,318,322	1,585,887	1,656,436	1,630,829
1896.....	1,648,367	1,517,806	1,632,234	1,842,564	1,746,079

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Total product of crude petroleum in the Pennsylvania and New York oil fields from 1871 to 1896, by months and years—Continued.

[Barrels of 42 gallons.]

Year.	June.	July.	August.	September.
1871	410, 340	456, 475	462, 582	461, 940
1872	491, 130	517, 762	549, 909	500, 430
1873	793, 470	867, 473	936, 138	954, 270
1874	621, 750	1, 033, 447	931, 519	840, 630
1875	696, 210	788, 361	718, 766	698, 940
1876	723, 600	763, 623	782, 223	780, 600
1877	1, 130, 790	1, 189, 005	1, 273, 759	1, 214, 910
1878	1, 217, 250	1, 283, 865	1, 341, 928	1, 315, 710
1879	1, 675, 650	1, 637, 767	1, 892, 302	1, 856, 700
1880	2, 158, 440	2, 248, 430	2, 341, 027	2, 346, 300
1881	2, 377, 860	2, 372, 678	2, 331, 727	2, 193, 420
1882	2, 825, 940	3, 258, 162	3, 104, 495	2, 620, 380
1883	1, 977, 900	2, 020, 394	1, 879, 437	1, 913, 370
1884	1, 862, 190	2, 059, 950	2, 099, 165	1, 948, 260
1885	1, 767. 210	1, 775, 804	1, 705, 961	1, 712, 790
1886	2, 335, 380	2, 418, 961	2, 413, 206	2, 418, 540
1887	1, 912, 860	1, 899, 525	1, 848, 877	1, 779, 930
1888	1, 450, 703	1, 394, 847	1, 382, 077	1, 273, 080
1889	1, 811, 485	1, 954, 168	1, 964, 227	1, 867, 610
1890	2, 370, 001	2, 524, 206	2, 514, 968	2, 584, 949
1891	2, 316, 988	2, 289, 089	2, 473, 398	2, 837, 562
1892	2, 439, 346	2, 360, 886	2, 328, 596	2, 125, 511
1893	1, 780, 836	1, 720, 088	1, 691, 652	1, 614, 021
1894	1, 663, 964	1, 624, 767	1, 612, 212	1, 512, 116
1895	1, 575, 940	1, 625, 958	1, 681, 579	1, 590, 696
1896	1, 784, 104	1, 853, 757	1, 726, 332	1, 699, 818

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Total product of crude petroleum in the Pennsylvania and New York oil fields from 1871 to 1896, by months and years—Continued.

[Barrels of 42 gallons.]

Year.	October.	November.	December.	Total.
1871	485,243	464,610	477,958	5,205,234
1872	442,432	638,610	645,575	6,293,194
1873	942,493	991,470	1,084,380	9,893,786
1874	919,739	861,060	858,142	10,926,945
1875	731,073	700,200	720,874	8,787,514
1876	809,162	786,480	787,090	8,968,906
1877	1,269,326	1,173,420	1,256,058	13,135,475
1878	1,369,797	1,348,950	1,318,678	15,163,462
1879	1,836,378	1,710,480	1,769,356	19,685,176
1880	2,385,636	2,274,420	2,238,634	26,027,631
1881	2,329,171	2,266,830	2,480,000	27,376,509
1882	2,297,658	2,192,940	1,897,510	30,053,500
1883	2,076,659	1,958,340	1,988,526	23,128,389
1884	1,961,866	1,811,700	1,822,614	23,772,209
1885	1,874,105	1,761,660	1,898,657	20,776,041
1886	2,408,111	2,222,790	2,181,625	25,798,000
1887	1,843,291	1,125,450	1,288,602	*a* 21,478,883
1888	1,304,518	1,442,405	1,582,741	16,488,668
1889	1,959,169	1,913,871	2,055,247	21,487,435
1890	2,750,698	2,575,941	2,626,035	*b* 29,130,910
1891	3,575,911	3,834,262	3,578,460	33,009,236
1892	2,072,022	1,950,553	1,937,986	28,422,377
1893	1,616,391	1,533,555	1,616,143	20,314,513
1894	1,640,982	1,527,752	1,598,282	19,019,990
1895	1,621,216	1,594,773	1,692,012	19,144,390
1896	1,746,257	1,642,846	1,744,257	20,584,421

a Not including 877,310 barrels dump oil and oil shipped by private lines.
b Pipe-line runs.

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In the following table is given a statement of the average daily production of crude petroleum in the Pennsylvania and New York oil fields for each month from 1871 to 1896. We desire to repeat that this table is not the same as the daily average receipts published by the pipe lines, but the daily average production, the total production including some oil that is not reported in the daily returns of the pipe lines. The averages are obtained by dividing the product of each month, in the table given elsewhere, by the number of days in each month, and the production of the year by 365 or 366, as the case may be.

Average daily product of crude petroleum in the Pennsylvania and New York oil fields each month for the years 1871–1896, by months and years.

[Barrels.]

Year.	January.	February.	March.	April.	May.	June.
1871.....	13,497	13,306	12,914	12,866	13,187	13,678
1872.....	18,825	15,965	14,890	15,403	17,326	16,371
1873.....	20,407	21,725	21,461	21,384	25,044	26,449
1874.....	37,653	29,839	28,598	25,958	28,895	30,725
1875.....	27,489	25,708	25,469	22,502	22,468	23,207
1876.....	22,975	23,065	23,167	23,383	23,721	24,120
1877.....	27,190	27,979	29,087	32,427	36,374	37,693
1878.....	38,816	39,102	38,980	39,863	40,802	40,575
1879.....	44,191	43,515	48,365	51,015	53,062	55,855
1880.....	61,423	64,552	65,032	67,190	71,901	71,948
1881.....	72,390	68,326	73,372	73,526	77,203	79,262
1882.....	75,921	76,119	80,070	80,093	80,212	94,198
1883.....	62,849	62,721	59,054	60,551	63,292	65,930
1884.....	58,898	64,850	66,202	68,862	76,834	62,073
1885.....	53,296	51,353	52,843	59,343	59,141	58,907
1886.....	56,418	57,316	62,208	64,612	70,283	77,846
1887.....	64,221	65,283	64,716	65,372	64,307	63,762
1888.....	37,228	44,508	43,190	44,980	47,528	48,357
1889.....	49,768	47,589	52,537	54,531	58,767	60,382
1890.....	68,008	73,408	74,619	77,629	76,722	79,000
1891.....	91,293	81,690	76,129	77,917	73,828	77,233
1892.....	89,888	93,230	85,724	85,827	80,163	81,312
1893.....	55,610	59,701	61,302	56,076	56,505	59,361
1894.....	50,949	51,152	53,632	51,250	52,521	55,465
1895.....	50,669	47,083	51,093	55,215	52,607	52,531
1896.....	53,173	52,338	52,653	61,419	56,325	59,470

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Average daily product of crude petroleum in the Pennsylvania and New York oil fields each month for the years 1871–1896, by months and years—Continued.

[Barrels.]

Year.	July.	August.	September.	October.	November.	December.	Yearly average.
1871	14,725	14,922	15,398	15,653	15,487	15,418	14,261
1872	16,702	17,739	16,681	14,272	21,287	20,825	17,194
1873	27,983	30,198	31,809	30,403	33,049	34,980	27,106
1874	33,337	30,049	28,021	29,669	28,702	27,682	29,937
1875	25,431	23,186	23,298	23,583	23,340	23,254	24,075
1876	24,633	25,233	26,020	26,102	26,216	25,390	24,505
1877	38,335	41,089	40,497	40,946	39,114	40,518	35,988
1878	41,415	43,288	43,857	44,187	44,965	42,538	41,544
1879	56,057	61,042	61,890	59,238	57,016	57,076	54,206
1880	72,530	75,517	78,210	76,956	75,814	72,214	71,114
1881	76,538	75,217	73,114	74,941	75,561	80,000	75,004
1882	105,102	100,145	87,346	74,118	73,098	61,210	82,338
1883	65,174	60,627	63,779	66,989	65,278	64,146	63,365
1884	66,450	67,715	64,942	63,286	60,390	58,794	65,129
1885	57,284	55,031	57,093	60,455	58,722	61,247	56,921
1886	78,031	78,426	80,618	77,681	74,093	70,375	70,679
1887	61,275	59,641	59,321	61,822	37,515	41,568	58,846
1888	44,995	44,661	42,436	43,694	48,080	51,057	45,058
1889	63,037	63,362	62,254	63,199	63,796	66,298	58,869
1890	81,426	81,128	86,165	88,732	85,865	84,710	79,810
1891	73,842	79,787	94,585	115,352	127,809	115,434	90,436
1892	76,158	75,116	70,850	66,839	65,018	62,516	77,657
1893	55,487	54,569	53,801	52,142	51,119	52,133	55,656
1894	52,412	52,007	50,404	52,935	50,925	51,557	52,110
1895	52,450	54,244	53,023	52,299	53,159	54,581	52,450
1896	59,799	55,688	56,661	56,331	54,762	56,266	56,241

NOTE.—Yearly average is the total product divided by the number of days in the year, not an average of monthly averages.

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SHIPMENTS OF PETROLEUM FROM PENNSYLVANIA AND NEW YORK.

The following table gives a statement of the number of barrels of crude petroleum, or, in the early history of the oil field, refined petroleum reduced to its equivalent, shipped out of the New York and Pennsylvania oil regions, either by pipe lines, river, or railway, from 1871 to 1888, inclusive. In some years, especially in the earlier ones covered by this table, a considerable portion of the oil was shipped as refined. When the tables were prepared for these years, the oil shipped was reduced to its equivalent in crude, a barrel of crude being regarded as yielding three-fourths of a barrel of refined, or a barrel of refined was regarded as being produced from 1⅓ barrels of crude. Since 1888 it has been found very difficult to separate all of the oil shipped from West Virginia and eastern Ohio from the shipments from New York and Pennsylvania. The shipments since 1888 by months in the Appalachian oil field are given under that head in a preceding table.

Shipments of crude and refined petroleum, reduced to crude equivalent, out of the Pennsylvania and New York oil fields from 1871 to 1888, by months and years.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1871	437, 691	347, 718	383, 890	389, 147	587, 375
1872	476, 966	407, 606	276, 220	428, 512	510, 417
1873	573, 124	527, 440	668, 374	708, 191	768, 176
1874	843, 663	501, 220	518, 246	803, 409	899, 027
1875	453, 095	327, 776	693, 918	729, 581	681, 679
1876	677, 289	519, 193	623, 762	603, 037	646, 150
1877	743, 461	484, 904	913, 919	903, 526	1, 234, 324
1878	775, 791	774, 234	3, 741, 512	846, 632	960, 894
1879	663, 998	702, 729	973, 879	1, 136, 188	1, 331, 469
1880	1, 650, 409	1, 395, 151	1, 613, 371	842, 268	1, 095, 259
1881	1, 061, 617	915, 028	1, 276, 746	1, 348, 398	1, 563, 436
1882	1, 657, 067	1, 787, 909	1, 718, 956	1, 678, 134	1, 827, 356
1883	1, 357, 815	1, 250, 824	1, 641, 899	1, 908, 379	1, 995, 634
1884	1, 686, 961	1, 723, 261	1, 873, 890	1, 643, 336	1, 899, 329
1885	1, 804, 028	1, 895, 021	1, 887, 034	1, 823, 726	2, 097, 099
1886	1, 991, 561	2, 032, 794	2, 055, 750	2, 070, 468	2, 032, 672
1887	2, 312, 067	1, 995, 757	2, 332, 324	1, 938, 278	2, 328, 564
1888	2, 265, 109	2, 163, 957	1, 979, 753	1, 928, 435	1, 773, 994

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Shipments of crude and refined petroleum, reduced to crude equivalent, out of the Pennsylvania and New York oil fields from 1871 to 1888, by months and years—Continued.

[Barrels of 42 gallons.]

Year.	June.	July.	August.	September.
1871	501,754	541,137	528,134	551,075
1872	529,228	591,238	621,954	541,607
1873	696,414	814,449	864,768	952,955
1874	815,413	940,281	793,865	1,014,570
1875	745,986	904,537	882,089	1,109,392
1876	921,862	1,228,539	1,203,402	1,154,549
1877	1,391,124	1,096,951	1,425,943	1,563,797
1878	1,135,119	1,330,454	1,655,651	1,434,225
1879	1,369,314	1,625,035	1,808,239	1,627,120
1880	975,083	1,231,611	1,394,129	1,252,635
1881	1,729,697	1,925,532	2,214,877	2,131,950
1882	2,172,685	2,402,970	2,047,545	1,992,171
1883	1,747,789	1,634,407	2,086,478	2,325,574
1884	1,827,553	1,740,021	2,000,371	2,292,087
1885	2,034,025	1,961,152	2,049,099	2,116,659
1886	2,117,489	2,418,961	2,059,299	2,157,323
1887	2,165,439	2,000,173	2,220,768	2,342,227
1888	1,956,115	2,098,531	2,223,263	2,289,486

Year.	October.	November.	December.	Total.
1871	505,071	480,977	410,822	5,664,791
1872	607,468	477,945	430,786	5,899,947
1873	1,010,852	959,589	955,443	9,499,775
1874	543,341	546,117	602,348	8,821,500
1875	871,917	671,066	871,902	8,942,938
1876	524,190	871,496	1,190,983	10,164,452
1877	1,268,971	1,205,634	600,019	12,832,573
1878	1,747,390	1,281,410	992,688	13,676,000
1879	1,662,269	1,453,645	1,532,585	15,886,470
1880	1,665,933	1,226,030	1,335,613	15,677,492
1881	2,080,467	2,066,906	1,969,581	20,284,235
1882	2,089,428	1,404,640	1,121,453	21,900,314
1883	2,215.421	2,065,602	1,749,547	21,979,369
1884	2,510,283	2,078,261	2,382,244	23,657,597
1885	2,050,150	1,857,080	2,138,253	23,713,326
1886	2,441,848	2,724,796	2,550,891	26,653,852
1887	2,573,008	3,462,082	2,608,341	27,279,028
1888	1,558,115	2,503,491	2,397,782	25,138,031

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DRILLING WELLS IN THE PENNSYLVANIA AND NEW YORK OIL REGIONS.

In the following table will be found a statement of the number of drilling wells completed in each month from January, 1872, to the close of 1896, in Pennsylvania, New York, and West Virginia, by months and years:

Number of drilling wells completed in the Pennsylvania, New York, and northern West Virginia oil fields each month from 1872 to 1896.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1872 ..	37	120	89	121	135	84	128	118	82	100	64	105	1,183
1873 ..	93	94	100	105	102	130	114	120	106	101	100	98	1,263
1874 ..	102	104	110	113	109	101	121	107	104	120	106	120	1,317
1875 ..	190	187	195	186	172	190	200	210	201	220	217	230	2,398
1876 ..	240	231	242	200	202	261	248	270	209	273	272	272	2,920
1877 ..	281	241	291	269	320	403	317	255	322	467	391	382	3,929
1878 ..	274	226	211	409	470	269	203	186	174	229	248	165	3,064
1879 ..	136	132	238	270	402	330	327	283	210	232	227	261	3,048
1880 ..	320	230	367	500	426	310	338	368	356	364	336	302	4,217
1881 ..	222	220	271	316	406	374	336	332	312	322	363	406	3,880
1882 ..	347	340	385	432	469	340	185	253	164	117	150	122	3,304
1883 ..	125	126	142	209	231	228	261	309	321	321	302	272	2,847
1884 ..	229	227	256	298	311	244	268	145	89	59	73	66	2,265
1885 ..	64	62	82	116	213	242	217	283	356	397	384	345	2,761
1886 ..	270	280	291	328	343	365	357	313	253	272	221	185	3,478
1887 ..	158	162	138	160	148	162	159	142	134	100	101	96	1,660
1888 ..	57	52	56	49	56	97	82	96	132	229	307	302	1,515
1889 ..	284	288	353	401	431	537	549	508	478	559	540	471	a5,435
1890 ..	553	482	522	556	534	571	555	579	571	567	520	348	6,358
1891 ..	310	243	275	288	314	304	334	333	281	237	245	197	3,361
1892 ..	175	171	137	167	170	154	174	141	142	158	160	143	1,892
1893 ..	125	84	130	127	172	213	193	145	158	139	137	167	1,790
1894 ..	180	170	202	261	307	349	319	341	362	373	368	316	3,548
1895 ..	271	195	324	425	601	754	772	766	735	686	613	534	6,676
1896 ..	537	514	499	569	658	744	673	589	594	581	622	625	7,205

a Includes 36 wells drilled in Franklin district, data for which by months were not obtainable.

The drilling wells were much more evenly distributed throughout the year during 1896 than during 1895.

WEST VIRGINIA.

The developments in this State for 1896 have been fully described under the head of the extension of the Appalachian region. As there noted, the increase in crude oil was 23.39 per cent. The total product of natural lubricating oil, so far as it could be ascertained, was 13,804 barrels, of which 13,228 barrels were from the Volcano and 576 from the Petroleum district. The exact amount of light oil produced in these districts was not obtained, but is included with the total product for the State. The price averaged $1.18 in 1896, as compared to $1.36 in 1895.

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The production of crude petroleum in West Virginia, by months, from 1890 to 1896 is shown in the following table:

Total production of crude petroleum in West Virginia, by months, from 1890 to 1896.

Month	1890.	1891.	1892.	1893.	1894.	1895.	1896.
January	38,644	48,902	195,512	577,933	838,400	647,220	757,574
February	38,061	123,841	186,455	468,794	684,532	541,511	729,229
March	44,842	229,966	185,468	630,877	754,398	642,222	785,261
April	39,804	226,020	181,708	594,190	688,458	646,862	799,509
May	39,160	232,076	206,142	705,714	742,701	670,330	855,699
June	35,610	223,734	261,900	682,040	699,498	621,733	853,224
July	34,096	221,127	328,485	724,494	767,728	742,326	843,872
August	31,505	238,451	411,114	843,706	717,844	734,517	874,595
September	50,342	219,528	420,882	847,558	674,791	717,170	876,308
October	46,387	220,076	451,157	792,719	694,187	713,138	884,716
November	45,062	207,477	467,446	757,170	654,887	721,411	851,488
December	49,065	215,020	513,817	820,217	660,200	721,685	908,295
Total	492,578	2,406,218	3,810,086	8,445,412	8,577,624	8,120,125	10,019,770

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In the following table is given the production of petroleum in West Virginia in the years 1894, 1895, and 1896; by districts:

Total amount and value of petroleum produced in West Virginia in 1894, 1895, and 1896.

District.	1894.								
	Illuminating.			Lubricating.			Total.		
	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.
	Barrels.			*Barrels.*			*Barrels.*		
West Virginia	8,553,046	$7,173,867	$0.83⅞	.....	.....	.....	8,553,046	$7,173,867	$0.83⅞
Volcano	2,560	2,176	.85	12,000	$36,000	$3.00	14,560	38,176	2.62
Petroleum	8,348	6,751	.80⅞	1,670	2,923	1.75	10,018	9,674	.96½
Total	8,563,954	7,182,794	.83⅞	13,670	38,923	2.85	8,577,624	7,221,717	.84

District.	1895.								
	Illuminating.			Lubricating.			Total.		
	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.
	Barrels.			*Barrels.*			*Barrels.*		
West Virginia	8,105,341	$11,013,132	$1.35⅞	.....	.....	.....	8,105,341	$11,013,132	$1.35⅞
Volcano	260	338	1.30	9,910	$19,820	$2.00	10,170	20,158	1.98
Petroleum	4,181	4,181	1.00	433	1,299	3.00	4,614	5,480	1.19
Total	8,109,782	11,017,651	1.35⅞	10,343	21,119	2.04	8,120,125	11,038,770	1.36

The production of crude petroleum in West Virginia, by months, from 1890 to 1896 is shown in the following table:

Total production of crude petroleum in West Virginia, by months, from 1890 to 1896.

Month	1890.	1891.	1892.	1893.	1894.	1895.	1896.
January	38,644	48,902	195,512	577,933	838,400	647,220	757,574
February	38,061	123,841	186,455	468,794	684,532	541,511	729,229
March	44,842	229,966	185,468	630,877	754,398	642,222	785,261
April	39,804	226,020	181,708	594,190	688,458	646,862	799,509
May	39,160	232,076	206,142	705,714	742,701	670,330	855,699
June	35,610	223,734	261,900	682,040	699,498	621,733	853,224
July	34,096	221,127	328,485	724,494	767,728	742,326	843,872
August	31,505	238,451	411,114	843,706	717,844	734,517	874,595
September	50,342	219,528	420,882	847,558	674,791	717,170	876,308
October	46,387	220,076	451,157	792,719	694,187	713,138	884,716
November	45,062	207,477	467,446	757,170	654,887	721,411	851,488
December	49,065	215,020	513,817	820,217	660,200	721,685	908,295
Total	492,578	2,406,218	3,810,086	8,445,412	8,577,624	8,120,125	10,019,770

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In the following table is given the production of petroleum in West Virginia in the years 1894, 1895, and 1896; by districts:

Total amount and value of petroleum produced in West Virginia in 1894, 1895, and 1896.

District.	1894.								
	Illuminating.			Lubricating.			Total.		
	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.
	Barrels.			*Barrels.*			*Barrels.*		
West Virginia	8,553,046	$7,173,867	$0.83⅞	.....	.....	.....	8,553,046	$7,173,867	$0.83⅞
Volcano	2,560	2,176	.85	12,000	$36,000	$3.00	14,560	38,176	2.62
Petroleum	8,348	6,751	.80⅞	1,670	2,923	1.75	10,018	9,674	.96½
Total	8,563,954	7,182,794	.83$_{10}^{9}$	13,670	38,923	2.85	8,577,624	7,221,717	.84

District.	1895.								
	Illuminating.			Lubricating.			Total.		
	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.
	Barrels.			*Barrels.*			*Barrels.*		
West Virginia	8,105,341	$11,013,132	$1.35⅞	.....	.....	.....	8,105,341	$11,013,132	$1.35⅞
Volcano	260	338	1.30	9,910	$19,820	$2.00	10,170	20,158	1.98
Petroleum	4,181	4,181	1.00	433	1,299	3.00	4,614	5,480	1.19
Total	8,109,782	11,017,651	1.35$_{7}^{1}$	10,343	21,119	2.04	8,120,125	11,038,770	1.36

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Total amount and value of petroleum produced in West Virginia in 1894, 1895, and 1896—Continued.

District.	1896.								
	Illuminating.			Lubricating.			Total.		
	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.	Production.	Value.	Price per barrel.
	Barrels.			*Barrels.*			*Barrels.*		
West Virginia *a*	10,005,966	$11,794,532	$1.17⅞	.....	.....	.....	10,005,966	$11,794,532	$1.17⅞
Volcano	.....	.....	.....	13,228	$33,070	$2.50	13,228	33,070	2.50
Petroleum	.....	.....	.....	576	2,016	3.50	576	2,016	3.50
Total	10,005,966	11,794,532	1.17⅞	13,804	35,086	2.54	10,019,770	11,829,618	1.18

a Includes illuminating oil produced in Volcano and Petroleum.

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In the following table is given the production of oil in West Virginia from the beginning of operations, so far as obtainable:

Production of petroleum in West Virginia.

Year.	Barrels.	Year.	Barrels.
Previous to 1876.....	3,000,000	1887.....	145,000
1876.....	120,000	1888.....	119,448
1877.....	172,000	1889.....	544,113
1878.....	180,000	1890.....	492,578
1879.....	180,000	1891.....	2,406,218
1880.....	179,000	1892.....	3,810,086
1881.....	151,000	1893.....	8,445,412
1882.....	128,000	1894.....	8,577,624
1883.....	126,000	1895.....	8,120,125
1884.....	90,000	1896.....	10,019,770
1885.....	91,000	Total	47,199,374
1886.....	102,000		

THE LIMA FIELD OF OHIO AND INDIANA.

The total production of the Lima oil field in 1896 was 25,255,870 barrels, as compared with 20,236,741 barrels in 1895, showing an increase of 5,019,129 barrels, or about 25 per cent. Nearly all of this increase came from Ohio.

OHIO.

The oil-producing territory of Ohio can be divided into four fields or districts. These districts, named in the order of their importance as producers, are (1) Lima, (2) Eastern or Southern Ohio, (3) Mecca, and (4) Belden. As the production from the latter two districts is quite small, for statistical purposes they are united, and known as the Mecca-Belden districts. The production of the Mecca-Belden field in 1896 was only 666 barrels.

The total amount of crude petroleum produced in Ohio in 1896, as will be seen from the following tables, was 23,941,169 barrels. Of this amount 20,575,138 barrels came from the Lima field and 3,365,365 barrels from the eastern or southern field, as compared with 19,545,233 barrels in 1895, of which amount 15,850,609 barrels were produced in the Lima field and 3,693,248 barrels in the Eastern or Southern Ohio field. This represents a gain in the Lima field of 4,724,529 barrels in 1896, or nearly 30 per cent. This gain was not due to the finding of any new fields, but to the widening and extension of a number of the producing pools, as well as the development of more productive territory. There was a large amount of new work done in Seneca County,

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238 wells having been drilled during the year, which gave an initial daily production of 412 barrels.

The total number of wells drilled in 1896 was 4,458, as compared with 4,489 in 1895, showing 31 more wells drilled in 1895 than in 1896.

The production of crude petroleum in eastern or southern Ohio in 1896 was 327,883 barrels less than in 1895, showing a decrease of nearly 9 per cent in 1896.

The total value of the crude petroleum produced in Ohio in 1896 was $17,693,438, as compared with $16,399,242 in 1895.

The average price of Lima oil for 1896 was 66.7 cents, as compared to 71.7 cents in 1895, being 5 cents lower. The average price per barrel for eastern or southern Ohio oil declined from $1.36 in 1895 to $1.18 in 1896, while the value of Mecca-Belden oil declined from $5.98 per barrel in 1895, to $4.35 per barrel in 1896. The average price per barrel for all oil produced in the State in 1896 was 73.9 cents, as compared with 83.9 cents in 1895.

The Lima oil pools in this State, with their structural sections, have been very fully described in the previous reports. The Eastern or Southern Ohio field is discussed under the head of the Appalachian field, of which it is a part.

The total amount and value of crude petroleum produced in Ohio in 1895 and 1896 is shown in the following table:

Total amount and value of crude petroleum produced in Ohio in 1895 and 1896.

District.	1895.			1896.		
	Total production.	Total value.	Price per barrel.	Total production.	Total value.	Price per barrel.
	Barrels.			*Barrels.*		
Lima	15,850,609	$11,372,812	$0.71¼	20,575,138	$13,723,617	.667
Eastern	3,693,248	5,018,201	1.35⅞	3,365,365	3,966,924	1.17⅞
Mecca-Belden	1,376	8,229	5.98	666	2,897	4.35
Total	19,545,233	16,399,242	.839	23,941,169	17,693,438	.739

In the following tables will be found statements of the total production of crude petroleum in Ohio in 1896, by months and districts. In determining the total by months, an average production for each month in the Mecca-Belden district has been assumed.

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Total production of crude petroleum in Ohio in 1896, by months and districts.

[Barrels of 42 gallons.]

Month.	Lima.	Southern Ohio.	Mecca-Belden.	Total.
January	1,635,925	321,895	.....	1,957,875
February	1,523,866	281,776	.....	1,805,698
March	1,673,595	293,538	.....	1,967,188
April	1,697,848	291,358	.....	1,989,262
May	1,775,858	286,669	.....	2,062,582
June	1,822,817	278,634	.....	2,101,507
July	1,843,477	274,317	.....	2,117,849
August	1,789,341	270,135	.....	2,059,532
September	1,739,122	255,326	.....	1,994,503
October	1,770,493	270,752	.....	2,041,301
November	1,612,298	251,367	.....	1,863,720
December	1,690,498	289,598	.....	1,980,152
Total	20,575,138	3,365,365	666	23,941,169

The total amount and value of crude petroleum produced in Ohio from 1889 to 1896, inclusive, by districts, is shown in the following table:

Total amount and value of crude petroleum produced in Ohio from 1889 to 1896.

Year.	Lima district.		Southern Ohio district.	
	Production.	Value.	Production.	Value.
	Barrels.		*Barrels.*	
1889	12,153,189	$1,822,978	317,037	$340,683
1890	15,014,882	4,504,465	1,108.334	1,127,730
1891	17,315,978	5,281,373	422,883	283,332
1892	15,169,507	5,555,832	1,190,302	662,106
1893	13,646,804	6,448,115	2,601,394	1,664,892
1894	13,607,844	6,531,765	3,183,370	2,670,052
1895	15,850,609	11,372,812	3,693,248	5,018,201
1896	20,575,138	13,723,617	3,365,365	3,966,924

Year.	Mecca-Belden district.		Total.	
	Production.	Value.	Production.	Value.
	Barrels.		*Barrels.*	
1889	1,240	$10,334	12,471,466	$2,173,995
1890	1,440	12,000	16,124,656	5,644,195
1891	1,440	12,000	17,740,301	5,576,705
1892	3,112	21,101	16,362,921	6,239,039
1893	1,571	11,335	16,249,769	8,124,342
1894	940	4,476	16,792,154	9.206,293
1895	1,376	8,229	19,545,233	16,399,242
1896	666	2,897	23,941,169	17,693,438

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In the following table is given the total production of crude petroleum in Ohio for the years 1888 to 1896, by months:

Total productions of crude petroleum in Ohio from 1888 to 1896, by months.

[Barrels.]

Year.	January.	February.	March.	April.	May.
1888	444,804	507,686	612,830	656,186	774,267
1889	1,041,655	944,506	1,016,278	1,029,780	1,115,703
1890	948,780	929,810	1,008,933	1,101,773	1,223,241
1891	1,561,039	1,396,474	1,484,045	1,500,142	1,475,339
1892	1,124,194	1,160,634	1,242,936	1,173,952	1,216,416
1893	1,227,363	1,195,698	1,399,648	1,289,982	1,384,090
1894	1,326,282	1,187,891	1,431,894	1,368,268	1,486,678
1895	1,286,468	1,123,784	1,387,882	1,480,228	1,572,718
1896	1,957,875	1,805,698	1,967,188	1,989,262	2,062,582

Year.	June.	July.	August.	September.
1888	889,066	939,287	1,022,009	1,005,422
1889	1,074,384	1,052,430	1,075,008	1,060,982
1890	1,274,209	1,472,974	1,544,291	1,700,227
1891	1,516,362	1,545,298	1,538,210	1,523,826
1892	1,266,712	1,370,135	1,572,657	1,574,336
1893	1,419,758	1,444,572	1,480,285	1,402,213
1894	1,439,144	1,398,304	1,487,528	1,369,409
1895	1,590,936	1,779,452	1,877,470	1,904,985
1896	2,101,507	2,117,849	2,059,532	1,994,503

Year.	October.	November.	December.	Total.
1888	1,064,688	1,017,362	1,077,261	10,010,868
1889	1,048,448	1,030,795	981,497	12,471,466
1890	1,798,413	1,608,883	1,513,122	16,124,656
1891	1,527,490	1,299,737	1,372,339	17,740,301
1892	1,586,173	1,517,198	1,557,578	16,362,921
1893	1,397,125	1,306,883	1,302,152	16,249,769
1894	1,469,457	1,424,926	1,402,373	16,792,154
1895	1,963,297	1,840,501	1,737,512	19,545,233
1896	2,041,301	1,863,720	1,980,152	23,941,169

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The following table gives the production of petroleum in Ohio from the beginning of operations in that State to the close of 1896:

Production of petroleum in Ohio.

Year.	Barrels.	Year.	Barrels.
Previous to 1876	200,000	1886	1,782,970
1876	31,763	1887	5,022,632
1877	29,888	1888	10,010,868
1878	38,179	1889	12,471,466
1879	29,112	1890	16,124,656
1880	38,940	1891	17,740,301
1881	33,867	1892	16,362,921
1882	39,761	1893	16,249,769
1883	47,632	1894	16,792,154
1884	90,181	1895	19,545,233
1885	661,580	1896	23,941,169

LIMA DISTRICT.

In the following table is given the production of petroleum in the Lima (Ohio) oil field from 1886 to 1896. It will be seen that the production for 1896 is the largest in the history of the fields, being 4,724,529 barrels greater than in 1895 and 3,259,160 barrels greater than in 1891, when the largest production heretofore was recorded. The increase over 1895 is 29.8 per cent.

Production of petroleum in the Lima (Ohio) district from 1886 to 1896.

Year.	Barrels.	Year.	Barrels.
1886	1,064,025	1892	15,169,507
1887	4,650,375	1893	13,646,804
1888	9,682,683	1894	13,607,844
1889	12,153,189	1895	15,850,609
1890	15,014,882	1896	20,575,138
1891	17,315,978		

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In the following table is found the production of petroleum in the Lima (Ohio) field from 1887 to 1896, by months, so far as the same was obtainable:

Production of petroleum in the Lima (Ohio) field from 1887 to 1896.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1887	131,011	206,026	303,084	352,798	449,062
1888	422,125	479,824	586,781	629,932	745,896
1889	1,016,697	921,185	989,793	1,004,969	1,090,638
1890	911,947	888,978	955,620	1,040,924	1,142,954
1891	1,471,858	1,355,734	1,455,628	1,470,661	1,446,284
1892	1,090,173	1,127,481	1,200,305	1,128,253	1,165,750
1893	1,037,358	985,620	1,161,384	1,072,850	1,179,808
1894	1,116,979	974,091	1,177,837	1,099,453	1,203,229
1895	1,034,489	900,530	1,111,346	1,194,799	1,287,167
1896	1,635,925	1,523,866	1,673,595	1,697,848	1,775,858

Year.	June.	July.	August.	September.
1887	474,535	389,997	490,862	465,743
1888	862,106	905,218	995,938	979,943
1889	1,050,269	1,029,707	1,050,152	1,038,072
1890	1,175,821	1,354,672	1,411,998	1,559,473
1891	1,491,228	1,514,607	1,509,262	1,492,115
1892	1,210,523	1,300,197	1,461,020	1,422,534
1893	1,213,521	1,231,010	1,258,289	1,181,493
1894	1,165,190	1,131,081	1,212,090	1,090,626
1895	1,300,058	1,474,115	1,540,149	1,527,085
1896	1,822,817	1,843,477	1,789,341	1,739,122

Year.	October.	November.	December.	Total.
1887	444,941	458,612	483,704	4,650,375
1888	1,036,712	988,997	1,049,211	9,682,683
1889	1,019,961	997,825	943,921	12,153,189
1890	1,660,069	1,495,099	1,417,327	15,014,882
1891	1,499,834	1,271,189	1,337,578	17,315,978
1892	1,379,909	1,328,548	1,354,814	15,169,507
1893	1,154,641	1,084,324	1,086,506	13,646,804
1894	1,165,938	1,146,686	1,124,644	13,607,844
1895	1,579,693	1,494,985	1,406,193	15,850,609
1896	1,770,493	1,612,298	1,690,498	20,575,138

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PIPE-LINE RUNS IN THE LIMA-INDIANA FIELD.

There are no statements of the pipe-line runs and shipments in the Lima-Indiana field that distinguish between oil produced in Ohio and that produced in Indiana. Therefore the following statement of pipe-line runs and shipments, which are those of the Buckeye Pipe Line Company, will include reports for both Ohio and Indiana. As has been so often stated in this report, pipe-line runs are not production. This is especially true of the Lima-Indiana field. The production of petroleum in the Lima-Indiana field, distributed between the States, is quite accurately given in our statement of production:

Pipe-line runs, Lima-Indiana field, from 1887 to 1896.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1887	164,474	207,026	303,084	352,798	449,062
1888	359,860	428,008	534,588	587,043	705,045
1889	973,980	800,828	830,559	845,377	932,067
1890	683,750	622,799	676,175	842,416	887,590
1891	1,241,154	1,147,947	1,255,611	1,202,583	1,191,147
1892	971,607	1,008,069	1,083,801	1,042,087	1,064,478
1893	1,049,778	974,944	1,163,641	1,074,290	1,187,939
1894	1,265,267	1,106,493	1,353,591	1,295,619	1,424,182
1895	1,213,841	1,029,385	1,291,355	1,405,424	1,540,972
1896	1,739,291	1,631,939	1,795,745	1,859,882	1,945,979

Year.	June.	July.	August.	September.	October.
1887	474,535	389,997	490,162	465,743	444,941
1888	774,710	896,034	975,235	868,826	939,468
1889	813,844	805,744	968,449	875,201	850,077
1890	916,289	1,105,885	1,149,877	1,289,577	1,342,158
1891	1,207,884	1,236,291	1,240,841	1,252,375	1,257,986
1892	1,099,145	1,190,015	1,346,949	1,232,385	1,264,536
1893	1,245,880	1,289,991	1.390,894	1,315,933	1,302,295
1894	1,402,417	1,366,310	1,469,372	1,325,352	1,405,042
1895	1,541,221	1,713,937	1,752,150	1,778,653	1,822,002
1896	2,026,387	2,016,564	1,953,876	1,883,814	1,896,033

Year.	November.	December.	Total.	Average.
1887	458,613	483,704	4,684,139	390,345
1888	891,999	938,188	8,899,004	741,584
1889	774,073	755,553	10,255,752	854,646
1890	1,215,960	1,186,434	11,918,910	993,243
1891	1,070,131	1,211,820	14,515,770	1,209,648
1892	1,209,953	1,244,712	13,657,737	1,138,145
1893	1,230,658	1,224,952	14,451,195	1,204,266
1894	1,334,334	1,326,371	16,074,350	1,339,529
1895	1,705,506	1,621,184	18,415,630	1,534,636
1896	1,681,715	1,778,786	22,210,011	1,850,834

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SHIPMENTS FROM THE LIMA-INDIANA FIELD.

In the following table is given a statement of the shipments of crude petroleum from the Lima-Indiana field, from 1887 to 1896, by months and years, as reported by the Buckeye Pipe Line Company. Here it should be again remarked that pipe-line shipments and consumption are not the same:

Shipments of crude petroleum from the Lima-Indiana field from 1887 to 1896.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1887	.....	10,957	32,613	77,900	101,306
1888	81,569	207,040	243,964	210,725	159,620
1889	367,524	862,807	391,026	340,889	309,238
1890	156,085	111,604	123,125	115,223	169,662
1891	968,887	837,928	330,448	336,854	1,078,489
1892	1,355,362	1,346,541	1,532,606	1,512,358	1,427,753
1893	1,306,612	1,270,595	1,390,646	1,205,748	1,321,782
1894	1,199,752	1,109,110	1,247,295	1,210,391	1,150,298
1895	1,473,730	1,289,686	1,409,761	1,206,172	1,212,061
1896	1,802,361	1,593,328	1,618,117	1,546,888	1,574,627

Year.	June.	July.	August.	September.	October.
1887	104,440	174,824	20,019	30,944	43,168
1888	179,192	227,707	401,175	301,316	370,378
1889	352,886	361,694	464,325	626,207	715,386
1890	700,422	874,121	846,360	813,817	723,725
1891	923,605	997,681	1,166,054	1,260,598	1,408,343
1892	1,492,543	1,389,501	1,342,949	1,125,335	1,315,994
1893	1,235,843	1,152,374	1,040,860	1,038,819	1,196,018
1894	1,303,957	1,023,316	1,238,183	1,023,232	1,198,801
1895	1,279,618	1,302,596	1,298,502	1,452,640	1,507,992
1896	1,667,914	1,617,519	1,745,657	1,702,721	1,704,065

Year.	November.	December.	Total.	Average.
1887	78,827	76,327	751,325	68,302
1888	287,934	382,448	3,053,068	254,422
1889	759,702	750,244	5,801,928	483,494
1890	657,614	907,548	6,199,306	516,609
1891	1,391,400	1,454,578	12,154,865	1,012,905
1892	1,323,204	1,340,734	16,504,880	1,375,407
1893	1,262,130	1,230,216	14,651,643	1,220,970
1894	1,285,861	1,463,566	14,453,762	1,204,480
1895	1,587,449	1,810,159	16,830,366	1,402,531
1896	1,720,720	1,727,549	20,021,466	1,668,456

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STOCKS OF CRUDE PETROLEUM IN THE LIMA-INDIANA FIELD.

In the following table is given a statement of the stocks of crude petroleum in the Lima-Indiana field at the close of each month from 1887 to 1896, as reported by the Buckeye Pipe Line Company:

Total stocks of crude petroleum in the Lima-Indiana field at the close of each month from 1887 to 1896.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.
1887	.....	847,817	1,118,288	1,393,186	1,740,942
1888	4,367,355	4,588,323	4,949,446	5,367,401	5,980,283
1889	10,415,880	10,852,202	11,288,793	11,792,707	12,413,137
1890	14,104,018	14,180,090	14,241,340	14,153,259	14,298,966
1891	21,233,645	21,537,789	21,957,948	22,319,191	22,424,364
1892	21,692,318	21,350,912	20,896,185	20,425,914	20,062,639
1893	18,355,492	18,059,846	17,877,265	17,747,249	17,616,527
1894	18,565,823	18,566,158	18,675,275	18,763,242	19,041,624
1895	19,898,378	19,642,870	19,524,463	19,723,715	20,052,627
1896	21,431,778	21,473,447	21,651,075	21,964,069	22,335,420

Year.	June.	July.	August.	September.
1887	2,111,037	2,326,211	2,632,828	2,957,900
1888	6,593,165	7,282,088	7,852,705	8,392,493
1889	12,902,628	13,344,795	13,846,765	14,092,706
1890	14,513,553	14,744,004	19,086,736	19,843,950
1891	22,704,034	22,930,048	22,993,496	22,975,470
1892	19,668,894	19,467,900	19,505,399	19,150,058
1893	17,642,117	17,779,733	18,129,767	18,408,814
1894	19,142,598	19,504,651	19,736,628	20,040,748
1895	20,314,230	20,725,571	21,179,219	21,351,757
1896	22,693,894	23,094,851	23,304,312	23,091,525

Year.	October.	November.	December.	Average.
1887	3,359,674	3,739,459	4,148,469	2,397,801
1888	8,920,086	9,499,482	9,810,714	6,966,962
1889	14,224,747	14,554,662	14,105,149	12,819,514
1890	20,442,065	20,967,258	20,971,395	16,795,553
1891	22,722,465	22,375,030	22,103,705	22,456,438
1892	18,800,715	18,687,464	18,604,442	19,859,403
1893	18,527,901	18,499,669	18,497,340	18,095,143
1894	20,246,989	20,295,461	20,158,266	19,394,788
1895	21,565,766	21,683,823	21,494,848	20,596,439
1896	23,290,538	23,251,533	23,502,770	22,573,768

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PRICES OF CRUDE PETROLEUM IN THE LIMA-INDIANA FIELD.

In the following table is given the average monthly prices of Lima (Ohio) and Indiana crude petroleum, per barrel of 42 gallons each, in the year 1896:

Average monthly prices of Ohio and Indiana crude petroleum, per barrel of 42 gallons, in 1896.

1896.	North Lima.	South Lima.	Indiana.
	Cents.	*Cents.*	*Cents.*
January	89	79	76
February	87	77	77
March	83	75	75
April	75	66	66
May	68	63	63
June	64	59	59
July	61	56	56
August	59	54	54
September	61	56	56
October	64	59	59
November	65	60	60
December	62	57	57
Average	70	63.4	63
Average of North and South Lima	66.7		

In the following table are given the fluctuations in prices for the various grades of Lima oil in 1896. The dates are those on which changes in prices were made:

Fluctuation in prices of Lima (Ohio) and Indiana crude petroleum in 1896.

Date.	North Lima.	South Lima.	Indiana.
January 1	$0.90	$0.80	$0.75
January 22	.88	.78	.78
February 20	.85	.75	.75
March 14	.87	.77	.77
March 25	.85	.75	.75
March 26	.83	.73	.73
March 27	.80	.70	.70
April 7	.77	.67	.67
April 10	.74	.64	.64
April 18	.72	.65	.65
April 24	.72	.67	.67
May 11	.70	.65	.65
May 14	.68	.63	.63
May 18	.65	.60	.60
May 26	.64	.59	.59
June 2	.63	.58	.58

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Fluctuation in prices of Lima (Ohio) and Indiana crude petroleum in 1896—Continued.

Date.	North Lima.	South Lima.	Indiana.
June 11	.64	.59	.59
June 12	.65	.60	.60
July 13	.64	.59	.59
July 14	.63	.58	.58
July 15	.60	.55	.55
July 16	.57	.52	.52
July 23	.58	.53	.53
July 27	.59	.54	.54
August 27	.60	.55	.55
September 23	.62	.57	.57
September 25	.64	.59	.59
October 27	.65	.60	.60
November 10	.66	.61	.61
November 19	.65	.60	.60
November 30	.63	.58	.58
December 16	.62	.57	.57
December 23	.61	.56	.56
December 28	.60	.55	.55

WELL RECORDS IN THE LIMA (OHIO) DISTRICT.

In the following tables will be found statements showing the well records in the Lima (Ohio) oil field from 1894 to 1896, inclusive:

Wells completed in the Lima (Ohio) district from 1894 to 1896, inclusive.

	Number.	Average per month.
Wells completed in 1894	2,472	206
Wells completed in 1895	4,489	374
Wells completed in 1896	4,458	371

The effect of the large number of wells drilled in the latter part of 1895 and in 1896 added about 30 per cent to the production of 1895.

The increase and decrease in the number of wells, by counties, is as follows:

Increase and decrease in the number of wells, by counties, in 1895 and 1896.

	Wells.
Allen County increased in 1896 over 1895	11
Hancock County increased in 1896 over 1895	186
Van Wert County increased in 1896 over 1895	19
Seneca County, first time reported in 1896	238
Miscellaneous increase in 1896	12
Auglaize County decreased in 1896 below 1895	174
Mercer County decreased in 1896 below 1895	126
Wood County decreased in 1896 below 1895	54
Sandusky County decreased in 1896 below 1895	143

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Total number of wells completed in the Lima (Ohio) district in 1896.

Month.	Allen.	Auglaize.	Hancock.	Sandusky.	Wood.	Mercer.	Van Wert.	Seneca.	Miscellaneous.	Total.
January ...	18	29	33	77	107	20	21	17	6	328
February ..	15	28	34	81	121	35	21	13	7	355
March	22	32	48	80	123	23	20	14	8	370
April	14	37	54	92	165	25	13	21	11	432
May	27	47	80	98	164	24	23	26	15	504
June	22	36	81	106	184	31	15	25	13	513
July	16	17	68	68	161	27	5	21	13	396
August.....	20	16	62	60	114	20	7	22	16	337
September .	9	24	62	57	130	13	7	27	17	346
October	11	11	51	48	100	17	9	17	15	279
November ..	22	15	55	39	112	10	6	21	19	299
December ..	30	16	51	45	111	16	2	14	14	299
Total ..	226	308	679	851	1,592	261	149	238	154	4,458

From the following table it will be seen that the average initial daily production for wells completed in 1896 was 85,003 barrels. Dividing this amount by 3,908, the number of productive wells completed (that is the total number of wells completed, 4,458, less 550 dry holes), we get 21.7 barrels per day, as compared to 90,384 barrels of initial daily production in 1895, 3,925 as the number of wells, and 23 barrels as the average initial daily production:

Initial daily production of wells completed in the Lima (Ohio) district in 1896.

[Barrels.]

Month.	Allen.	Auglaize.	Hancock.	Sandusky.	Wood.	Mercer.	Van Wert.	Seneca.	Miscellaneous.	Total
January....	117	605	745	1,305	1,619	515	395	280	70	5,651
February...	170	537	699	1,628	2,183	762	395	150	180	6,704
March.....	355	455	980	1,765	2,420	1,055	440	295	120	7,885
April.....	210	655	975	2,300	3,405	680	430	555	125	9,335
May.....	435	765	1,672	2,180	2,980	350	615	590	315	9,902
June.....	315	585	1,620	2,095	3,235	480	285	665	390	9,670
July	220	280	1,070	1,435	2,610	500	120	435	215	6,885
August.....	350	385	990	1,070	1,790	485	170	650	285	6,175
September .	150	735	1,060	950	1,730	185	90	525	215	5,640
October	140	195	1,330	885	1,860	215	170	225	335	5,355
November..	385	275	920	800	2,315	215	65	240	415	5,630
December ..	730	145	1,045	806	2,355	205	25	340	520	6,171
Average..	298	468	1,092	1,435	2,375	471	267	412	265	7,084

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It will be seen from the following table that of the 4,458 wells drilled in the Lima (Ohio) district in 1896, 550 were dry. In 1895, out of 4,489 wells drilled 564 were dry. In 1895 there were drilled 31 more wells and 14 more dry holes than were completed in 1896:

Total number of dry holes drilled in the Lima (Ohio) district in 1896.

Month.	Allen.	Auglaize.	Hancock.	Sandusky.	Wood.	Mercer.	Van Wert.	Seneca.	Miscellaneous.	Total.
January.....	9	3	2	5	15	4	4	0	1	43
February	5	3	7	5	9	6	3	2	4	44
March	6	7	8	8	15	7	3	1	2	57
April	4	9	6	3	11	1	1	0	4	39
May	6	12	7	4	14	4	4	0	4	55
June.....	3	6	17	8	19	4	4	0	2	63
July	3	1	9	1	25	5	0	2	1	47
August.....	3	0	12	0	11	3	1	1	4	35
September ...	0	4	13	3	22	2	2	1	5	52
October	2	4	7	2	7	2	1	1	0	26
November....	5	5	6	0	17	1	1	2	5	42
December	6	8	9	2	16	4	0	0	2	47
Total ..	52	62	103	41	181	43	24	10	34	550

The number of rigs building in 1896 shows a considerable falling off toward the close of the year, just the reverse of 1895, which increased toward the close; and it was the year 1896 that increased the production. The average number of rigs building per month in 1894 was 87; in 1895, 244; and in 1896, 159.

The following tables show the number of rigs building and wells drilling in the Lima (Ohio) field at the close of each month in 1896:

Total number of rigs building in the Lima (Ohio) district in 1896.

Month.	Allen.	Auglaize	Hancock.	Sandusky.	Wood.	Mercer.	Van Wert.	Seneca.	Miscellaneous.	Total.
January.....	10	13	26	35	82	17	7	11	4	205
February	14	13	25	40	93	7	11	8	5	216
March	6	19	29	58	88	7	8	12	4	231
April	8	9	32	43	82	13	3	9	2	201
May	8	10	51	43	71	5	5	8	5	206
June.....	3	7	24	29	67	4	3	10	0	147
July	2	6	19	24	58	6	4	8	3	130
August.....	1	3	17	25	41	7	3	4	5	106
September ...	1	2	12	27	49	6	1	8	8	114
October	3	7	13	19	61	8	0	6	3	120
November....	9	6	22	27	58	8	0	1	7	138
December	7	2	17	16	35	5	3	0	6	91
Average..	6	8	24	32	65	8	4	7	5	159

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Total number of wells drilling in the Lima (Ohio) district in 1896.

Month.	Allen.	Auglaize	Hancock.	Sandusky.	Wood.	Mercer.	Van Wert.	Seneca.	Miscellaneous.	Total.
January	18	25	37	65	114	27	18	15	8	327
February	22	23	38	61	114	20	11	17	11	317
March	13	15	51	52	145	23	6	19	14	338
April	21	25	52	64	141	16	11	23	15	368
May	17	24	64	57	150	25	8	15	11	371
June.....	12	14	56	44	124	18	5	8	12	293
July	11	10	67	40	109	16	4	15	10	282
August.....	5	12	51	30	105	14	2	15	17	251
September ...	13	6	48	23	96	17	6	21	21	251
October.....	16	10	56	22	87	11	4	12	22	240
November....	25	7	65	22	86	15	3	7	13	243
December	24	17	66	14	83	11	1	8	25	249
Average..	16	16	54	41	113	18	7	14	15	294

In the following tables are given the well records in the Lima (Ohio) district from 1890 to 1896:

Number of wells completed in the Lima (Ohio) district from 1890 to 1896, by months

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1890..	44	62	.....	.....	147	165	224	271	307	319	243	187	1,969
1891..	142	123	129	156	116	143	144	138	157	134	104	88	1,574
1892..	67	82	93	93	93	121	134	166	171	174	147	105	1,446
1893..	100	85	163	135	128	160	152	133	131	120	132	130	1,569
1894..	130	175	179	205	248	230	233	219	204	226	214	209	2,472
1895..	200	158	244	316	412	461	484	519	462	427	470	336	4,489
1896..	328	355	370	432	504	513	396	337	346	279	299	299	4,458

Initial daily production of new wells in the Lima (Ohio) district from 1890 to 1896, by months.

[Barrels.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.
1890.....	.....	.....	.....	.....	.....	.....	.....
1891.....	5,858	5,474	4,428	6,543	4,411	6,667	8,461
1892.....	2,853	4,485	3,973	4,665	4,750	8,314	11,648
1893.....	5,510	4,809	6,241	5,477	6,858	9,701	9,588
1894.....	3,853	4,211	4,486	5,586	7,291	6,391	5,637
1895.....	4,432	3,753	5,281	6,208	8,161	9,772	9,011
1896.....	5,651	6,704	7,885	9,335	9,902	9,670	6,885

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Initial daily production of new wells in the Lima (Ohio) district from 1890 to 1896, by months—Continued.

[Barrels.]

Year.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1890	18,944	16,309	17,426	13,779	8,424	14,976
1891	8,427	7,855	8,033	5,592	2,989	6,228
1892	14,631	12,908	13,772	7,554	4,907	7,872
1893	5,124	6,752	4,223	4,205	3,275	5,980
1894	5,642	5,020	5,991	10,464	5,539	5,843
1895	10,025	9,175	8,586	9,695	6,284	7,532
1896	6,175	5,640	5,355	5,630	6,171	7,084

Total number of dry holes drilled in the Lima (Ohio) district, from 1890 to 1896, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1890	3	2	.....	.....	4	11	10	23	30	32	37	41	193
1891	28	27	23	28	14	18	22	14	26	20	17	13	250
1892	9	9	8	13	10	18	16	18	27	22	18	15	183
1893	12	15	20	24	18	19	18	12	14	16	13	22	203
1894	17	41	37	27	32	41	30	34	35	27	28	35	384
1895	33	19	38	33	66	65	70	48	59	48	49	36	564
1896	43	44	57	39	55	63	47	35	52	26	42	47	550

Number of wells drilling in the Lima (Ohio) district, at the close of each month, from 1890 to 1896.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1890	47	59	.....	.....	135	188	237	182	238	294	148	111	164
1891	90	105	94	82	79	90	90	93	85	88	67	53	85
1892	61	78	76	51	64	95	101	112	120	114	106	81	88
1893	72	78	88	92	117	119	103	101	89	102	118	114	99
1894	120	113	127	138	127	139	117	138	136	136	138	140	131
1895	132	176	214	269	302	369	397	413	404	435	306	331	312
1896	327	317	338	368	371	293	282	251	251	240	243	249	294

Rigs building in the Lima (Ohio) district, from 1890 to 1896, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1890	56	69	.....	.....	173	239	248	212	210	194	149	109	166
1891	120	137	155	117	115	123	137	120	117	106	91	99	120
1892	95	115	106	112	113	104	128	126	121	112	112	49	108
1893	62	70	63	58	90	72	52	52	61	76	66	69	66
1894	60	83	90	88	85	76	68	95	86	92	112	110	87
1895	114	171	208	245	305	339	317	282	294	264	194	195	244
1896	205	216	231	201	206	147	130	106	114	120	138	91	159

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The following table shows the wells completed, the initial production, the dry holes, wells drilling, and rigs building in the Lima (Ohio) district in 1896:

Well record in the Lima (Ohio) district in 1896.

Month.	Wells completed.	Initial production.	Dry holes.	Wells drilling.	Rigs building.
		Barrels.			
January	328	5,651	43	327	205
February	355	6,704	44	317	216
March	370	7,885	57	338	231
April	432	9,335	39	368	201
May	504	9,902	55	371	206
June	513	9,670	63	293	147
July	396	6,885	47	282	130
August	337	6,175	35	251	106
September	346	5,640	52	251	114
October	279	5,355	26	240	120
November	299	5,630	42	243	138
December	299	6,171	47	249	91
Total	4,458	*a* 7,084	550	*a* 294	*a* 159

a Average.

EASTERN OR SOUTHERN OHIO DISTRICT.

In this district are included the old Macksburg field and the new developments in the territory adjacent in West Virginia and western Pennsylvania, in addition to the Macksburg, Corning, Steubenville, and Marietta districts. The name of this district, heretofore called the Eastern Ohio district, has been changed to Southern Ohio district.

The production of the Southern Ohio district for the last twelve years is given in the following table:

Production of petroleum in the Southern Ohio district, from 1885 to 1896.

Year.	Barrels.	Year.	Barrels.
1885	661,580	1891	422,883
1886	703,945	1892	1,190,302
1887	372,257	1893	2,601,394
1888	297,774	1894	3,183,370
1889	317,037	1895	3,693,248
1890	1,108,334	1896	3,365,365

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The figures given in the above table for years prior to 1891 are chiefly the production of the Macksburg field. In the following table is given the total production of crude petroleum in the Southern Ohio and Macksburg districts from 1888 to 1896, by months:

Total production of crude petroleum in the Southern Ohio district from 1888 to 1896, by months.

[Barrels.]

Year.	January.	February.	March.	April.	May.	June.	July.
1888..	20, 144	25. 327	23, 515	23, 720	25, 837	24, 426	31, 535
1889..	24, 855	23, 218	26, 382	24, 708	24, 961	24, 011	22, 619
1890..	36, 713	40, 712	53, 193	60, 729	80, 167	98, 268	118, 182
1891..	89, 061	40, 620	28, 297	29, 361	28, 935	25, 014	30, 571
1892..	33, 762	32, 894	42, 371	45, 439	50, 407	55, 930	69, 678
1893..	189, 874	209, 948	238, 133	217, 001	204, 151	206, 106	213, 431
1894..	209, 225	213, 721	253, 979	268, 736	283, 371	273, 876	267, 144
1895..	251, 865	223, 140	276, 422	285, 314	285, 436	290, 763	305, 222
1896..	321, 895	281, 776	293, 538	291, 358	286, 669	278, 634	274, 317

Year.	August.	September.	October.	November.	December.	Total.
1888..	23, 537	22, 945	25, 442	25, 831	25, 515	297, 774
1889..	24, 752	22, 807	28, 384	32, 867	37, 473	317, 037
1890..	132, 173	140, 634	138, 224	113, 664	95, 675	1, 108, 334
1891..	28, 828	31, 591	27, 536	28, 428	34, 641	422, 883
1892..	111, 377	151, 543	206, 005	188, 391	202, 505	1, 190, 302
1893..	221, 865	220, 589	242, 353	222, 428	215, 515	2, 601, 394
1894..	275, 360	278, 704	303, 441	278, 162	277, 651	3, 183, 370
1895..	337, 206	377, 785	383, 489	345, 402	331, 204	3, 693, 248
1896..	270, 135	255, 326	270, 752	251, 367	289, 598	3, 365, 365

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PIPE-LINE RUNS IN THE SOUTHERN OHIO DISTRICT.

In the following table the pipe-line runs and the shipments from the Macksburg or Southern Ohio district are given from 1885 to 1896:

Pipe-line runs in the Southern Ohio district from 1885 to 1896.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.
1885..	11, 894	20, 626	27, 066	40, 527	58, 258	64, 982	75, 737
1886..	54, 806	46, 694	58, 795	64, 137	58, 596	65, 379	56, 966
1887..	37, 134	28, 514	33, 995	29, 796	30, 601	29, 586	22, 413
1888..	16, 257	18, 861	17, 283	21, 187	21, 349	21, 511	21, 785
1889..	18, 174	16, 239	19, 676	20, 144	20, 283	18, 536	16, 705
1890..	29, 872	34, 022	45, 362	53, 905	72, 158	90, 827	111, 584
1891..	86, 058	45, 618	23, 055	25, 070	24, 263	21, 689	24, 858
1892..	24, 801	27, 620	39, 010	40, 424	43, 569	50, 007	64, 107
1893..	183, 781	211, 658	235, 177	211, 102	199, 929	146, 626	148, 622
1894..	138, 172	121, 627	150, 095	190. 677	239, 912	228, 267	221, 999
1895..	94, 999	181, 155	220, 883	229, 159	225, 816	227, 643	251, 003
1896..	321, 468	272, 933	296, 565	294, 603	279, 317	283, 385	267, 797

Year.	August.	September.	October.	November.	December.	Total.	Average.
1885..	74, 228	68, 110	63, 619	60, 926	61, 113	627, 086	52, 257
1886..	57, 492	48, 918	46, 937	41, 359	40, 578	640, 657	53, 388
1887..	26, 659	22, 903	20, 458	19, 902	17, 079	319, 040	26, 587
1888..	18, 558	22, 058	18, 809	20, 802	20, 950	239, 410	19, 951
1889..	16, 607	16, 875	21, 555	25, 415	28, 567	238, 776	19, 898
1890..	121, 349	138, 310	129, 717	106, 552	87, 955	1, 021, 613	85, 134
1891..	24, 432	27, 006	23, 428	23, 073	28, 682	377, 232	31, 436
1892..	106, 082	135, 353	212, 470	176, 852	196, 852	1, 117, 147	93, 096
1893..	152, 912	156, 124	149, 773	134, 923	144, 488	2, 075, 115	172, 926
1894..	249, 472	202, 364	220, 557	199, 787	199, 774	2, 362, 703	196, 892
1895..	279, 602	310, 400	322, 439	286, 932	324, 447	2, 954, 478	246, 207
1896..	270, 280	252, 351	267, 337	253, 909	278, 231	3, 338, 176	278, 181

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Shipments of crude petroleum and refined petroleum reduced to crude equivalent from the Southern Ohio district from 1886 to 1896.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.
1886..	60,119	42,525	32,277	23,578	28,986	40,211	28,832
1887..	52,065	23,908	17,593	16,558	16,002	17,384	16,504
1888..	40,076	30,045	4,122	14,920	15,275	15,630	9,083
1889..	11,847	16,168	23,939	8,611	9,027	8,934	15,269
1890..	44,306	38,898	35,041	30,975	13,070	22,851	46,394
1891..	54,363	27,160	1,040	2,094	1,060	41,725	820
1892..	2,594	2,200	1,763	1,600	252	37,989	1,834
1893..	7,174	6,556	8,218	5,906	2,338	1,123	1,025
1894..	3,366	3,932	2,874	2,272	1,998	959	2,569
1895..	4,370	3,106	3,154	1,130	869	1,756	583
1896..	4,128	3,116	1,874	1,309	1,026	300	0

Year.	August.	September.	October.	November.	December.	Total.	Average.
1886..	45,882	47,992	53,156	51,608	49,260	504,426	42,036
1887..	27,719	35,030	37,978	34,508	39,654	334,903	27,909
1888..	6,989	32,698	47,572	47,066	26,940	290,416	24,201
1889..	14,507	22,669	50,447	47,924	47,090	276,432	23,036
1890..	107,175	73,469	50,780	54,540	53,704	578,203	48,184
1891..	2,318	3,283	3,040	2,700	2,236	141,839	11,820
1892..	1,555	2,102	3,773	4,358	6,443	66,463	5,539
1893..	586	1,964	2,524	4,538	2,563	44,515	3,710
1894..	2,309	3,839	4,377	4,264	3,999	36,758	3,063
1895..	1,874	2,124	4,177	6,716	3,332	33,191	2,766
1896..	235	599	3,641	2,560	2,561	21,349	1,779

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STOCKS OF CRUDE PETROLEUM IN THE SOUTHERN OHIO DISTRICT.

In the following table will be found figures regarding stocks of crude petroleum in the Southern Ohio district at the close of each month from 1886 to 1896. This by no means represents all the stocks of crude petroleum held in this district, but forms the best statement that can be obtained as to stocks held by pipe lines that derived most of their oil from eastern and southern Ohio:

Total stocks of crude petroleum in the Southern Ohio district at the close of each month from 1886 to 1896, by months and years.

[Barrels of 42 gallons.]

Year.	January.	February.	March.	April.	May.	June.	July.
1886..	324,483	332,322	362,923	407,212	440,329	467,599	468,796
1887..	404,315	408,926	425,325	438,562	453,162	465,363	472,273
1888..	380,551	386,293	400,602	407,086	413,858	420,631	434,573
1889..	363,620	357,527	360,121	361,796	376,052	397,718	387,089
1890..	296,413	291,536	301,856	324,786	388,874	451,851	517,042
1891..	685,120	503,284	480,618	480,364	453,809	433,773	401,358
1892..	461,616	468,861	460,750	462,383	475,768	447,685	457,176
1893..	410,715	418,513	397,127	404,951	407,715	421,222	413,935
1894..	390,977	388,341	379,037	376,883	325,664	294,427	271,801
1895..	172,461	193,935	236,022	242,317	204,030	211,740	184,784
1896..	246,557	290,225	345,405	348,997	324,443	248,799	220,759

Year.	August.	September.	October.	November.	December.	Average.
1886.....	456,621	461,842	437,299	427,950	419,248	417,219
1887.....	471,214	459,085	441,563	426,957	404,382	439,261
1888.....	444,006	427,797	394,807	365,873	351,128	402,267
1889.....	389,189	383,393	354,498	331,939	310,848	364,732
1890.....	531,215	596,056	660,573	703,031	698,129	480,113
1891	378,857	388,855	431,450	461,037	454,232	462,730
1892.....	462,306	441,494	434,560	432,283	422,142	452,252
1893.....	426,552	443,669	458,692	446,503	415,900	422,124
1894.....	241,439	197,660	179,867	152,200	147,318	278,801
1895.....	182,203	169,850	192,060	211,591	231,048	202,671
1896.....	214,159	217,946	434,786	469,580	465,953	318,967

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WELL RECORDS IN THE SOUTHERN OHIO DISTRICT.

In the following tables are given statistics of the total number of wells completed, the initial daily production of wells drilled, total number of dry holes drilled, total number of wells drilling, and total number of rigs building in the Southern Ohio district during the year 1896, by months:

Total number of wells completed in the Southern Ohio district in 1896.

Month.	Corning.	Macksburg.	Steubenville.	Marietta.	Miscellaneous.	Total.
January	14	14	3	10	2	43
February	14	15	3	4	5	41
March	15	14	0	4	10	43
April	16	12	2	10	5	45
May	17	21	1	17	15	71
June	22	19	2	4	2	49
July	32	21	2	8	3	66
August	19	16	2	11	3	51
September	26	13	2	8	1	50
October	17	17	1	5	3	43
November	21	14	3	8	14	60
December	26	9	4	6	12	57
Total	239	185	25	95	75	619

Initial daily production of wells completed in the Southern Ohio district in 1896.

[Barrels.]

Month.	Corning.	Macksburg.	Steubenville.	Marietta	Miscellaneous.	Total.
January	129	95	40	44	30	338
February	171	106	20	30	32	359
March	190	115	0	7	475	787
April	182	57	15	79	80	413
May	110	196	0	123	125	554
June	171	105	15	100	35	426
July	299	143	6	25	0	473
August	111	52	10	126	1	300
September	252	64	10	108	0	434
October	195	144	10	245	0	594
November	157	240	28	97	70	592
December	175	94	23	100	106	498
Average	179	118	15	90	79	481

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Total number of dry holes drilled in the Southern Ohio district in 1896.

Month.	Corning.	Macksburg.	Steubenville.	Marietta.	Miscellaneous.	Total.
January	2	3	0	5	1	11
February	3	5	2	2	3	15
March	1	4	0	2	2	9
April	3	4	1	6	2	16
May	4	6	1	9	11	31
June	2	7	0	2	0	11
July	2	12	0	6	3	23
August	3	8	1	5	2	19
September	2	4	1	4	1	12
October	2	6	0	2	3	13
November	4	6	1	5	8	24
December	5	2	2	3	4	16
Total	33	67	9	51	40	200

Total number of wells drilling in the Southern Ohio district in 1896.

Month.	Corning.	Macksburg.	Steubenville.	Marietta.	Miscellaneous.	Total.
January	6	10	3	5	9	33
February	8	7	0	5	2	22
March	10	12	1	6	9	38
April	8	13	1	4	16	42
May	10	9	2	2	4	27
June	14	15	1	3	3	36
July	12	14	1	7	1	35
August	14	7	0	3	2	26
September	14	10	0	6	3	33
October	9	9	3	1	13	35
November	14	9	3	3	11	40
December	10	11	1	6	8	36
Average	11	11	1	4	7	34

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Total number of rigs building in the Southern Ohio district in 1896.

Month.	Corning.	Macksburg.	Steubenville.	Marietta.	Miscellaneous.	Total.
January	20	10	1	4	3	38
February	9	7	1	6	1	24
March	7	6	2	6	3	24
April	10	13	1	3	3	30
May	8	12	0	2	0	22
June	10	7	1	2	1	21
July	10	7	1	5	0	23
August	12	7	2	4	1	26
September	7	8	1	6	0	22
October	7	13	2	2	6	30
November	5	11	2	1	3	22
December	4	12	1	0	5	22
Average	9	9	1	4	2	25

In the following tables are given the well records in the Southern Ohio district from 1891 to 1896:

Number of wells completed in the Southern Ohio district from 1891 to 1896, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891	.....	.....	.....	.....	.....	.....	.....	.....	.....	9	10	8	27
1892	7	9	12	7	4	8	5	2	4	2	14	2	76
1893	10	15	13	19	24	15	26	18	21	15	7	7	190
1894	9	6	15	17	17	21	23	18	19	21	22	27	215
1895	25	17	31	37	57	56	50	48	40	41	25	33	460
1896	43	41	43	45	71	49	66	51	50	43	60	57	619

Initial daily production of new wells in the Southern Ohio district from 1891 to 1896, by months.

[Barrels.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891	.....	.....	.....	.....	.....	.....	.....	.....	.....	36	265	70	124
1892	60	152	393	65	291	25	43	2	0	20	117	0	97
1893	209	168	109	254	350	210	323	398	240	234	37	78	218
1894	143	50	74	172	246	223	262	232	180	468	215	433	225
1895	387	348	680	506	748	465	528	406	398	269	284	317	445
1896	338	359	787	413	554	426	473	300	434	594	592	498	481

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Total number of dry holes drilled in the Southern Ohio district from 1891 to 1896, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891..	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	5	4	14
1892..	2	3	4	4	4	5	1	0	4	1	4	2	34
1893..	0	2	4	3	8	2	7	3	7	4	4	2	46
1894..	3	2	8	7	5	9	8	8	7	8	11	9	85
1895..	11	3	6	9	9	18	11	14	7	20	5	12	125
1896..	11	15	9	16	31	11	23	19	12	13	24	16	200

Number of wells drilling in the Southern Ohio district at the close of each month from 1891 to 1896, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891..	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	14	10	13
1892..	15	15	12	9	14	9	6	6	6	10	7	9	10
1893..	14	10	15	15	13	15	13	19	12	8	9	12	13
1894..	11	4	19	5	17	15	18	18	16	15	19	22	15
1895..	19	21	16	34	32	38	35	41	35	27	33	33	30
1896..	33	22	38	42	27	36	35	26	33	35	40	36	34

Rigs building in the Southern Ohio district from 1891 to 1896, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891..	.....	.....	.....	.....	.....	.....	.....	.....	.....	20	20	4	15
1892..	18	17	14	13	21	10	8	11	13	16	13	13	14
1893..	16	17	23	11	4	9	12	9	13	9	13	13	12
1894..	9	13	13	9	13	13	18	18	15	27	19	17	15
1895..	16	23	21	26	24	28	25	30	24	24	38	31	26
1896..	38	24	24	30	22	21	23	26	22	30	22	22	25

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The following table shows the wells completed, the initial production, the dry holes, wells drilling, and rigs building in the Macksburg district or the Southern Ohio oil field in 1896:

Well record in the Macksburg (Ohio) district in 1896.

Month.	Wells completed.	Initial production.	Dry holes.	Wells drilling.	Rigs building.
		Barrels.			
January	43	338	11	33	38
February	41	359	15	22	24
March	43	787	9	38	24
April	45	413	16	42	30
May	71	554	31	27	22
June	49	426	11	36	21
July	66	473	23	35	23
August	51	300	19	26	26
September	50	434	12	33	22
October	43	594	13	35	30
November	60	592	24	40	22
December	57	498	16	36	22
Total	619	*a* 481	200	*a* 34	*a* 25

a Average.

THE MECCA-BELDEN DISTRICT.

The following table gives the production of crude petroleum in the Mecca-Belden district in 1896:

Production of crude petroleum in the Mecca-Belden district in 1896.

District.	1896.		
	Barrels of 42 gallons.	Value.	Price per barrel.
Belden, Lorain County	520	$1,848	$3.55
Mecca, Trumbull County	146	1,049	7.18
Total	666	2,897	4.35

At the close of 1896 there were 10 producing wells in the Mecca district, Trumbull County, Ohio, and 4 wells in the Belden district, Lorain County.

Some of the wells in the Mecca district were not pumped during 1896. One well that was put down during the first oil excitement, in 1860, has been pumped a portion of each year since that time, and last summer this well produced 21 barrels. The oil in both these fields is among

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the best natural lubricating produced; it comes from the Berea sandstone, near its outcrop toward the north and northwest. These wells are shallow; in one or two instances shafts 70 to 90 feet have been sunk to the oil-bearing strata.

In the following tables are given the production and stocks and value of the crude petroleum in this district from 1892 to 1896:

Production and value of crude petroleum in the Mecca-Belden district of Ohio from 1892 to 1896.

Year.	Belden district, Lorain County.			Mecca district, Trumbull County.			Total.		
	Production.	Value.	Value per barrel.	Production.	Value.	Value per barrel.	Production.	Value.	Value per barrel.
	Barrels.			*Barrels.*			*Barrels.*		
1892....	1,732	$9,280	$5.36	1,380	$11,821	$8.57	3,112	$21,101	$6.78
1893....	1,120	8,014	7.15	451	3,321	7.36	1,571	11,335	7.21½
1894....	740	3,276	4.43	200	1,200	6.00	940	4,476	4.76
1895....	833	4,200	5.04	543	4,029	7.42	1,376	8,229	5.98
1896....	520	1,848	3.55	146	1,049	7.18	666	2,897	4.35

Stocks at wells in the Mecca-Belden district of Ohio.

Year ending December 31—	Barrels.	Year ending December 31—	Barrels.
1891	4,048	1894	225
1892	161	1895	390
1893	403	1896	70

INDIANA.

The oil belt in this State is a continuation of the Lima (Ohio) field, though no direct contact between the two has been traced out. Outside of three wells at Terre Haute, all the production comes from the Trenton.

The oil belt extends in an almost due west course from near the southern line of Adams County to the northeast quarter of Grant County, slightly curving to the north in this county, being in a general way 35 miles long by 10 or 12 miles wide. It includes a part of the counties of Adams, Jay, Blackford, Wells, Grant, and Huntington. The elevation of the top of the Trenton limestone ranges from 100 to 200 feet below tide, being lowest at the eastern end of the field and gradually climbing higher as the western end is approached. The general dip is to the north or northeast. The floor of the Trenton limestone is full of slight dimples and domes. The flanks of these domes are the oil areas, and farther up toward the crowns are the gas areas. The depressions are full of salt water. More or less salt water is found throughout the field. A difference of only a few feet in eleva-

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tion or depression defines oil and salt-water territory. It is not unusual for a well to pump a large amount of salt water with the oil.

Mr. W. S. Blatchley, in the twenty-first annual report of the department of geology and natural resources of Indiana for 1896, gives the following as the general average sections for the eastern and western halves of the field, to which a section at Lima, Ohio, has been attached for comparison:

Average sections of the Indiana oil fields with a section of the Lima (Ohio) field.

Formation.	Western half.	Eastern half.	Lima, Ohio.
Drift	175	125	18
Niagara limestone	225	150	400
Hudson River limestone	380	425	450
Utica shale	200	300	350
Total	970	1,000	1,218

The top of the Trenton is well defined; the drill passes at once out of the soft black Utica shale into hard limestone. The pay streak is usually found at from 15 to 40 feet from the top of the Trenton; below this a few feet salt water is usually found. This dividing line is very uncertain, and the driller aims to go as near the salt water as he can without tapping it. Ten-inch drive pipe is put down through the drift to the Niagara limestone. The water that is generally found in the Niagara is cut off in the shale at the bottom of that formation by $5\frac{3}{8}$ or 6-inch casing. A combination of natural conditions, such as, a gently sloping surface, transportation facilities, the fact that but from 100 to 150 feet of drive pipe, and only 300 to 400 feet of casing, is required, with depth of hole generally less than 1,000 feet, together with usual supply of natural gas for fuel, the easy manner in which wells can be connected up and pumped by a single engine, and the possibilities of the gas engine, all go to make this a comparatively cheap field to operate. However, in Indiana, there was 1 dry hole drilled to 7.4 producing wells completed, as compared with 1 dry hole in 8.1 wells in the Lima (Ohio) field.

The year 1896 was one of activity, and several of the pools were widened out. The productive wells drilled show a decrease of 87 from 1895, and 9 less than was completed in 1894. The general reduction in the price from 78 cents in January, 1896, to 55 cents at the close of the year has had a depressing effect on new work. Notwithstanding this there was a gain of 294,600 barrels in the production for 1896, or an increase of $6\frac{3}{4}$ per cent over 1895. The total production of crude petroleum for 1896 was 4,680,732 barrels, as compared with 4,386,132 barrels in 1895.

The average price of Indiana crude for 1896 was 63 cents per barrel, as compared with 64 cents in 1895.

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PRODUCTION.

In the following table will be found a statement of the production of petroleum in Indiana from 1889 to 1896:

Production of petroleum in Indiana from 1889 to 1896.

	1889.	1890.	1891.	1892.
Total production (barrels of 42 gallons)	33,375	63,496	136,634	698,068
Total value at wells of all oils produced, excluding pipage	$10,881	$32,462	$54,787	$260,620
Value per barrel	$0.32⅝	$0.51⅛	$0.40	$0.37

	1893.	1894.	1895.	1896.
Total production (barrels of 42 gallons)	2,335,293	3,688,666	4,386,132	4,680,732
Total value at wells of all oils produced, excluding pipage	$1,050,882	$1,774,260	$2,811,444	$2,954,411
Value per barrel	$0.45	$0.48	$0.64	$0.63

The following table gives the production of petroleum in Indiana, by months, from 1891 to 1896. The largest in any one month seems to have been in July, 1895, when 434,376 barrels were produced.

Total production of petroleum in Indiana from 1891 to 1896, by months.

[Barrels.]

Month.	1891.	1892.	1893.	1894.	1895.	1896.
January	6,171	15,841	111,824	259,000	300,568	365,582
February	5,981	18,946	96,025	232,107	230,559	341,743
March	5,159	24,794	134,549	282,376	310,303	386,586
April	4,973	26,184	146,493	287,330	352,077	395,032
May	5,757	31,033	186,939	321,502	397,001	417,963
June	8,136	40,888	209,616	333,479	403,569	434,167
July	10,809	49,203	221,666	327,349	434,376	422,968
August	11,603	56,109	248,353	345,031	420,132	407,238
September	16,500	66,034	245,615	319,588	409,169	415,675
October	19,029	95,699	252,568	339,424	393,153	394,283
November	20,801	129,270	245,607	304,030	373,789	337,331
December	21,715	144,067	236,038	337,450	361,436	362,164
Total	136,634	698,068	2,335,293	3,688,666	4,386,132	4,680,732

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WELL RECORDS.

In the following tables are given statistics of the total number of producing wells drilled, total number of new wells completed, total number of dry holes, and total number of wells drilling and rigs building in the Indiana oil fields for each month in 1896:

Total number of wells completed in Indiana in 1896, by counties.

Month.	Adams.	Blackford.	Grant.	Huntington.	Jay.	Wells.	Total.
January	5	8	10	3	11	39	76
February	5	22	11	2	16	34	90
March	10	22	6	3	15	30	86
April	6	33	14	6	32	45	136
May	20	32	18	5	25	48	148
June	16	36	14	4	22	58	150
July	8	17	8	13	18	49	113
August	9	19	13	7	28	45	121
September	10	11	5	7	9	28	70
October	9	6	5	3	10	25	58
November	5	7	8	7	9	30	66
December	8	8	6	3	11	30	66
Total	111	221	118	63	206	461	1,180

Initial daily production of wells completed in Indiana in 1896, by counties.

[Barrels.]

Month.	Adams.	Blackford.	Grant.	Huntington.	Jay.	Wells.	Total.
January	65	162	300	25	200	805	1,557
February	75	425	255	80	265	775	1,875
March	210	405	225	55	445	750	2,090
April	330	355	340	190	495	1,115	2,825
May	420	390	500	100	349	1,390	3,149
June	420	510	310	55	490	1,330	3,115
July	230	212	195	320	260	1,115	2,332
August	275	325	225	140	450	1,235	2,650
September	290	185	80	205	210	730	1,700
October	165	90	145	60	220	835	1,515
November	140	45	185	145	160	725	1,400
December	180	70	115	40	95	600	1,100
Average	233	265	240	118	303	950	2,109

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Total number of dry holes drilled in Indiana in 1896, by counties.

Month.	Adams.	Blackford.	Grant.	Huntington.	Jay.	Wells.	Total.
January	1	1	0	1	5	2	10
February	1	1	1	0	7	3	13
March	1	0	1	1	2	1	6
April	0	7	0	1	11	9	28
May	2	8	0	2	8	6	26
June	3	7	0	0	7	3	20
July	0	1	0	0	8	5	14
August	2	2	2	1	9	3	19
September	1	1	0	0	0	2	4
October	2	0	0	0	2	0	4
November	1	1	0	1	1	2	6
December	0	2	0	0	3	3	8
Total	14	31	4	7	63	39	158

Total number of wells drilling in Indiana in 1896, by counties.

Month.	Adams.	Blackford.	Grant.	Huntington.	Jay.	Wells.	Miscellaneous.	Total.
January	10	20	12	2	16	37	0	97
February	9	17	10	3	17	23	1	80
March	6	17	11	7	24	25	0	90
April	18	20	13	2	18	28	0	99
May	10	22	15	4	17	31	0	99
June	5	11	11	5	17	39	0	88
July	6	8	10	3	25	36	0	88
August	6	7	3	0	7	29	0	52
September	4	3	5	6	9	20	0	47
October	4	1	4	5	5	26	0	45
November	4	3	5	3	8	20	0	43
December	5	5	9	5	6	22	0	52
Average	7	11	9	4	14	28	0	73

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Total number of rigs building in Indiana in 1896, by counties.

Month.	Adams.	Blackford.	Grant.	Huntington.	Jay.	Wells.	Total.
January	13	7	10	4	9	29	72
February	3	5	3	3	11	25	50
March	10	9	5	0	7	22	53
April	10	12	8	6	10	21	67
May	12	17	8	5	11	26	79
June	8	13	1	1	10	15	48
July	8	12	2	4	10	16	52
August	7	6	4	2	4	10	33
September	9	4	2	1	4	12	32
October	8	7	3	3	3	10	34
November	7	8	3	2	2	20	42
December	8	3	2	3	1	7	24
Average	9	9	4	3	7	18	49

In the following tables are given the well records in the Indiana oil fields from 1891 to 1896:

Number of wells completed in the Indiana oil fields from 1891 to 1896, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891	.....	.....	.....	.....	.....	.....	6	6	15	15	15	8	65
1892	11	13	18	13	17	19	17	30	25	52	33	47	295
1893	20	30	31	36	45	47	47	55	27	72	56	76	542
1894	90	103	103	80	110	107	84	123	100	107	97	85	1,189
1895	61	45	81	111	122	153	132	140	129	106	102	85	1,267
1896	76	90	86	136	148	150	113	121	70	58	66	66	1,180

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Initial daily production of new wells in Indiana oil fields from 1891 to 1896, by months.

[Barrels.]

Month.	1891.	1892.	1893.	1894.	1895.	1896.
January	.....	342	1,020	2,361	2,132	1,557
February	.....	250	913	2,935	1,413	1,875
March	.....	289	2,805	3,395	2,504	2,090
April	.....	316	4,135	3,175	3,473	2,825
May	.....	505	3,155	4,450	3,035	3,149
June	.....	545	5,595	4,886	4,923	3,115
July	253	595	3,880	3,530	3,067	2,332
August	135	1,295	4,184	3,435	2,760	2,650
September	875	2,145	2,055	3,149	3,175	1,700
October	330	4,155	3,442	3,455	2,651	1,515
November	390	3,050	2,305	3,323	2,560	1,400
December	175	3,160	2,968	2,654	2,025	1,100
Average	360	1,387	3,038	3,396	2,810	2,109

Total number of dry holes drilled in Indiana oil fields from 1891 to 1896, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891	.....	.....	.....	.....	.....	.....	0	2	5	4	3	1	15
1892	2	6	6	2	3	4	2	3	3	18	6	21	76
1893	7	10	10	6	14	6	11	9	5	14	10	9	111
1894	19	14	24	14	13	13	9	21	15	14	8	17	181
1895	7	4	13	16	22	20	15	23	12	12	9	13	166
1896	10	13	6	28	26	20	14	19	4	4	6	8	158

Number of wells drilling in the Indiana oil fields at the close of each month from 1891 to 1896, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891	.....	.....	.....	.....	.....	.....	5	13	12	8	4	12	9
1892	17	15	11	12	13	16	11	16	23	23	26	24	17
1893	24	19	22	18	20	28	29	45	27	50	36	50	31
1894	63	71	37	56	60	61	71	64	58	62	62	58	60
1895	66	52	62	82	112	101	109	110	103	102	78	81	88
1896	97	80	90	99	99	88	88	52	47	45	43	52	73

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Rigs building in the Indiana oil fields from 1891 to 1896, by months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1891....	....	....	.....	.....	.....	.....	7	2	12	8	6	6	7
1892....	8	18	23	23	17	21	16	15	29	31	39	19	22
1893....	12	15	17	14	17	26	32	28	9	25	27	30	21
1894....	36	39	34	40	35	30	32	35	35	57	38	32	37
1895....	37	50	73	89	102	91	78	69	83	70	61	80	74
1896....	72	50	53	67	79	48	52	33	32	34	42	24	49

The following table shows the wells completed, the initial production, the dry holes, wells drilling, and rigs building in Indiana in 1896:

Well record in Indiana in 1896.

Month.	Wells completed.	Initial production.	Dry holes.	Wells drilling.	Rigs building.
		Barrels.			
January.....	76	1,557	10	97	72
February	90	1,875	13	80	50
March	86	2,090	6	90	53
April	136	2,825	28	99	67
May	148	3,149	26	99	79
June	150	3,115	20	88	48
July	113	2,332	14	88	52
August.....	121	2,650	19	52	33
September	70	1,700	4	47	32
October	58	1,515	4	45	34
November.....	66	1,400	6	43	42
December	66	1,100	8	52	24
Total	1,180	*a* 2,109	158	*a* 73	*a* 49

a Average.

TENNESSEE.

By an examination of the tables given in that part of this report which refers to the extension of the Appalachian oil field, it will be noticed that there were many deep wells drilled in northern central Tennessee, and it will also be noticed that there was only one well in the State that can be called an oil producer, the Bobs Bar well in Fentress County. Of the 4,325 barrels produced in this part of Tennessee and Kentucky, which we find it difficult to subdivide, a large part must have come from this well. A pipe-line company, in 1896, erected two large iron tanks in anticipation of a large production at Spurriers, in Pickett County, 5 miles below the Bobs Bar well, connecting the

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well and tanks by pipe line. This production is at least 30 miles from any railroad and can not be marketed until it is connected to some of the railroads by pipe line, hence it is difficult to place any value upon it.

There is an absence of any well-defined porous stratum holding oil or gas, and what oil or gas is found seems to be in crevices or pockets, usually in the limestone, and when these are drained the production ceases entirely. A considerable amount of oil is scattered through the measures; the surface shows are often numerous, but the condition necessary for concentration seems to be wanting. The following section is taken from a well drilled in 1896 in Scott County, by the Forest Oil Company, to a depth of 2,401 feet, known as the Skull Creek No. 1. Another, about 4 miles northwest, near the town of Rugby, was drilled 2,793 feet.

Record of well drilled by the Forest Oil Company on the Rugby lands, Scott County, Tennessee.

[Commenced January 1, 1896; finished July 1, 1896; elevation at mouth of well, +1,297 feet.]

LOWER PART OF CARBONIFEROUS.

	Depth of member, in feet.	Total depth, in feet.
Lower Coal Measures:		
Shale and clay, yellow, soft	15	15
Slate, black, soft	15	30
Coal, soft	3	33
Slate, soft	15	48
Slate, dark and hard	12	60
Pottsville conglomerate:		
Sand, white, very hard	70	130
Slate, dark, soft	20	150
Sand, gray, very hard	100	250
Slate, dark and hard	50	300
Sand, white, very hard	95	395
Slate, black and soft	80	475
Sand, white, hard	287	762
When 37 feet in this sand found 5 feet of soft sand showing dark oil, 512 to 517.		
SUBCARBONIFEROUS.		
Mauch Chunk:		
Limestone, gray	18	780
Slate, light and soft	15	795
Red shale, dark red, soft	21	816
Red shale, brown, soft	30	846
Slate, black	27	873
Limestone, hard shells	5	878
Red shale, red, soft	28	906
Mountain limestone, or Chester and St. Louis groups:		
Limestone, dark, hard	39	945
Slate, black, soft	25	970
Limestone, dark and hard	13	983
Limestone, gray, hard (small show of gas in it, 25 feet)	52	1,035
Do	25	1,060
Do	7	1,067

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SUBCARBONIFEROUS—continued.

	Depth of member, in feet.	Total depth, in feet.
***Mountain limestone, or Chester and St. Louis Groups*—Continued.**		
Limestone, dark, hard	39	1,106
Do	14	1,120
Slate, black and soft	11	1,131
Shells, dark and hard	9	1,140
White sand, hard	8	1,148
Limestone, dark and hard	22	1,170
Do	74	1,244
Limestone, gray and hard	37	1,281
Do	22	1,303
Do	3	1,306
Limestone shells, white, very hard	3	1,309
Limestone shells, gray, hard	18	1,327
Do	8	1,335
Limestone grit, gray, hard	5	1,340
Do	3	1,343
Do	3	1,346
Do	41	1,387
Sand, gray and hard	1	1,388
Limestone, dark gray, hard	26	1,414
Limestone shells, gray, very hard	7	1,421
Keokuk or Waverly group, or siliceous group:		
Big Injun—		
Sandstone, light brown, very hard	5	1,426
Do	16	1,442
Sandstone, gray and hard	18	1,460
Limestone, light brown	13	1,473
Limestone, brown	3	1,476
Slate, dark, soft	8	1,484
Limestone, dark and hard	4	1,488
Sandstone, dark gray, hard	2	1,490
Sandstone, light gray, hard	13	1,503
Slate, black	4	1,507
Limestone, dark gray, hard	7	1,514
Do	16	1,530
Do	10	1,540
Slate, black and soft	18	1,558
Limestone, light gray, hard	19	1,577
Limestone, light gray, very hard	15	1,592
Limestone, gray, very hard	19	1,611
Flint stone	23	1,634
Do	27	1,661
Do	20	1,681
DEVONIAN.		
Black shale:		
Shale, gray and soft	2	1,683
Shale, black, soft (Huron black shale)	45	1,728
UPPER SILURIAN.		
Niagara shale and limestone:		
Slate and limestone, blue	28	1,756
Limestone, gray, hard	42	1,798
Limestone, blue, soft	99	1,897

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UPPER SILURIAN—continued.

	Depth of member, in feet.	Total depth, in feet.
Niagara shale and limestone—Continued.		
Limestone, brown, soft	13	1,910
Limestone and slate, medium hard	31	1,941
Limestone and slate, soft	59	2,000
Limestone and slate, brown, medium hard	42	2,042
Limestone and slate, dark gray, medium hard	75	2,117
Do	228	2,345
Do	43	2,388
Clinton limestone:		
Limestone and slate, brown, medium hard	5	2,393
Do	8	2,401

KENTUCKY.

Under the heading "Extension of the Appalachian oil field" there is considerable information relating to this State. The hopes of finding oil in large, or even moderate quantities, have not been realized so far. Wayne and Barren counties, in southern-central Kentucky, have some producing wells, and there are several light wells in Floyd County.

For the number of wells drilled in the past two years in this State, as the table found under the head of the extension of the Appalachian oil field will show, there have been no returns to justify so large an expenditure. No conditions have been found, so far, similar to the white or red sands of the northern part of the Appalachian field, or the open magnesian limestone of the Lima field. The oil thus far developed seems to exist in pockets.

The total production of oil in Kentucky, so far as we have been able to ascertain the same with any details, is as follows:

Production of petroleum in Kentucky, 1883–1896.

[Barrels.]

Year.	Production.	Year.	Production.
1883	4,755	1890	6,000
1884	4,148	1891	9,000
1885	5,164	1892	6,500
1886	4,726	1893	3,000
1887	4,791	1894	1,500
1888	5,096	1895	1,500
1889	5,400	1896	1,680

In addition to the above, 4,325 barrels were produced in Kentucky and Tennessee, for which, owing to the isolated position of this production, so far away from transportation, no value could be assigned.

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RECORD OF BEAR CREEK WELL, NEAR PINE KNOT, WHITLEY COUNTY, KENTUCKY.

The following is a complete record of the Bear Creek well, carefully compiled and classified by Mr. W. G. Strubbe. It was drilled by the Cumberland Basin Oil and Mining Company, June–August, 1896. Elevation, top of conglomerate, 1,450 feet; elevation of Pine Knot, 1,418 feet; elevation of derrick floor, 900 feet.

Record of Bear Creek well, near Pine Knot, Whitley County, Kentucky, 2 miles from Tennessee State line.

	Depth of member, in feet.	Total depth, in feet.
CARBONIFEROUS.		
Lower Coal Measures:		
Sandstone, buff, coal at 60 feet	....	145
Sandstone, chocolate (oil)	13	158
Sandstone, buff	28	186
Shale, black, cased at 200 feet	44	230
Sandstone, buff	10	240
Shale, black	20	260
Sandstone, gray	10	270
Chester group:		
Shale, black (gas 325 feet)	55	325
Sandstone, white (oil)	20	345
Shale, green	5	350
Shale, brown	10	360
Sandstone, blue	50	410
Shale, red	6	416
Limestone, dark crinoidal	35	451
Shale, red	18	469
Limestone, gray crinoidal	6	475
Sandstone, dark	6	481
Shale, red	6	487
SUBCARBONIFEROUS.		
St. Louis limestone:		
Limestone, dark	50	537
Shale, dark	6	543
Limestone, dark	105	648
Shale, black, fractured	10	658
Limestone, dark	174	832
Limestone, gray, flinty	31	863
Limestone, dark	43	906
Keokuk:		
Sandstone, gray (gas), Big Injun	119	1,025
Shale, dark	65	1,090
Sandstone, gray (gas)	110	1,200
Devonian:		
Shale, black (Huron)	95	1,295
Sandstone, dark, calcareous	15	1,310
Lower Helderberg:		
Limestone, dark	53	1,362
Shale, dark	15	1,378
Limestone, dark, siliceous (Niagara)	72	1,450

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SUBCARBONIFEROUS—continued.

	Depth of member, in feet.	Total depth, in feet.
Clinton:		
Limestone, dark, slaty	30	1,480
Limestone, brown	38	1,518

RECAPITULATION.

1.	Lower Coal Measures	....	270
	Chester group	217	487
2.	St. Louis Mountain limestone	419	906
	Keokuk group (Waverly)	294	1,200
3.	Black shale (Huron shale)	95	1,295
4.	Lower Helderberg	155	1,450
5.	Clinton	68	1,518

COLORADO.

The geological conditions of the Florence oil field were fully described in Mineral Resources for 1892. The United Oil Company and the Rocky Mountain Oil Company have been reported as having drilled a number of good wells, from 1,300 to 2,000 feet deep. The production has fallen off from 482,232 barrels in 1895 to 361,450 in 1896, a decrease of 17.52 per cent. A table of monthly production is presented for the first time:

Production of crude petroleum in Colorado in 1896, by months.

Month.	Barrels of 42 gallons.	Month.	Barrels of 42 gallons.
January	31,846	August	31,453
February	28,699	September	30,872
March	29,938	October	29,669
April	31,506	November	27,909
May	30,911	December	27,218
June	30,188	Total	361,450
July	31,241		

At the close of 1895 there were 43 producing wells reported. During 1896 there were 15 productive wells drilled, and 17 dry holes, and 5 wells were abandoned, leaving a total of 53 at the close of 1896.

In the following table will be found a statement of the production of crude oil in Colorado from 1887 to 1896:

Product of crude oil in Colorado from 1887 to 1896.

Year.	Barrels.	Year.	Barrels.
1887	76,295	1892	824,000
1888	297,612	1893	594,390
1889	316,476	1894	515,746
1890	368,842	1895	438,232
1891	665,482	1896	361,450

Stock at the close of 1895 was 70,658 barrels; the stock at the close of 1896 was only 17,929 barrels.

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CALIFORNIA.

Nothing new in the way of development has taken place in California during 1896. The report of 1894 contained most of the leading facts. The high price of fuel in California makes this liquid fuel find many markets that it could not otherwise secure, such as fuel for locomotives, sugar refineries, and many other manufactures.

In Bulletin No. 11 of the State of California, the fields in the counties of Los Angeles, Ventura, and Santa Barbara are described by Mr. W. L. Watts, M. E., who records some interesting details. The fossils were identified by Dr. J. G. Cooper. In his summary, Mr. Watts says:

"At Los Angeles all the evidence secured indicates that the oil-bearing strata penetrated by the wells at Second Street Park are of Pliocene age. The fact that in California Pliocene formations have been observed resting nonconformably on Miocene rocks, and that the Miocene has heretofore been assumed by many to be exclusively the geological horizon of the petroleum-yielding rocks of California, suggests that the oil wells referred to have penetrated Pliocene strata and reached the oil-bearing sands of the Miocene age. The latter conclusion is not borne out by the evidence in sight.

"The evidence thus far obtained warrants the conclusion that the oil-yielding formations in the districts described in this bulletin belong respectively to the following geological horizons:

Name of oil field.	Geological horizon of oil-yielding rocks.
Second Street wells at Los Angeles..	Pliocene.
Puente wells	Older than Pliocene; exact age undetermined.
Brea Canyon on Puente Hills	Miocene (Eocene and Miocene).
Upper oil-yielding formations, south side of sulphur mountain.	Probably Oligocene, i. e., transition (between Eocene and Miocene).
Silver-thread wells	Probably Oligocene.
Lower oil-yielding horizon, Sespe district.	Eocene.
Santa Monica wells, Santa Barbara County.	Eocene.
Occidental wells	Probably Eocene.
Summerland wells.....	Undetermined.

"The evidence thus far gathered concerning the petroleum-yielding rocks of California leads to the following conclusions:

"First, that the Oligocene formations, previously referred to, contain a primary deposit of petroleum; second, that this deposit is found in the lower portion of a certain bed of dark-colored shales, and in certain strata of sandstone interstratifying and immediately underlying the said shales; third, that the Eocene formation also contains primary deposits of petroleum. (At present there is only one productive well

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which derives its oil from this distinctively Eocene formation within the territory described in this bulletin.) Examples of secondary deposits of petroleum are found in the deposits of asphaltum and bituminous sand which are described as occurring in this formation, which have a range from Miocene to the Quaternary.

"At Los Angeles the petroleum-yielding rocks form an oil line far down the slope of what appears to be an ill defined anticlinal fold. There is no geological evidence in sight to show that this oil line has any particular reference to the axis of any anticline. Oil and oil and water have been found at intervals along this oil line for a distance of more than 5 miles. At the Second Street Park oil field, probably owing to the effect of subordinate folds or flexures, conditions have been produced favorable to the accumulation of the oil. There are numerous faults in the rocks of this locality, but it does not appear that the throw of any of them is very great. In the Puente oil field the productive wells are situated on both slopes of an anticlinal fold. In Brea Canyon, in the Puente Hills, there is a line of oil seepage along the axis on an anticlinal fold. It seems, therefore, that in nearly all instances observed the anticlinal structure has presented the conditions under which the petroleum has accumulated. As previously mentioned, the prevailing structure of the rocks, in the territory under discussion, is that of closely compressed anticlinal folds, and the compression has resulted in much crushing and fracturing of the rocky strata. These conditions favor the migration of petroleum and the formation of secondary deposits."

The oil found in the counties of Los Angeles, Ventura, and Santa Barbara has only a trace of paraffin and is classed with oils of an asphalt base. It contains from 0.075 to 3.5 per cent of nitrogen. The presence of nitrogen would indicate that a proportion of this variety of oil had its origin from animal matter, furnished by the slow decomposition of marine fauna, whose death was caused by some of the great changes that have taken place in the history of the continent.

The average gravity of the oils for the counties named is 23.5° B., or 0.9120 specific gravity.

An analysis, by Mr. Frederick Salathe, Ph. D., of the average oil, of 23.5 Baum or 0.912 specific gravity, in Ventura County, is as follows:

Analysis of average oil in Ventura County.

Constituents.	Per cent.
Carbon	84.0
Hydrogen	12.7
Nitrogen	1.7
Oxygen	1.2
Sulphur	.4
Total	100.0

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Distillation and yield of various southern California crude oils—Continued.

3. CRUDE OIL FROM TORREY CANYON, OF 27° B., OR 0.8917 SPECIFIC GRAVITY.

Distillates.	Per cent.
Naphtha	9.20
Illuminating distillate	21.50
Gas distillate	26.00
Lubricating distillate	30.30
Asphalt and loss	13.00
Total	100.00
The pyridine bases equal 1.52 per cent.	

4. CRUDE OIL FROM LIMEKILN CANYON (EUREKA OIL COMPANY), OF 29° B., OR 0.8805 SPECIFIC GRAVITY.

Distillates.	Per cent.
Naphtha	14.10
Illuminating distillate	26.40
Gas distillate	24.00
Lubricating distillate	27.00
Asphalt and loss	8.50
Total	100.00
The pyridine bases equal 1.44 per cent.	

5. CRUDE OIL FROM ADAMS CANYON (TUNNEL OIL), GREENISH OIL OF 24° B., OR 0.9090 SPECIFIC GRAVITY.

Distillates.	Per cent.
Naphtha	5.20
Illuminating distillate	24.50
Gas distillate	17.30
Lubricating distillate	46.00
Asphalt and loss	7.00
Total	100.00
The pyridine bases equal 0.88 per cent.	

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Distillation and yield of various southern California crude oils—Continued.

6. CRUDE OIL FROM LOS ANGELES WELLS OF 14.2° B., OR 0.9708 SPECIFIC GRAVITY.

Distillates.	Per cent.
Naphtha	Trace.
Illuminating distillate	6.00
Gas distillate	17.50
Lubricating distillate	51.50
Asphalt and loss	25.00
Total	100.00
The pyridine bases equal 3.2 per cent. This crude oil contains usually from 2.5 to 7 per cent of water and 0.16 to 2 per cent of suspended mineral matter, mainly a fine siliceous clay.	

7. FRESNO COUNTY CRUDE OIL FROM COALINGA OF 54° B., OR 0.7608 SPECIFIC GRAVITY.

[This oil represents a distillate made by nature, nearly all fractions having a low fire test.]

	Per cent.	Temperature.
		°C. °C.
Fraction 1	10	49 to 111
Fraction 2	10	110 to 121
Fraction 3	10	120 to 141
Fraction 4	10	140 to 161
Fraction 5	10	160 to 176
Fraction 6	10	175 to 196
Fraction 7	10	195 to 227
Fraction 8	10	226 to 249
Fraction 9	10	248 to 275
Fraction 10	*a* 10	

a Residue is hard asphalt.

REFINING.

From the investigations given so far it is evident that the refining of the crude California oils is not an easy task, and that they require refining methods different from those practiced with eastern or Russian oils. The complicated nature of this class of asphaltic crude oils necessitates complete elimination of all unstable hydrocarbons by inexpensive practical processes. Another great difference exists between the specific gravities of eastern oil distillates and those of California oils. Viscosity of distillate or reduced stock being equal, the gravities are from 5° to 6° B. lower in California oil fractions than in those of eastern oils. Flash and fire tests are from 10° to 30° F. lower in California oil distillates than in eastern distillates of the same gravity.

In the following table will be found a statement of the production of crude petroleum in California, from the beginning of operations in this

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State up to 1896, inclusive. The years 1895 and 1896 are remarkably close, the increase for the year 1896 being only $3\frac{2}{3}$ per cent over 1895:

Production of petroleum in California.

Year.	Barrels.	Year.	Barrels.
Previous to 1876	175,000	1886	377,145
1876	12,000	1887	678,572
1877	13,000	1888	690,333
1878	15,227	1889	303,220
1879	19,858	1890	307,360
1880	40,552	1891	323,600
1881	99,862	1892	385,049
1882	128,636	1893	470,179
1883	142,857	1894	705,969
1884	262,000	1895	1,208,482
1885	325,000	1896	1,252,777

The total value of the crude petroleum for 1896 was placed at $1,240,990, equal to 99 cents per barrel. Of the total production, 932,758 barrels were produced in Los Angeles County. The remainder, 320,019 barrels, was produced in Ventura, Santa Barbara, Santa Clara, Fresno, Kern, and San Mateo counties. Ventura County produced about three-fourths of the 320,019 barrels, and in the vicinity of Summerland, Santa Barbara County, one-sixth was produced from 72 wells.

WYOMING.

The production of Wyoming has fallen from 3,455 barrels in 1895 to 2,878 barrels in 1896, a decrease of 577 barrels. There are several reasons for this. First, all the oil fields are from 60 to 100 miles from a railroad. Second, the general surface of this section is elevated and there is no vegetation, no timber, and a great scarcity of good water. Third, the quality of the crude is such that generally only a small per centage of illuminating oil can be obtained. Fourth, the greater part must be disposed of as lubricating oil, and being so far from any large manufacturing section or points of distribution the freight rates, to carry it to any large market, eat up the profits.

There is no doubt that great quantities of oil could be produced in the State from wells now shut in, and it is only a question of time until some one of the fields will be reached by a railroad or pipe line, when the production will be greatly increased.

There is a series of anticlinal folds, in a general northeast-southwest course, some of which have been traced for 15 miles or more, whose flanks hold up the oil sands over large areas. The range of oil-bearing strata begins in the Eocene and extends down to the Carboniferous, and is generally found in sandstone 20 to 60 feet in thickness, so far as developed. Such a large range of productive oil strata is very unusual.

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The report of 1895 was very complete; the past year, owing to reasons before mentioned, has added very little of interest to it.

There are six wells producing oil, the remainder being shut in. These six wells are owned by the Pennsylvania Oil and Gas Company, and are located 50 miles north of the railroad station of Casper, in the Salt Creek oil field. The oil is hauled in large tank wagons to Casper, where the more volatile portion, amounting to about 5 per cent, and a small percentage of water, is removed in a small refinery. The remainder is a high grade of lubricating oil.

Production of petroleum in Wyoming from 1894 to 1896.

Year.	Barrels.
1894	2,369
1895	3,455
1896	2,878
Total	8,702

KANSAS.

The production of petroleum in Kansas in 1896 was increased 155.62 per cent over 1895. From the following statement it will be seen that 135 wells were drilled, of which 78 were dry, 10 were gas wells, and 47 were oil wells.

Production of crude petroleum in Kansas in 1896.

	Barrels.
Average production of producing wells drilled	12
Production for 1896	113,571
Daily average	311.17
Average number of wells producing	57
Daily average per well	5.45

At the close of 1895, 57 wells were reported producing. The Forest Oil Company is now the only producing company in the field. The following table shows by counties the well records in Kansas in 1896:

Well records in Kansas in 1896, by counties.

County.	Wells drilled.	Wells dry.	Gas wells.	Oil wells.
Lane	2	2	.....	.....
Bourbon	4	4	.....	.....
Allen	15	12	1	2
Neosho	18	7	1	10
Wilson	73	35	6	32
Elk	2	2	.....	.....
Montgomery	16	13	2	1
Chautauqua	5	3	.....	2
Total	135	78	10	47

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The total product of oil in Kansas, so far as records have been obtained, is as follows:

Production of petroleum in Kansas.

Year.	Barrels.	Year.	Barrels.
1889	500	1893	18,000
1890	1,200	1894	40,000
1891	1,400	1895	44,430
1892	.....	1896	113,571

TEXAS.

The increase in Texas from 50 barrels in 1895 to 1,450 barrels in 1896 is by far the greatest increase in any one State for that year. This new production comes from 5 wells drilled during 1896 in Navarro County, near the town of Corsicana. Oil was first discovered several years previous by the drilling of an artesian well in search of water. The oil was originally found at a depth of 1,035 feet, the formation being a sandy shale 12 to 20 feet in thickness in the "blue Ponderosa marl," which is reported as extending 500 feet below the oil shale. A fine flow of water was found at 2,400 feet. Corsicana is 165 miles nearly due west of Shreveport, Louisiana. The oil is rather dark in color, with a specific gravity of 0.833 to 0.824, or 38° to 40° Baumé, and its appearance and physical conditions are very similar to the Galician oil. The following tables of the fractional distillation were prepared by the chemists of the Texas agricultural experimental station, and appeared in Bulletin No. 35. The table of comparison indicates the very superior quality of this oil.

One-half liter (or about 1 pint) was subjected to distillation and the following fractions obtained at the respective temperatures expressed in degrees of the centigrade scale:

Began to boil at 80°.
Between 80° and 90° gave off 16.4 per cent of its volume.
Between 90° and 110° gave off 7.8 per cent of its volume.
Between 110° and 140° gave off 10.4 per cent of its volume.
Between 140° and 170° gave off 9.2 per cent of its volume.
Between 170° and 200° gave off 3.6 per cent of its volume.
Between 200° and 280° gave off 16.0 per cent of its volume.
Between 280° and 305° gave off 11.2 per cent of its volume.
Above 305° gave off 15.8 per cent of its volume.

Making the total volatile matter about 90 per cent, leaving a coke residue of about 10 per cent. Reported in a different way for the purpose of comparison, the following results are obtained:

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Crude oil from—	Specific gravity at 17° C.	Began to boil at—	Came over under 150° C.	Between 150° and 300° C.	Over 305° C.
		° C.	*Per cent.*	*Per cent.*	*Per cent.*
Texas—Corsicana	0.821	80	34.6	40	15.8
Pennsylvania	.818	82	21	38	40.7
Galicia	.824	90	26.5	47	26.5
Baku	.859	91	23	38	39
Alsace	.907	135	3	50	47
Hanover	.899	170	.....	32	68

It will be seen from this that the oil compares very favorably with Pennsylvania oil, which generally yields in practice from 60 to 75 per cent of burning oil of first and second quality.

The above figures, except for the Texas oil, are taken from Sadtler's Industrial Organic Chemistry, page 18.

There are a number of points in Texas where a dark oil of 28° to 30° gravity is found. This finds a market as a natural lubricating oil, and is obtained by drilling shallow wells. Near San Antonio, Bexar County, a few barrels are annually produced. In Nacogdoches County, 80 miles southwest of Shreveport, Louisiana, and at Sour Lake, in the western line of Jefferson County, there is a very small production of heavy dark lubricating oil.

The production of petroleum in Texas since 1889 has been as follows:

Production of petroleum in Texas from 1889 to 1896.

Year.	Barrels.	Year.	Barrels.
1889	48	1893	50
1890	54	1894	60
1891	54	1895	50
1892	45	1896	1,450

MISSOURI.

All the crude petroleum produced in this State during 1896 came from two wells in Bates County. It is considered a good grade of lubricating oil.

In the following table is given the production of crude petroleum in Missouri from 1889 to 1896:

Production of petroleum in Missouri from 1889 to 1896.

Year.	Barrels.	Year.	Barrels.
1889	20	1893	50
1890	278	1894	8
1891	25	1895	10
1892	10	1896	43

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ILLINOIS.

The only production of crude petroleum in this State is near Litchfield, Montgomery County. Four or five wells are producing a dark natural lubricating oil of 22° B., which finds a market at Litchfield. These wells are from 640 to 670 feet in depth.

The production of petroleum in this State since 1889 has been as follows:

Production of petroleum in Illinois from 1889 to 1896.

Year.	Barrels.	Year.	Barrels.
1889	1,460	1893	400
1890	900	1894	300
1891	675	1895	200
1892	521	1896	250

INDIAN TERRITORY.

There has been considerable work done in the Territory during 1896. The Creek Oil and Gas Company, of Muskogee, Creek County, has completed two wells. In both these wells a hard white sand was encountered at about 700 and 1,100 feet. Both sands yielded an excellent quality of light oil of an amber-green color, 47° B. This close sand has not yet been shot.

A well drilled at Red Fork, also in Creek County, by this Company in November, 1896, showed a small quantity of dark-brown oil, similar to the oil found in Kansas, at a depth of 1,500 feet.

The Okmulgee Oil Company, of Muskogee, began operations in December, 1896, at Eufaula. The Cherokee Oil and Gas Company, of Chelsea, had 9 productive wells at the close of 1896. None of them are now being pumped, but drilling is continued to more fully test their territory. The first oil was found at about 300 feet. There are two sands that have so far been developed that produce oil, separated by 120 feet of gray and black slate. The production is not large, being from ½ to 4 barrels per day; the gravity is 28° B. The flashing point is said to be 175°; cold test, 10° below zero. It is said to be an excellent lubricating oil and will be sold only as such.

The total production since 1891 has been as follows:

Production of petroleum in Indian Territory from 1891 to 1896.

Year.	Barrels.	Year.	Barrels.
1891	30	1894	130
1892	80	1895	37
1893	10	1896	170

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CANADA.

The regular production of the old fields of Petrolia and Oil Springs, about 18 miles southeast of Sarnia, at the mouth of the St. Clair River, for the past ten or twelve years, is one of the most remarkable facts connected with the field. In very many places the Corniferous limestone shows bitumen, some oil, and gas, but nowhere else is there anything like the quantity of oil that is produced at these localities, now over thirty years old.

There are about 16 square miles in the Petrolia field proper and 2 square miles in the Oil Springs field. Several wells were drilled near Bothwell, 15 miles southeast of Oil Springs, and several very fair wells secured, but nothing yet has been found that will compare with the old fields. The wells in these fields have to be torpedoed with from 8 to 10 quarts of nitroglycerin, which shatters the rock and increases their production.

South Essex County and Pelee Island have furnished several wells that have been reported as ranging from 20 to 40 barrels. The oil is found below the gas.

The usual manner of pumping the wells at Petrolia and Oil Springs is by clusters, and by the system of "Jerker rods." A pair of 12-horsepower engines will pump 60 to 80 wells that are strung out for a mile. The derricks are used only to put down the well, and are movable. To pull the rods three ash poles are used, 45 to 50 feet long and about 6 inches through, meeting at a point directly over the hole; from the apex a link is suspended, so that the tackle can be fastened. The oil fields present the appearance of a mass of large tripods scattered over the ground. The surface, and extending down to the Hamilton limestone, is a tough plastic clay, which is waterproof; this is utilized in storing the oil. The tank of wood is placed in a circular excavation and the back thoroughly rammed with the clay; the top is in some instances covered also; this prevents drying out, and adds many years to the life of the tank. The Canadian system of drilling, with poles instead of rope, seems to have been exclusively used in this field. Crews trained to this system have introduced it into all the fields of Europe, and were the first to open up several of the large developments that had formerly been operated in a very unsatisfactory manner by the old system of pits.

Numerous wells have been drilled outside of the Province of Ontario in search of oil. A well was drilled to the depth of 1,011 feet at Athabascus Landing, on the Athabasca River, by the Canadian government in 1894, which showed some gas but no oil. There are numerous shows of tar springs in the sandstone, which has been placed in the Cretaceous formation, and traces of both oil and gas are found along the Athabasca River for many miles. North of this, along the valleys of the Slave and Mackenzie rivers, tar and gas springs are reported.

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The Geological Survey of Canada reports oil springs in the Province of Quebec, near the extremity of the Gaspé peninsula. In 1891, 5 wells were drilled near Point St. Peter, one being about 3,000 feet deep; several shows of oil were reported, but nothing to indicate its presence in paying quantities. One of the incentives to find oil in Canada to supply the home demand, which it does not, is the import duty on crude and refined oils. The following is a list of the import duties:

Import duties on Canadian petroleum.

	Per barrel.
Crude petroleum, 3½ cents per imperial gallon	$1.12
Illuminating oil, etc., 7½ cents per imperial gallon	2.52
Lubricating oil, 6 cents per imperial gallon	2.10

The Canadian barrel has 35 imperial gallons of 277.27 cubic inches, making 9,704.4 cubic inches; the United States barrel has 42 gallons of 231 cubic inches, making 9,702 cubic inches—a very slight difference. The imperial or Canadian gallon is 20 per cent, or one-fifth, larger than the United States gallon. The following table shows the shipments of crude petroleum and refined petrolum reduced to crude equivalent, from Canada in 1895 and 1896:

Shipments of crude petroleum and refined petroleum reduced to crude equivalent from Canada in 1895 and 1896.

[Barrels of 35 imperial gallons.]

Month.	1895.			1896.		
	Crude.	Refined.	Crude equivalent.	Crude.	Refined.	Crude equivalent.
January	21,155	27,323	89,462	25,696	19,255	83,495
February	18,810	25,875	83,497	20,585	16,316	66,797
March	17,380	19,825	66,943	20,030	18,101	65,283
April	15,400	17,955	60,287	16,353	21,912	71,133
May	18,165	18,382	64,120	17,156	10,484	43,386
June	15,670	17,725	59,982	15,476	13,191	48,459
July	18,985	17,370	62,410	15,413	18,168	60,833
August	17,335	24,335	78,173	16,314	24,881	78,518
September	20,772	32,615	102,309	19,461	38,673	116,144
October	24,970	46,727	141,787	23,290	42,649	129,913
November	19,890	32,484	101,100	25,966	33,147	103,834
December	23,750	31,346	102,115	19,508	30,001	94,486
Total	232,282	311,962	1,012,185	235,248	286,778	962,281

From Mr. Kerr, of Petrolia, is received the following statement regarding the shipments and production of oil in 1894, 1895, and 1896. These are the shipments by railroad, and are given in barrels of 35 gallons each, by months.

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Shipments of crude petroleum from the Petrolia (Ontario) oil field in 1894, 1895, and 1896.

[Barrels of 35 imperial gallons.]

Month.	1894	1895.	1896.
January	101.570	89, 462	83, 495
February	76, 183	83, 497	66, 797
March	60, 661	66, 943	65, 283
April	73, 463	60, 287	71, 133
May	67, 369	64, 120	43, 386
June	57, 830	59, 982	48, 459
July	69, 586	62, 410	60, 833
August	86, 345	78, 173	78, 518
September	109, 973	102, 309	116, 144
October	156, 163	141, 787	129, 913
November	122, 513	101, 100	103, 834
December	97, 170	102, 115	94, 486
Total	1, 078, 826	1, 012, 185	962, 281
Shipped by pipe line	10, 000	0	0
Total	1, 088, 826	1, 012, 185	962, 281
Stocks in tanks—			
January 1	77, 000	40, 898	26, 000
December 31	40, 000	27, 987	33, 560
Increase or decrease in stocks	—37, 000	—12, 911	+7, 560
Approximate production	1, 051, 826	999, 274	969, 841

Owing to possibilities of the duplication of shipments, Mr. Kerr considers the production given to be too great by about 10 per cent, and estimates the production for 1895 and 1896 to be as shown in the following table:

Estimated production of petroleum in Canada in 1894, 1895, and 1896, by Mr. James Kerr.

[Barrels of 35 imperial gallons.]

	1894.	1895.	1896.
Shipped by road	970, 943	910, 967	866, 053
Shipped by pipe line	10, 000	.....	0
Total	980, 943	910, 967	866, 053
Increase or decrease of stocks	—37, 000	—12, 911	+7, 560
Making the production	943, 943	898, 056	873, 613

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In the following table is given a statement of the production of petroleum in Canada in the years 1886 to 1896, and the value of the same. These figures, it is stated, are calculated from the official inspection returns, and the values are computed at the average yearly price per barrel of 35 imperial gallons.

Production and value of petroleum in Canada from 1886 to 1896.

[Barrels of 35 imperial gallons.]

Year.	Production.	Value.
1886	486,441	$437,797
1887	763,933	595,868
1888	733,564	755,571
1889	639,991	612,101
1890	765,029	902,734
1891	755,298	1,004,596
1892	779,753	982,489
1893	798,406	834,344
1894	829,104	835,322
1895	728,665	1,090,520
1896	726,822	1,155,646

The average closing prices of petroleum for each year from 1885 to 1896 at the Petrolia Oil Exchange, together with the total sales for the year on this exchange, are as follows:

Average price and sales of crude petroleum in the Petrolia Oil Exchange from 1885 to 1896.

Year.	Price.	Sales.
		Barrels.
1885	$0.82½	871,500
1886	.86¼	782,570
1887	.78	406,203
1888	1.02½	516,007
1889	.92½	400,932
1890	1.18	394,924
1891	1.33¼	377,453
1892	1.26¼	165,315
1893	1.09½	20,941
1894	1.00¼	32,348
1895	1.49⅞	9,755
1896	1.59	0

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There was a great falling off of sales for the last three years previous to 1896, and during last year they ceased altogether. This does not imply a decrease in the actual business in the oil field, but simply that the petroleum went direct to the refineries instead of being sold by the brokers through the exchange. The exchange prices show the value in the market.

In the following table will be found a statement of the average closing prices for crude oil on the Petrolia Oil Exchange for 1892 to 1896:

Average closing price of crude petroleum on the Petrolia Oil Exchange from 1892 to 1896, by months.

Month.	1892.	1893.	1894.	1895.	1896.
January	$1.29¼	$1.18¼	$1.01¼	$1.16	$1.72
February	1.29	1.18¾	1.01	1.19⅛	1.72
March	1.27¾	1.19	1.01	1.27	1.72
April	1.26½	1.19	.99½	1.55¾	1.71
May	1.25¾	1.07	.92	1.67½	1.70
June	1.27½	1.07	.92¾	1.52	1.50
July	1.26¾	1.06	.94	1.52½	1.50
August	1.26	1.05	.96	1.54	1.50
September	1.26	1.04½	.98	1.55⅛	1.50
October	1.26¾	1.04	1.06	1.59⅞	1.50
November	1.25	1.04	1.12½	1.64½	1.50
December	1.18½	1.02	1.13½	1.72⅝	1.50
Average	1.26½	1.09½	1.00¾	1.49⅜	1.59

It will be noticed that the price of petroleum in the above table was highest in December, 1895, and January, February, and March, 1896. The price of Lima oil was highest in April, 1895. The large difference in the price of Lima oil, as compared to Canadian oil, which is nearly of the same quality, is owing to the protection given the Canadian product by the import duty already mentioned.

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The following statement is given of the operations of the refineries in Canada for the years 1890 to 1896, inclusive:

Production of Canadian oil refineries from 1890 to 1896.

[Imperial gallons.]

Year.	Illuminating oils.		Benzine and naphtha.		Paraffin oils.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*		*Gallons.*	
1890	11,129,277	$1,264,677	636,247	$37,026	446,888	$64,713
1891	10,427,040	1,170,241	603,971	36,790	622,287	75,772
1892	10,806,806	1,176,720	793,263	60,130	1,051,163	127,351
1893	11,100,810	1,073,738	721,192	54,760	1,243,924	116,233
1894	11,289,741	1,003,973	645,031	54,515	1,282,749	118,053
1895	10,711,378	1,217,426	642,484	63,026	1,016,039	140,245
1896	11,207,150	1,251,122	719,453	70,733	1,014,271	132,308

Year.	Gas and fuel oils.		Lubricating oils and tar.	
	Quantity.	Value.	Quantity.	Value.
	Gallons.		*Gallons.*	
1890	4,246,447	$84,752	2,877,388	$130,349
1891	3,373,720	89,267	2,500,000	101,752
1892	6,343,589	202,047	3,177,853	133,336
1893	7,559,489	217,740	1,876,633	92,616
1894	7,323,374	197,193	1,801,174	74,309
1895	6,095,355	218,692	1,698,559	75,578
1896	6,788,353	261,618	1,447,455	77,109

Year.	Paraffin wax.		Value of other products.	Total value.
	Quantity.	Value.		
	Pounds.			
1890	913,730	$56,903	.....	$1,638,420
1891	741,611	60,687	.....	1,534,509
1892	876,570	82,781	.....	1,782,365
1893	1,659,167	120,697	.....	1,675,784
1894	1,950,172	119,091	.....	1,567,134
1895	1,840,021	82,970	$8,300	1,806,327
1896	1,532,670	466,978	7,774	2,267,642

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The following table shows the amount of Canadian oils and naphtha inspected, together with the amount of crude that is assumed as the equivalent of the refined oils and the ratio of crude to refined:

Canadian oils and naphtha inspected, and corresponding quantities of crude oil.

Fiscal year.	Refined oils inspected.	Crude equivalent calculated.	Ratio of crude to refined.
	Gallons.	*Gallons.*	
1881	6,406,783	12,813,566	100:50
1882	5,910,787	13,134,998	100:45
1883	6,970,550	15,490,111	100:45
1884	7,656,011	19,140,027	100:40
1885	7,661,617	19,154,042	100:40
1886	8,149,472	21,445,979	100:38
1887	8,243,962	21,694,637	100:38
1888	9,545,895	25,120,776	100:38
1889	9,462,834	24,902,195	100:38
1890	10,121,210	26,634,763	100:38
1891	10,270,107	27,026,597	100:38
1892	10,370,707	27,291,334	100:38
1893	10,618,804	27,944,221	100:38
1894	11,027,082	29,018,637	100:38
1895	10,674,232	28,090,084	100:38
1896	9,666,733	25,438,770	100:38

AUSTRIA-HUNGARY.

GALICIA.

Galicia occupies the third place in the production of oil among the countries of the world yielding this important article of commerce.

The year 1895 was remarkable for the large development at Schodnica, about 8 miles southwest of the town of Boryslaw. During the summer of this year a number of large wells were found, producing from 200 to 400 barrels per day.

In the month of August, 1895, the "Jacob well" commenced to flow, when a depth of 303 meters, or 985 feet, was reached, at the rate of between 6,000 and 7,000 barrels per day. Three months after it was down to 1,000 barrels per day, and would have reached this amount much sooner had not the flow been shut off most of the time for want of tankage.

During the fall of 1895 there were in all about 100 wells producing and 50 drilling wells.

At Schodnica a number of large iron tanks were erected. A 2-inch pipe line 6 miles long connects Schodnica and Boryslaw, and another, a

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3-inch line, was recently completed. The oil in this field comes from a dark, compact Eocene sand. The wells are from 1,000 to 1,350 feet in depth, and in this locality are comparatively free from caving strata, requiring only from two to three strings of casing to reach the oil-bearing formation.

Potok is the next field in importance, and is located 4 miles northwest of Krosno. It was opened up in 1889. There are 45 to 50 wells here on an area of not more than 50 acres. About 100 wells are producing in this field. The largest wells found their production at 400 to 550 meters. The deepest oil-producing well in Europe is found here. It is 653 meters (2,140 feet) deep, and is a fair producer. One well six years old is still producing at the rate of 100 barrels per day. This locality is also noted for the presence of a whole tribe of minute fossils, known as foraminifera.

Rowne, Wietrzno, and Bobrka.—These three divisions are really continuous. The general course is N. 55° E., and extends for 3 miles. There are in all 65 producing wells, from 330 to 360 meters in depth. The production in 1895 was about 80,000 barrels from the Eocene formation.

Rapica, Ruska, Siary, and Sekowa.—These are a connected line of development. The general course is S. 65° E. for 6 meters, and the fields have a combined production of 75,000 barrels per annum. The depth of the wells varies from 260 to 380 meters. There are about 110 wells in the entire group. Some of the oldest pits that have been worked in Galicia are found here. There is a series of folds lying parallel to the general length that has given unusual width to the producing territory. The oil is found in the upper Cretaceous and lower Eocene.

Pasieczna.—This place is 50 meters southwest of Stanislaw, quite near the Hungarian border, and is a comparatively new field. There are 25 producing wells, having a production of 125 barrels per day. The oil found here is of a very light-green color and a gravity of 50° to 52° Baumé. It is mostly refined on the spot and hauled by wagons over a mountain pass to Hungary. The river here cuts through an arch of the measures at nearly right angles and finely exposes the strata. The oil is produced from the lower Eocene.

Sloboda.—This is the most southeasterly field in Galicia, and covers an area of about 100 acres, on which over 200 wells have been drilled. From 1880 to 1885 these produced about 30,000 barrels per month; their production now is hardly 3,000. For more detailed figures of production of the numerous fields, see the table on a later page.

All of the places enumerated are on the flank of the Carpathian Mountains, and run parallel for over 220 miles. The course is northwest-southeast, and the belt is just where the foothills lose themselves in the plain. The force that reared the great backbone of the Carpathian Mountains has brought the older crystalline rocks to the surface and caused a series of gradually decreasing parallel folds toward the

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northeast. This force has buckled and folded up the remaining newer sedimentary deposits, belonging to the Jurassic, Cretaceous, Eocene, and Miocene, and slid them upon one another to an extent that seems to be almost incredible. To these folded and inclined rocks, more or less fractured and porous, together with the impervious nature of the strata that encase them, the reservoirs of oil are due. In nearly every case the oil is found on an arch or saddle, with steep sloping flanks. The oil finds its way to the surface near the apex. The folding of the strata has generally been so violent that most of the natural gas has escaped.

The following table shows in a general way the succession of the strata, in descending order:

Succession of strata in the petroleum region of Galicia.

Miocene.—Red and blue clay and salt clays; sandstone and clays with salt; ozocerite, sulphur, gypsum, and oil shows.

Oligocene.—Lignite coal, sandstone with calamites; flagstone with oil shows; conglomerate with oil shows; menilite slate, with fish remains; hornstone (flint stone).

Eocene.—Upper fucoidal stone and slate; numulitic sandstone; hieroglyphic limestone with oil.

Cretaceous.—Red and blue marl clays; Jamna sandstone; Ropianka sandstone, with oil.

There are many shows of oil and gas above, and some in the menilite slate, but the tests made in the horizon have not so far produced any lasting quantity of either. The first real oil horizon is the sandstone with more or less hieroglyphics, interstratified with green marl above, which are the red and blue clays. The second real horizon is the Ropianka sandstone, which is usually a heavy bed of coarse-grained sandstone containing some pebbles.

Drilling in Galicia is generally slow and uncertain, because of the broken condition and inclination of the strata, the numerous quicksands, and beds of putty clay. It is usual to start a hole as large as 26 inches, using 24-inch riveted casing. After this has been forced down as far as possible, the hole is continued below through this casing until the walls will stand no longer. Then another casing, about 1 inch less in diameter, is put in, and so on, one telescoping inside of the other, until there are 8 or 10 strings of casing, commencing at the mouth and reaching down to various depths. From 8 feet down, artesian casing is generally used, the others being riveted casing.

The system of undercutting and following the drill by casing is also in use. This requires care, as the sand must not be allowed to settle around it. To prevent this the casing must be kept on the move and never allowed to stand more than three or four hours.

Nearly all the drilling is done by what is known as the Canadian system, using poles instead of rope. Where the wells are shallow it answers fairly well, but it is very slow and uncertain in deep holes. Some wells are drilled by hand, using the "free fall system," which requires the services of 4 to 6 men.

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PIPE LINES.

The oil is generally carried to the nearest railroad or to the refinery by pipe lines. The following are the principal:

Potok to Jedlicze, two lines, 6 kilometers in length.

Wietrzno, Bobrka, and Rowne to Krosno, 16 kilometers in length.

Ropianka and Wankowa to Olszanica, two lines, 14 kilometers in length.

Schodnica to Boryslaw, two lines, 14 kilometers in length.

Schodnica to Brohobycz, one line, 23 kilometers in length.

Weglowka to Korezyna, one line, 8 kilometers in length.

A considerable portion is hauled by teams to the refineries when the distance is not more than 10 kilometers.

There are 72 iron tanks scattered among the various fields and railroad transfer points, with a total capacity of about 250,000 barrels of 42 gallons.

REFINERIES.

There are a considerable number of refineries. The principal ones are as follows:

Peczenizya: Szczepanowski & Co., near Kolomea.

Drohobycz: M. Gartenberg; Lautenbach, Schreyer & Co.

Maryampolski: Bergheim and MacGarvey, near Gorlice.

In some localities the refinery is operated by one or two men, with only one small still, in the most crude manner.

The gravity of the oil varies greatly. That of the main body of production is from 33° to 36° Baumé (0.859 and 0.843), and ranges from black to dark amber and to nearly pea-green. It usually has from 2 to 5 per cent of paraffin.

The following table of comparison has been prepared by Mr. Engler, and is no doubt approximately correct:

Comparison of the products of Pennsylvania oil with those of Europe.

Character of product.	Pennsylvania.	Galicia.	Roumania.	Alsace.	Baku.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Light oils	10 to 20	3 to 6	4	.....	5 to 10
Illuminating	60 to 70	55 to 65	60 to 70	35 to 40	32 to 50
Residuum	5 to 10	30 to 40	25 to 35	55 to 60	36 to 60

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PRODUCTION.

The following is a list in detail of approximate daily production and approximate number of producing wells in 1895:

Approximate daily production and number of wells in Galicia in 1895.

District.	Number of wells producing.	Approximate daily production (barrels, 42 gallons).	District.	Number of wells producing.	Approximate daily production (barrels, 42 gallons).
Rowne	24	125	Mrnkowa	.....	2
Wietrzno	15	10	Ropianka - Wankowa	35	130
Bobrka	33	30	Pasieczna	27	125
Rapica-Ruska	42	150	Sloboda	100	100
Siary	43	45	Zagorz	6	5
Sekowa	35	50	Weglowke	17	80
Harklowa	23	40	Jwonicz-Bath	12	10
Wojtowa	31	6	Potok	90	310
Lipinki	10	4	Sekowa-Wola	14	10
Kryg	17	20	Klimkowka	6	15
Plowco	.....	3	Kobylanka	17	50
Libusza	11	5	All others estimated at	200	500
Schodnica	220	3,065	Total	1,100	5,000
Boryslaw	7	60			
Rypne	38	30			
Ropianka	6	10			
Lodyna	21	10			

Multiplied by 300 days, approximate yearly production 1,500,000 barrels.

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Mr. Boverton Redwood kindly furnished the statistics of the production of crude petroleum in Galicia given in the following table:

Production of crude petroleum in Galicia from 1883 to 1896.

Year.	Barrels of 1½ metric centners (of 100 kilos) each.	Barrels of 42 United States gallons.
1883	166,500	179,584
1884	233,000	251,309
1885	333,000	359,167
1886	433,000	467,025
1887	532,000	573,805
1888	665,000	717,256
1889	746,000	804,620
1890	816,000	880,121
1891	1,083,168	1,168,283
1892	1,096,242	1,182,385
1893	1,192,016	1,285,685
1894	1,200,000	1,294,296
1895	1,432,067	1,544,591
1896	2,265,100	2,443,080

As it may be of interest, the production of crude petroleum in 1895 and 1896, by fields, is given as follows:

Production of crude petroleum in Galicia in 1895 and 1896, by fields.

Fields.	1895.		1896.	
	Meter centners.	Barrels of 42 gallons.	Meter centners.	Barrels of 42 gallons.
Marcinkowce, Gorlice, Zagórzany	275,880	198,372	291,300	209,459
Skolyszyn, Jaslo, Krosno	773,400	556,113	788,600	567,043
Rymanów, Sanok	15,600	11,217	14,200	10,211
Olszanica, Ustrzyki, Chyrów, Sambor	127,680	91,808	130,300	93,692
Drohobycz, Boryslaw, Skole, Krechowice	850,734	611,720	2,047,950	1,472,578
Stanislawów, Nadwórna, Kolomyja	104,806	75,361	125,300	90,037
Total	2,148,100	1,544,591	3,397,650	2,443,080

The greatest increase in production occurred at Schodnica, near Drohobycz. This district produced 1,330,387 barrels of crude petroleum, or nearly 60 per cent of the total output. The year 1896 shows an increase of 60 per cent over 1895.

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The average price for 1895 was 23.5 florins per metric ton, equal to $1.30 per barrel.

1 florin = 40 cents.
1 metric ton = 2,204.74 pounds.
1 metric ton = 7.1905 barrels of crude oil of 42 gallons.
1 metric centner = 100 kilos = 220.462 pounds.

According to the latest statistics compiled by "Naphtha," the Galician oil production in 1896 amounted to 339,765 metric tons, or about 2,443,080 barrels. Of the total, 287,705 metric tons, or about 2,068,743 barrels, were produced by the 48 members of the Galician Producers' Syndicate, and but 52,060 metric tons, or 374,337 barrels, by the 108 independent producers. The Austro-Hungarian refineries consumed 315,260 metric tons, or 2,266,877 barrels, of crude, and 260 metric tons, or 1,870 barrels, were exported. There were 26,247 metric tons, or 188,714 barrels, consumed by small refineries at points of production. The shipments from the different fields were as follows:

Shipments and consumption of petroleum in Austria-Hungary in 1896.

	Metric tons.	Barrels of 42 gallons.
Gorlice	29,130	209,459
Jaslo-Krosno	74,870	538,353
Rymanow-Sanok	410	2,948
Ustrzyki-Dolne-Sambor	13,030	93,692
Drohobycz-Schodnica	185,020	1,330,387
Stanislaw-Kolomea	11,060	79,527
Total shipments	313,520	2,254,366
The consumption of crude by—		
Galician refineries	108,250	778,372
Austrian refineries (outside Galicia)	120,050	863,219
Hungarian refineries	84,960	610,905
Exported	260	1,870
Total consumption	313,520	2,254,366

The following tables are taken from the reports of the Imperial Minister of Finance. They do not include all of the crude oil produced, but refer to the excise tax on the refined product principally. Crude oil pays an import duty into Austria-Hungary of 2.40 florins in gold per 100 kilos, which is equal to about $1.33 per barrel; if below 0.830 specific gravity, about 38° Baumé; if above 0.830 specific gravity, it pays 2 florins per 100 kilos, or $1.11 per barrel. Refined petroleum pays an import duty into Austria-Hungary of 10 florins for 100 kilos, or about $5.56 per barrel. Refined petroleum made in Austria-Hungary pays 6.50 florins excise tax, equal to about $3.70 per barrel.

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Crude oil imported first pays the import duty and if refined must pay the excise duty:

Petroleum in Austria-Hungary.

Year.	Number of refineries.	Mineral oil shipped from places of production subject to excise duty—			
		Under payment of consumption tax.		Without payment of consumption tax. To be exported beyond the customs line.	
		Quintals.	*Barrels of 42 gallons.*	*Quintals.*	*Barrels of 42 gallons.*
1883	65	201,811.52	160,504	92.80	74
1884	62	232,943.85	185.264	259.01	206
1885	65	340,033.77	270,434	1,499.64	1,193
1886	63	450,989.87	358,679	918.15	730
1887	61	541,172.56	430,403	576.26	458
1888	58	644,145.32	512,298	1,684.55	1,340
1889	56	671,742.20	534,247	6,478.66	5,153
1890	53	737,296.66	586,383	5,491.77	4,368
1891	51	805,753.30	640,828	5,789.18	4,604
1892	50	941,240.12	748,582	8,531.42	6.785
1893	49	949,863.36	755,441	23,948.19	19,046
1894	49	1,059,531.87	842,662	35,083.64	27,903

Year.	Mineral oil shipped from places of production subject to excise duty—			
	Without payment of consumption tax. Of less density than 770° for industrial purposes as solvent and for extracts.		Total.	
	Quintals.	*Barrels of 42 gallons.*	*Quintals.*	*Barrels of 42 gallons.*
1883	822.28	654	202,726.60	161,232
1884	1,334.12	1,061	234,536.98	186,531
1885	2,877.38	2,288	344,410.79	273,915
1886	3,362.42	2,674	455,270.44	362,083
1887	5,288.38	4,206	547,037.20	435,067
1888	4,398.67	3,498	650,228.54	517,136
1889	5,749.21	4,572	683,970.07	543,972
1890	7,036.76	5,596	749,825.19	596,347
1891	7,224.91	5,746	818,767.39	651,178
1892	10,463.75	8,322	960,235.29	763,689
1893	11,979.92	9,528	985,791.47	784,015
1894	14,004.50	11,138	1,108,620.01	881,703

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Petroleum in Austria-Hungary—Continued.

Year.	Number of refineries.	Mineral oil subject to excise duty.		Mineral oil not subject to excise duty (refined).	
		Quintals.	*Barrels of 42 gallons.*	*Quintals.*	*Barrels of 42 gallons.*
1883	65	202,726.60	161,232	60,731.53	48,301
1884	62	234,536.98	186,531	66,802.69	53,129
1885	65	344,410.79	273,915	66,131.31	52,595
1886	63	455,270.44	362,083	86,737.06	68,983
1887	61	547,037.20	435,067	70,031.07	55,697
1888	58	650,228.54	517,136	77,214.47	61,410
1889	56	683,970.07	543,972	99,242.77	78,929
1890	53	749,825.19	596,347	124,211.92	98,788
1891	51	818,767.39	651,178	137,761.68	109,564
1892	50	960,235.29	763,689	170,778.27	135,823
1893	49	985,791.47	784,015	170,673.61	135,739
1894	49	1,108,620.01	881,703	220,228.78	175,152

Year.	Mineral oil not subject to excise duty (crude).		Total.	
	Quintals.	*Barrels of 42 gallons.*	*Quintals.*	*Barrels of 42 gallons.*
1883	4,309.45	3,099	267,767.58	212,632
1884	723.36	520	302,063.03	240,180
1885	250.57	180	410,792.67	326,690
1886	2,483.16	1,786	544,490.66	432,852
1887	11,402.53	8,199	628,470.80	498,963
1888	11,532.27	8,292	738,975.28	586,838
1889	6,462.33	4,647	789,675.17	627,548
1890	11,657.91	8,383	885,695.02	703,518
1891	2,595.09	1,866	959,124.16	762,608
1892	12,205.43	8,776	1,143,218.99	908,288
1893	17,298.47	12,438	1,173,763.55	932,192
1894	848.41	610	1,329,697.20	1,057,465

1 quintal=220.462 pounds.
1 gallon refined oil=6.6 pounds.
1 gallon crude oil=7.3 pounds.
1 quintal of refined=0.795317 barrels of 42 gallons.
1 quintal of crude=0.71905 barrels of 42 gallons.

ROUMANIA.

The oil belt follows on the flank of the Carpathian Mountains, from near the Iron gate to Galicia, its course being first nearly east for about 200 miles, then swinging a little west of north for about 200 additional miles. It is by no means a continuous line of development, but a line connecting, in a general way, points where oil is being produced, with a width of from 5 to 15 miles along this zone.

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The Carpathian Mountains have a backbone of igneous rock, and are from 6,000 to 8,000 feet in height. As we approach the plain we find the newer rocks in contact with the older ones very violently folded and crushed. This violent folding grows less as we descend, until a series of well-marked anticlines and synclines are observed, and finally these are lost in the drift-filled valley of the Danube River to the south and the Pruth to the east. Near the crest of the comparatively symmetrical anticlines the oil is found, or it may be a short distance down the slope. The early shaft workers located their pits, attracted to the locality by springs of oil, near the crest of the anticlinal.

The exact division of the Tertiary strata holding the oil is difficult to determine, owing to the few fossils exposed. It is probably found in both the Miocene and Pliocene, and may extend in some localities to the Cretaceous.

The oil is generally found in a dark, loosely cemented sandstone, from 1 to 30 feet in thickness. The thicker strata often carry gravel and bowlders; the covering is a compact blue clay or shale with crystals of gypsum scattered through it. The presence of water in quantity will of course prevent the sinking of a shaft. This fact necessitates the selection of locations near the anticlines; the depth of the shaft is often above the drainage of the valley. These shafts are simply wells dug down, in some instances to 700 feet in depth, usually 1 meter square. The sides are secured by a slight cribbing of wood or wickerwork woven in a circle. The man at the bottom has a separate rope attached to his body, so that in case he is overcome by gas he can be hoisted up and revived. Air is carried down by a 6-inch tin pipe secured to the corner, and the air is supplied by a pair of immense bellows at the top or a large fan worked by hand. The oil is hoisted in buckets, sometimes by hand windlasses, or it may be by a gin worked by horses. In some instances the winding drum is driven by steam. There are about 750 of these hand-dug wells, which produce over 75 per cent of the product, and about 40 drilled wells that produce the remaining 25 per cent. Some 20 to 25 scattered throughout the region are dry or hopelessly "plugged."

The loose nature of the sand prevents the general use of the working barrel and cups, and necessitates the hoisting of the oil in a bailer inside the casing, attached to a small wire rope, propelled by steam, when the wells cease to flow.

The cost of drilling wells, owing to the soft nature of the soil, is greater than for the average well in Pennsylvania. The inclination of the strata, together with the presence of scattered bowlders, increases the risk of getting a crooked hole. In some cases they use a series of light riveted casing, telescoped one inside of the other, using a smaller size when it is impossible to drive the larger size deeper. Several wells have been under-reamed below the 8-inch casing to the oil sand. The depth of drilled wells runs from 800 to 1,500 feet.

There are a number of short pipe lines connecting the scattered oil

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fields with the railroads. A considerable quantity of the oil is hauled in casks, holding from 5 to 6 barrels, mounted on a wagon and drawn by oxen.

The pipe lines are generally owned by the producers and refiners. Several of them are well equipped with iron tanks and pumps. They are as follows:

Glodeni to Gosa Doicesti, 6 miles, 3-inch pipe; Soloncu to refinery at Moenesti, 12 miles, 3-inch pipe; Busteni to Doftana, 7 miles, 3-inch pipe; Busteni to Ploesci, 6 miles, 2-inch pipe; Calibasi to Baicoi, 16 16 miles, 2¾-inch pipe.

From these points the crude oil is transported in tank cars that hold from 80 to 100 barrels.

There are 85 refineries, with a yearly capacity of 940,000 liters. The great majority of these do not deserve the name, however, as they have only one or two small stills. The largest refinery is at Bucharest; one is at Moenesti and one at Monteosa. Those at Tergoviste and Campina are of good size and well equipped. There are smaller ones at Ploesci and Buzeu.

The quality of the oil differs considerably almost in the same locality, one having a large percentage of paraffin and another showing only a slight trace. The color is usually a dark green tinged with yellow. The gravity varies from 33 to 42°, the general average being from 36 to 40°. The general average obtained by refining is as follows:

Average yield of Roumanian oil.

	Per cent.
Naphtha	5 to 12
Illuminating oil	35 to 50
Lubricating oil	10 to 12
Paraffin	¼ to 4
Loss and residuum	35 to 45

The price of crude oil at the wells ranges from $1 to $1.20 per barrel.

The import duty on foreign oil imposed by the Roumanian Government is as follows:

Import duty on foreign oil in Roumania.

Crude oil	francs per 100 kilos	20
Refined oil	do	15

The Government, in 1895, passed some very liberal laws allowing foreigners to lease oil lands from the natives, and also to lease Government lands on payment of 4 per cent of the net profits The Government owns about one-quarter of the entire Kingdom.

The capital invested in wells, pipe lines, tanks, and fixtures is estimated at $1,680,000; capital in refineries is estimated at $800,000; total, $2,480,000.

Out of a total of 543,348 barrels, or 7,557 tank cars, produced in 1896, Roumania absorbed about 435,348 barrels. The remaining 108,000 barrels, or 1,500 tank cars, were exported to Kronstadt in Hungary and there refined, no import duty being imposed on this amount by special agreement with the Austrian Government.

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The population of Roumania is, in round numbers, 6,000,000. The consumption per capita is therefore light, owing to the unenlightened condition of the large rural population.

The price of water-white oil is about 15 francs per 100 kilos, or about 9 cents per gallon.

Production of crude petroleum in Roumania in 1896.

Locality.	Tank carloads of 100 metric centners.
Baicoi	250
Glodeni	1,365
Campina	300
Dolftana and Busteni	2,960
Ochisori and Matitza	178
Sarata (Buzeu)	902
Tega	
Other localities	1,602
Total	7,557

Production of crude petroleum in Roumania from 1874 to 1896.

Year.	District.				Total.	
	Prahova.	Buzeu.	Bacau.	Dimbovitza.	Tank cars.	Barrels (42 U. S. gallons).
1874	155	780	220	280	1,435	103,176.5
1875	160	820	230	300	1,510	108,569
1876	150	760	280	320	1,510	108,569
1877	180	760	250	320	1,510	108,569
1878	210	750	250	300	1,510	108,569
1879	250	700	280	300	1,530	110,007
1880	290	710	300	290	1,590	114,321
1881	350	740	300	300	1,690	121,511
1882	540	700	310	350	1,900	136,610
1883	570	700	320	350	1,940	139,486
1884	1,560	700	300	370	2,930	210,667
1885	1,350	700	300	340	2,690	193,411
1886	880	750	290	425	2,345	168,605.5
1887	950	800	280	500	2,530	181,907
1888	890	840	360	950	3,040	218,576
1889	950	1,010	380	1,800	4,140	297,666
1890	1,030	1,100	600	2,600	5,330	383,227
1891	1,150	1,050	790	3,800	6,790	488,201
1892	1,600	1,100	850	4,700	8,250	593,175
1893	1,700	950	1,300	3,500	7,450	535,655
1894	2,600	925	1,650	1,880	7,055	507,254.5
1895	3,714	904	1,838	1,544	8,000	575,200
1896	3,688	902	1,602	1,365	7,557	543,348

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GERMANY.

The most important oil field in Germany is that of Alsace, which is one of the provinces that formerly belonged to France. The principal points of production center around Hagenau, some 25 miles north of Strasburg, surrounded by a gently sloping fertile plain, the River Rhine being to the east and the Vosges Mountains on the west. The western limit of the oil field is considered to be marked by the outcropping of the Jura formation, which has a general trend northeast and southwest. To the east of this line the Oligocene, whose geological position is toward the lower part of the Tertiary period, is credited with producing the bulk of the oil. The Cretaceous seems to be wanting.

The oil-bearing sands are dark and coarse, more or less compact, and seem to form great lenticular-shaped islands from 50 to 250 feet wide, 1,500 to 2,500 feet long, and from 1 foot to 20 feet in thickness. A well may pass through three of these pays—the first at 135 to 160 meters, the second at 70 meters below the first, and the third at 30 meters below the second pay, or one or all may be missed.

At Pechelbronn (meaning pitch spring) oil has been known for many centuries. Mining, by sinking shafts, was commenced there in 1742, and had gone on until 1880, at which time workings were 296 feet below the surface. They collected the sand and secured 4 per cent of oil from it, by heating in hot water or distilling. The main supply oozed out of the sand in the openings. Since 1880 over 600 wells have been drilled, chiefly with the free fall hydraulic system. Several large flowing wells have been secured, and a large number of moderate wells, from 130 to 500 meters in depth. The majority were dry holes; yet there are a number of wells now pumping 50 to 100 barrels per day. There are 23,000 acres embraced in the concessions to this property. The production on this property is about 80,000 barrels of crude per year, from about 60 wells.

The Gewerskschaft-Rudolf property embraces 200 concessions, amounting to 85,000 acres, and is producing 90 barrels per day.

The T. O. Steib concessions cover a large area, but are not considered so well located. The oil is almost black, has a gravity of about 0.876 (28° B.), and carries 20 per cent of water as it comes from the wells. By steaming it most of the water can be separated from it. From 25 to 30 per cent of illuminating oil of very good quality is obtained, and a large proportion of lubricating oil.

The import duty of 6 marks per 100 kilos ($1.96 per barrel) on illuminating and 10 marks per 100 kilos on lubricating gives all the oil produced in Germany a decided advantage.

Oil is also reported in the southern portion of Alsace, near the town of Colmar, in a formation similar to that producing oil in the northern portion.

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Hannover oil fields.—Sixty miles southeast of Bremen, at Weitze, and 25 miles farther southeast, at Oelheim, there is a production of about 11,000 barrels annually of a very dark, heavy oil. Besides these points, there are a large number of abandoned wells. There are several places where the surface sand has been saturated with this heavy oil. By scraping it up and placing it in a large wooden trough, and pouring on hot water and agitating with a wooden paddle, several gallons of dark, heavy oil can be skimmed off. This is generally used for cart grease.

At Weitze there were 14 wells operated in 1895, and the entire production is 20 to 25 barrels per day.

Oelheim.—This place is 18 miles east of the city of Hannover and about 5 miles north of Peine. This is an old field; it is about twenty years since the first wells were drilled, by Canadians. When the oil sand was tapped in some of the first wells, they started off at the rate of 200 to 300 barrels per day, and caused great excitement, but in a short time salt water took the place of the oil. Both here and at Weitze operators have to handle a large amount of water to get a barrel of oil. One company here had 88 wells, another 25; of this number only 18 are producing about 100 barrels per week, and they probably pump 100 barrels of water to get 1 barrel of oil. The wells are 60, 80, 120, and 150 meters deep.

Refineries.—At Pechelbronn, in Alsace, there is a refinery of some magnitude; one at Bodromstein, from which 22 to 26 per cent of illuminating oil and 30 per cent of lubricating oil is obtained; and one in Hannover, at Peine, from which not more than 15 to 18 per cent of illuminating oil is obtained, but a much larger proportion of lubricating oil.

The production of petroleum in Germany from 1890 to 1896 is shown in the following table.

Production of petroleum in Germany from 1890 to 1896, inclusive.

Year.	Production.	
	Metric tons.	Barrels (42 gallons).
1890	15,226	108,295
1891	15,315	108,927
1892	14,257	103,323
1893	13,974	99,395
1894	17,232	122,563
1895	17,051	121,277
1896	20,395	145,061

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The following table shows the production and value of petroleum in the German Empire in 1894 and 1895, by states.

Production and value of petroleum in the German Empire in 1894 and 1895.

State.	1894.			
	Quantity.		Value.	
	Metric tons.	Barrels.	Marks.	Dollars.
Alsace-Lorraine	15,632	111,183	813,284	195,188
Prussia	1,600	11,380	159,163	38,199
Total	17,232	122,563	972,447	233,387

State.	1895.			
	Quantity.		Value.	
	Metric tons.	Barrels.	Marks.	Dollars.
Alsace-Lorraine	15,439	109,812	776,671	186,401
Prussia	1,612	11,465	185,784	44,588
Total	17,051	121,277	962,455	230,989

The value of the 20,395 metric tons produced in Alsace and Prussia in 1896 was 1,188,511 marks, amounting to $285,243, or $1.97 per barrel.

GREAT BRITAIN.

The mineral statistics of the United Kingdom give the production of petroleum from 1886 to 1895 as follows:

Production of petroleum in Derbyshire, England, from 1886 to 1895.

Year.	Tons (2,240 pounds).	Barrels (42 gallons).
1886	43	314
1887	66	482
1888	35	256
1889	30	219
1890	35	256
1891	100	731
1892	218	1,594
1893	260	1,900
1894	49	358
1895	15	110

Value of 49 long tons in 1894, £92=$448.
Value of 15 long tons in 1895, £28=$136.

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The quantity and value of oil shale produced in Great Britain from 1890 to 1895 are shown in the following table. Most of the oil shale is mined in Scotland.

Production and value of oil shale in Great Britain from 1890 to 1895.

Year.	Production.	Value.
	Tons.	
1890	2,212,250	£608,369
1891	2,361,119	707,177
1892	2,089,937	522,484
1893	1,956,520	489,130
1894	1,986,385	496,596
1895	2,246,865	561,716

The crude oil varies from about 20 to 30 imperial gallons per ton of 2,240 pounds; the ammonia water, yielding sulphate of ammonia, from 25 to 65 pounds per ton. The products from crude oil vary to a less extent, and from 100 gallons thereof the following may be considered as about an average yield:

Average yield of 100 gallons of crude shale oil.

	Gallons.
Spirit	5
Burning oil	30
Gas oils, 0.840 to 0.865 sp. gr	8
Heavy oils, 0.875 to 0.895 sp. gr	16
Paraffin scale	14
Total	73

There is also a small residue of tar and coke suitable for burning.

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ITALY.

Natural petroleum produced in Italy has been used for more than a century, the first oil being obtained by sinking shafts 30 to 60 feet in the valley of the river Faro, near Parma, in the division of Emilia. It was used in the crude state for lighting the cities of Genoa, Parma, and Borgo San Donnino.

A number of localities have produced oil in more or less quantity from artesian wells, namely: Ozzano, in the valley of Faro, district of Emilia; Rivanazzano, in the valley of Stafforia; Salsomozzoni, west of Parma, district of Emilia; Salosominore, west of Parma, district of Emilia; Vallea, in the province of Piacenza; Monteechino, in the province of Piacenza. There are also a great number of small pits furnishing oil, and numerous natural gas outlets have been found scattered along the northern slope of the Apennines, from southeast of Bologna to Rivanazzano near the Stafforia River, in what is generally known as the zone of Emilia. Numerous pits and wells have ceased to yield oil.

The geological horizon which produces the oil has been assigned to the Tertiary, and is probably Miocene or Pliocene. The formation consists of the usual tough clay, covering a bed of loose, or it may be rather compact, sand. There are a number of short anticlines parallel to the trend of the mountains.

Some of the natural oils are as white as refined burning oils, and are burned without refining, the wick taking up all of the oil in the lamp; some are black, and some have a straw color, but the greater part of the product is a light-green amber. The gravity varies from 0.802 (45° B.) to 0.905 (25° B.).

The history of drilling artesian wells in Italy shows a series of disappointments. The free fall hydraulic, the Canadian, and the rope systems have all encountered serious difficulties, owing to the irregular nature of the upper measures and their inclination.

Oil is also found in the valley of the Pescara River near Chieti, and in the valley of the Livi River, between Rome and Naples. Asphalt is found 20 miles east of Pescara. Petroleum from Ozzano, with a specific gravity of 0.807, will give 37.3 per cent naphtha and benzine, 40.4 per cent illuminating oils, and 20.2 per cent lubricating oil.

The excise duty imposed on oil produced in Italy is 10 francs per 100 kilos, while a duty of 48 francs is placed upon all foreign oil imported.

The mining laws in Italy are different in every one of the ancient States. The minerals of all descriptions are controlled by the Government. Usually the Government gives to a party that wishes to prospect for oil the right to do so in a temporary way. Should the search prove successful, the party is then entitled to a royal definite concession.

The returns in Italy, notwithstanding the many shows of oil and gas, have not been satisfactory in a general way.

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From the volumes of Rivista del Servizio Minerario the following statements are extracted regarding the production of petroleum in this country:

Production of petroleum in Italy from 1860 to 1895.

Year.	Number of wells in operation.	Quantity.		Production.				Number of workmen employed.
		Metric tons.	United States barrels.	Unit value.		Total value.		
				Lire.	Dollars.	Lire.	Dollars.	
1860....	3	5	36	800.00	21.44	4,000	772	5
1861....	5	4	29	800.00	21.31	3,200	618	8
1862....	4	4	29	800.00	21.31	3,200	618	9
1863....	7	8	58	800.00	21.29	6,400	1,235	18
1864....	7	10	72	800.00	21.41	8,000	1,544	32
1865....	10	315	2,265	209.52	5.62	66,000	12,738	70
1866....	12	138	992	269.86	7.24	37,240	7,187	57
1867....	11	110	791	349.10	9.37	38,400	7,411	58
1868....	9	51	367	435.29	11.67	22,200	4,285	52
1869....	8	20	144	800.00	21.65	16,000	3,118	45
1870....	6	12	86	800.00	21.55	9,600	1,853	30
1871....	6	38	273	263.16	7.07	10,000	1,930	40
1872....	6	46	331	208.69	5.60	9,600	1,853	36
1873....	5	65	467	172.31	4.63	11,200	2,162	35
1874....	4	84	604	152.38	4.00	12,800	2,470	37
1875....	3	113	812	138.05	3.70	15,600	3,011	38
1876....	3	402	2,890	123.38	3.31	49,600	9,573	72
1877....	2	408	2,934	132.35	3.55	54,000	10,422	45
1878....	4	602	4,328	102.99	2.76	62,000	11,966	98
1879....	4	402	2,890	124.37	3.34	50,000	9,650	70
1880....	2	283	2,035	313.05	8.40	88,595	17,099	24
1881....	2	172	1,237	445.00	11.94	76,540	14,772	24
1882....	4	183	1,316	474.55	11.97	86,844	15,761	121
1883....	5	225	1,618	259.49	6.96	58,387	11,269	92
1884....	6	397	2,854	341.18	9.16	135,452	26,142	110
1885....	6	270	1,941	407.65	10.92	110,066	21,243	136
1886....	7	219	1,575	416.11	11.16	91,130	17,588	145
1887....	7	208	1,497	364.04	9.76	75,720	14,614	135
1888....	5	174	1,251	319.71	8.58	55,630	10,737	75
1889....	7	177	1,273	288.13	7.73	51,000	9,843	70
1890....	9	417	2,998	289.21	7.77	120,603	23,276	177
1891....	7	1,100	7,909	298.91	8.02	328,800	63,458	230
1893....	8	2,652	19,068	299.80	8.05	795,050	153,445	130
1894....	9	2,854	20,520	296.88	7.97	847,260	163,521	194
1895....	6	3,594	25,841	258.90	6.95	930,496	179,586	134

7.19 barrels in 1 metric ton of crude.
7.955 barrels in 1 metric ton of refined.

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Production of crude petroleum in Italy in 1895, by districts.

Mining district.	Number of wells.	Production.						Number of laborers.
		Quantity.		Value.				
		Metric tons.	Barrels of 42 gallons.	Per ton.	Per barrel.	Total.	Total.	
				Lire.		*Lire.*		
Emilia	3	3,532	25,395	260.00	$6.98	918,320	$177,236	114
Roma	3	62	446	196.71	5.27	12,176	2,350	20
Total ..	6	3,594	25,841	258.90	6.95	930,496	179,586	134

Production of refined petroleum, benzine, and gasoline in Italy in 1895, by districts.

Mining district.	Province.	Number of works in operation.	Production.						Number of laborers.
			Quantity.		Value.				
			Metric tons.	Barrels of 42 gallons.	Per ton.	Per barrel.	Total.	Total.	
					Lire.		*Lire.*		
Milano .	Parma ...	2	4,185	33,291	526.03	$12.76	2,201,464	$424,883	50
	Piacenza .								
Roma ..	Chieti....	1	6	48	550.00	13.27	3,300	637	11
Total...	.....	3	4,191	33,339	526.07	12.76	2,204,764	425,520	61

Production of refined petroleum in Milano district, Italy, in the year 1895.

Kind of product.	Number of works.	Quantity.		Value.				Number of laborers.
		Metric tons.	Barrels of 42 gallons.	Per ton.	Per barrel.	Total.		
				Lire.		*Lire.*		
Refined petroleum.....	2	2,902	23,085	559.82	$13.58	1,624,614	$313,551	50
Benzine.....		638	5,075	499.76	12.12	318,850	61,538	
Gasoline		645	5,131	400.00	9.70	258,000	49,794	
Total ..	.....	4,185	33,291	526.03	12.76	2,201,464	424,883	

The production of the Chieti district was all reported as illuminating oil.

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INDIA.

Petroleum is found in Upper and Lower Burma. This division of India lies in the extreme east.

In the tables following a number of localities have been placed under the head of Burma, and this includes 98 per cent of the entire production. The year 1894 shows a gain of about 8 per cent over 1893, and the year 1895 shows a gain of about 10.5 per cent over the year 1894. All varieties from tar to natural lamp oil are produced. Some are very rich in paraffin; others have only a trace.

A refinery is operated by the Burma Oil Company, on the river at Dunniedaw, close to Ragoru. It has been recently enlarged, and is now said to have a capacity of 250,000 barrels per year.

The following table shows the production of petroleum in India from 1889 to 1895.

Production of petroleum in India from 1889 to 1895.

Year.	Production.	
	Gallons.	Barrels (42 U. S. gallons).
1889	3,298,737	94,250
1890	4,931,093	140,888
1891	6,136,495	175,328
1892	8,725,331	249,295
1893	10,359,812	295,994
1894	11,139,600	318,274
1895	13,014,000	371,830

In the following table is given the production of petroleum in India, by Provinces or States, in 1894 and 1895.

Production of petroleum in India in 1894 and 1895.(a)

Province or State.	1894.		1895.	
	Quantity.	Value.	Quantity.	Value.
	Liters.	*Rupees.*	*Liters.*	*Rupees.*
Assam	758,321	33,380	165,541	7,287
Burma	49,618,882	1,057,545	58,955,888	1,534,951
Punjab	7,915	409	7,088	353
Native States	227,173	9,375	.....	.....
Total	50,612,291	1,100,709	59,128,517	1,542,591

a Furnished by the Department of Revenue and Agriculture, Calcutta, in "Review of Mineral Production in India for 1894 and 1895."

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1 rupee=$0.436; 1 imperial gallon=4.54 liters; 35 imperial gallons=1 barrel.

The oil wells in Burma furnish most of the petroleum, and the output of this Province in 1895 shows an increase of nearly 19 per cent as compared with the previous year.

JAPAN.

The following tables, translated from a report on "The Occurrence of Petroleum in Japan," published last year by the Geological Survey of Japan, show that this country produces only 9.5 per cent of the oil consumed, and nearly all of this amount comes from the district of Echigo. A great part of this comes from shafts, although there are a number of wells producing in a small way. The tables, however, show a large increase from 1893 to 1894. This report also states that in the oil fields of Japan 2,390,839 tsubo, equal to 1,976 acres (1 tsubo being equal to about 6 square feet), were in operation, while 3,188,090 tsubo (equal to 2,634 acres) were in suspension at the close of 1894. Mineral Resources for 1894 gave a large amount of detailed information on the production of oil in this country.

Mr. K. Nakashima, of the Geological Survey of Japan, writes as follows: "There is no doubt that the production of petroleum is annually increasing in Japan, due partly to the introduction of boring apparatus from the United States, and partly to the discovery of new localities five years ago in the neighborhood of Nagaoka town, in Echigo. But if the extent and nature of oil fields in Japan are compared to those of the United States and Russia, they are nothing but pigmy to giant, and however much the production of Japan may increase, it will be only a small proportion of the imported oil."

Production of petroleum in Japan 1875 to 1894, inclusive.

Year.	Production.				Value received for crude and refined sold.	
	Crude.		Refined.			
	Koku. *a*	Gallons.	Koku. *a*	Gallons.	Yen. *b*	Dollars.
1875....	4,830	191,751	.....	.....	.....	.....
1876....	8,155	323,753	.....	.....	.....	.....
1877....	10,114	401,526	.....	.....	.....	.....
1878....	18,920	751,124	.....	.....	.....	.....
1879....	24,816	985,195	.....	.....	.....	.....
1880....	26,974	1,070,868	.....	.....	.....	.....
1881....	17,721	703,524	.....	.....	.....	.....
1882....	16,450	653,065	.....	.....	.....	.....
1883....	21,659	859,862	.....	.....	.....	.....
1884....	29,541	1,172,778	6,215	246,735	107,964	55,170
1885....	30,931	1,227,961	7,326	290,842	98,496	50,331
1886....	40,113	1,592,486	13,487	535,434	136,911	69,962

a 1 koku = 39.7 gallons. *b* 1 yen = $0.511.

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Production of petroleum in Japan 1875 to 1894, inclusive—Continued.

Year.	Production.				Value received for crude and refined sold.	
	Crude.		Refined.			
	Koku. *a*	Gallons.	Koku. *a*	Gallons.	Yen. *b*	Dollars.
1887....	30,304	1,203,069	8,830	350,551	126,298	64,538
1888....	39,605	1,572,318	4,511	179,087	138,602	70,826
1889....	55,871	2,218,079	7,097	281,751	250,977	128,249
1890....	54,399	2,159,640	11,180	443,846	221,478	113,175
1891....	55,983	2,222,525	13,012	516,576	207,029	105,792
1892....	72,893	2,893,852	13,431	533,211	207,245	105,902
1893....	83,644	3,320,667	10,941	434,358	178,290	91,106
1894....	138,077	5,481,657	13,980	555,006	245,697	125,551
Total.	781,000	31,005,700	110,010	4,367,397	1,918,987	980,602

a 1 koku = 39.7 gallons. *b* 1 yen = $0.511.

Production of crude petroleum in Japan in 1880, 1884, 1885, 1892, 1893 and 1894, by districts.

District.	1880.		1884.		1885.	
	Koku.	Gallons.	Koku.	Gallons.	Koku.	Gallons.
Echigo.....	22,607	897,498	24,482	971,935	25,923	1,029,143
Totoumi	3,875	153,838	3,784	150,225	3,630	144,111
Ugo.....	229	9,091	771	30,609	805	31,959
Shinano.....	263	10,441	481	19,096	425	16,873
Ishikari.....	.....	.....	23	913	148	5,875
Iburi	.....	.....	.....	.....	.....	.....
Kotsuke	.....	.....	.....	.....	.....	.....
Total	26,974	1,070,868	29,541	1,172,778	30,931	1,227,961

District.	1892.		1893.		1894.	
	Koku.	Gallons.	Koku.	Gallons.	Koku.	Gallons.
Echigo.....	69,042	2,740,968	80,259	3,186,282	134,826	5,352,592
Totoumi	2,832	112,430	2,507	99,528	2,548	101,156
Ugo.....	340	13,498	118	4,685	345	13,697
Shinano.....	626	24,852	402	15,959	248	9,846
Ishikari.....	53	2,104	78	3,097	105	4,168
Iburi	.....	.....	280	11,116	.....	.....
Kotsuke	.....	.....	.....	.....	5	198
Total	72,893	2,893,852	83,644	3,320,667	138,077	5,481,657

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Importation of petroleum into Japan from 1868 to 1894, inclusive.

Year.	Quantity (gallons).	Value.	
		a Yen.	Dollars.
1868	31,954	7,236	3,698
1869	5,867	1,662	849
1870	52,711	21,516	10,995
1871	152,296	72,170	36,879
1872	446,804	160,608	82,071
1873	1,000,959	330,599	168,936
1874	1,291,179	306,723	156,735
1875	2,775,354	573,671	293,146
1876	2,888,729	444,134	226,952
1877	2,682,252	605,598	309,461
1878	10,687,753	1,803,076	921,372
1879	16,799,642	2,185,223	1,116,649
1880	14,895,892	1,400,471	715,641
1881	8,007,200	979,112	500,326
1882	20,682,205	2,320,905	1,185,982
1883	23,631,055	2,456,261	1,255,149
1884	17,534,885	1,773,361	906,187
1885	17,636,020	1,667,722	852,206
1886	25,100,220	2,358,498	1,205,192
1887	21,058,865	1,871,428	956,300
1888	28,507,767	3,519,255	1,798,339
1889	36,998,843	4,587,135	2,344,026
1890	42,663,580	4,950,256	2,529,581
1891	40,482,160	4,535,720	2,317,753
1892	32,689,275	3,328,398	1,700.811
1893	49,763,392	4,401,041	2,248,932
1894	55,643,719	5,135,332	2,624,155
Total	474,110,578	51,797,111	26,468,323

a 1 yen = $0.511.

JAVA.

The reports and statements from this oil field show a great increase in the production and refining of petroleum. The largest operators are the Dordrecht Society for the Petroleum Industry of Amsterdam. They own a number of wells in central and eastern Java, and very large concessions of territory. The Soerabaya field has 25 flowing wells and the Koetei 15 partly flowing. These two fields yield enough crude to produce 20,000 gallons of refined petroleum daily. A number of large wells recently developed are reported. This company operates

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two large refineries, one at Soerabaya, the other at Samarang. They have a tin-can factory at Soerabaya and a wooden case factory on the island of Borneo. The following table, giving the production of petroleum in the above districts in 1895 and 1896, shows an increase of 72 per cent in 1896 over 1895.

Production of petroleum in Java in 1895 and 1896, by districts.

	1895.	1896.
Residency of Soerabaya:		
Crude.....gallons..	8,915,088	11,069,668
Refined.....cases..	525,004	604,418
Residency of Rembang:		
Crude.....gallons..	3,418,380	10,141,535
Refined.....cases..	222,904	638,916

Oil is also found in Timor, Borneo, and the Philippine Islands.

The production of petroleum in Java for four years past is shown in the following table:

Production of crude petroleum in Java from 1893 to 1896.

Year.	United States barrels of 42 gallons.
1893	400,000
1894	168,000
1895	293,654
1896	505,029

Of the 505,029 barrels produced in 1896, 263,564 barrels were produced in Soerabaya and 241,465 in Rembang.

SUMATRA.

Perhaps no localities producing petroleum have shown more wonderful possibilities during the past year than these far-off islands of Sumatra and Java. Their position, so far east of present competition, and near to China, India, and Australia with their immense population, together with cheap labor and nearness to tide water, gives these localities great commercial advantages.

The following translation, published by the American Manufacturer, of a report made by Mr. F. Stampfel,[1] is very clear and instructive:

"The northeastern part of the island of Sumatra occupies a prominent and promising position among the oil fields of more recent development. The existence of mineral oil in those regions was known

[1] Correspondence Chemiker und Techniker Zeitung, Vienna, August 21, 1896.

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since time immemorial, especially in the district of Langkat, where it rose to the surface in considerable quantity at different places at the foot of the low hills which branch off from the principal mountain range in an easterly direction. The natives used the oil for medicinal and other purposes.

"The topography of Sumatra is very simple. An uninterrupted range of mountains called Boukit Barisan, or Chain Mountains, branching out only in the extreme northeastern end, traverses the island from north to south for a distance of about 1,000 miles. Its height averages from 1,500 to 6,000 feet. The highest peak, which at the same time is a very active volcano, is the Indrapura, 11,800 feet high and about 1½° south of the equator. The watershed of this mountain chain runs near the coast of the Indian Ocean, falling off very abruptly, on one side almost directly into the ocean, while along the eastern coast a broad, level, and uniform alluvial territory extends in a north and south direction through the whole length of the island.

"The first practical attempts to produce oil in large quantities and to utilize it commercially were made by the Royal Dutch Oil Company in 1892 at a locality named Telaga Side, where the natives for generations procured their oil, that rises here in small pits to the surface. Operations in this neighborhood were accompanied by excellent results, each fountain producing from 300 to 400 barrels a day. The wells were drilled in depths ranging between 400 and 600 feet. Within a short time the company had such an enormous stock of crude oil on hand that drilling operations had to be stopped. The erection of a refinery and pipe line was pushed energetically, with the result that since September, 1894, this company has been able to ship large quantities of refined petroleum. The present shipments amount to 10,000 cans of 4 gallons each every week. The refinery is now being enlarged so as to triple its capacity. It is located at Pankalan Berandan, on a bay about 10 miles from Telaga Side, which offers good anchorage for vessels. The oil is piped to this port through a 5-inch pipe line. A second 8-inch pipe line is now in course of construction in order to supply the enlarged refinery with sufficient crude oil. The Royal Dutch Oil Company, of Pankalan Berandan, has obtained from the Dutch Government a land grant covering 10 square miles. Telaga Side is the center of this territory. The company has produced only illuminating oil so far, all the residue is burned up so that the column of smoke can be seen for miles around. The petroleum is shipped in 4-gallon tin cans, two always being packed in one wooden box.

"The company operates its own sawmill to cut boards for these boxes, as well as a factory provided with the most modern machinery for the wholesale manufacture of the tin cans. The management consists entirely of Americans, who employ the usual rope-drill method, and procure their apparatus from the Oil Well Supply Company, of Brad-

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ford and Pittsburg, Pennsylvania. This firm supplies all the drilling machinery in double sets, and sends a reliable fitter-up and driller along. The large machine shops at Penang are called upon for repairs and other material. The refinery of Pankalan Berandan lies 18 miles northeast of the city of Langkat or Tandjong Poera.

"The success of this company drew many foreign operators to the province of Langkat, but only a few were able to secure oil land, for the whole territory is now controlled almost exclusively by the following firms, which are all pushing the drill with utmost activity: (1) The Maatschappij tot Mijn en Bosch Exploitatie; (2) the Bombay-Burmah Trading Corporation, Limited; (3) the Netherlandsche Handel en Petroleum Maatschappij, all of Tandjong Poera.

"The Maatschappij tot Mijn en Bosch Exploitatie is now building a large refinery, which is being fitted up by the machine-building firm of Hirtzel & Sons, of Leipzic, Germany. The company has a number of flowing wells, 75 feet deep, at Bukit Tua, about 14 miles southwest of Tandjong Poera. The site of the refinery is on the bank of the Langkat River, 4 miles below Tandjong Poera. A 6-inch pipe line, 17 miles long, will connect the refinery with the wells of Bukit Tua, where large tanks for the storage of the crude oil are being erected. It will take more than a year before the refinery will be ready for operation.

"The field of the Bombay-Burma Trading Corporation, Limited, comprises an area of about 20 square miles. The company is drilling at three different points. At two of these, named Tinggi and Tankalan Siping, good wells have been opened up and a large refinery is being built by the company on the bank of the Gebang or Lapan River.

"The Netherlandsche Handel en Petroleum Maatschappij controls also a large territory in which oil will probably be found in paying quantities.

"In the province of Deli, which adjoins Langkat on the south, the Deli Maatschappij, of Medan, an enormously wealthy tobacco-growing company, on whose lands surface traces of oil have been found, will commence drilling. North of Langkat lies the province of Atchin, where two oil fields have been discovered by the Dutch rangers. Near Fort Damiang and the village of Edie the oil rises freely to the surface. Both localities are in the immediate neighborhood of the coast.

"The lands around Edie have been secured by the Oostersche Exploratie en Exploitatie Maatschappij, of 11 St. Mary Axe, London, E. C., and operations will begin here as soon as the drilling apparatus ordered in the United States has been received.

"The mineral resources of Atchin are said to be extremely rich, but this province has not been opened yet to colonization, for the Atchinese have been successful so far in preventing the Dutch troops from entering their territory beyond the range of the Dutch marine guns.

"The geological formation of the strata to be pierced is uniform in almost all parts of Langkat. A thick surface layer of alluvium is suc-

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ceeded by very soft, grayish blue, sandy, clay slate, interspersed by thin veins of hard, bluish, and fine-grained sandstone. All the formations are rich in marine fossils and belong to the Eocene. The wells in Sumatra are being drilled after the American method. Tubes 10 to 12 feet long, with socket and nozzle joints, are being used, which are driven in as lining, because there is much afterfall, owing to the softness of the ground. The deepest well that has been drilled so far is 800 feet.

"With the exception of the cultivated land the whole island of Sumatra is covered by impenetrable jungle and virgin forest. The transportation of the working apparatus and other supplies is always very difficult. Each company has to make its own roads. The climatic conditions in the Province of Langkat are not very favorable for Europeans. The land is but a little above sea level and abounds in swamps, which, together with a luxurious vegetation, breed malaria and other diseases. All manual labor is done by Javanese and Chinese.

"In southern Sumatra, west of the city of Palembang, drilling has been commenced by the Bombay-Burma Trading Corporation, Limited, and the Netherlandsche Handel en Petroleum Maatschappij, each company working with one rig. The first firm struck a bed of very heavy and tough asphalt at a depth of 360 feet. On the island of Java the Dordtsche Petroleum Maatschappij is working with several rigs in the districts of Soerabaja and Samarang, but the wells are not as productive as those of Sumatra. The same company is also drilling on the island of Borneo, while a new concern is being organized at Batavia to develop the lately discovered petroleum resources of the island of Timor.

"There can be no doubt any longer that the American and Russian petroleum exporters to Eastern Asia will suffer a heavy loss within a few years, if it is not destroyed altogether. Sumatra, with its immense quantities of oil, controlled by enormously rich companies, with a favorable geographical position as well as extremely cheap labor, can enter easily into competition with Europe and America in the oil markets of the far east."

Since this report was written more recent reports state that a well was lately completed by the Royal Dutch Petroleum Company, at Langkat, that started off at 4,800 barrels.

A total production of 12,000 barrels per day is reported.

A refinery with a monthly capacity of 90,000 barrels is in course of construction.

RUSSIA.

The great flood in the fall of 1895, which crippled the Transcaucasian Railroad that connects Baku with the seaport town of Batoum, had a great influence on the trade in the early part of 1896. This event for many months cut off the communication between the points named. The other outlet that was used for the time being was the port of Novorossisk, also on the Black Sea and the terminus of another line of rail-

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road connecting Petroskoe, on the Caspian Sea, which point is about 300 miles northwest of Baku. This distance the oil had to be transported by water. The delay necessarily ensuing from the indirect connection with the Black Sea was a serious matter to the export trade.

There are many oil shows and oil wells on both flanks of the Caucasus Mountains, from the Taman Peninsula, near where these mountains begin, to Baku, where they terminate near the Caspian Sea, a distance of nearly 750 miles. At some localities oil is found high up on the flanks of the mountains, and at others down on the level plains, yet almost the entire production comes from the Apsheron Peninsula from what are known as the Balakhany, Saboontchy, Romany, and Bibi-Eibat districts. Their combined area is not more than 8 square miles. These fields are connected by a series of pipe lines, 3 to 9 miles long, centering at the refineries at Blacktown, a suburb of Baku.

In round numbers this small area has produced 344,000,000 barrels of crude oil from 1859 to 1896, inclusive. Allowing 5.6 cubic feet to a barrel, it amounts to 1,926,400,000 cubic feet, which would equal a cube whose sides measure 1,244½ feet. The total production in the United States for the same period was 770,673,764 barrels, amounting to 4,315,773,078 cubic feet (more than double the quantity produced in Russia), which would equal a cube whose sides measure about 1,629 feet.

The Tertiary formation in a general way is considered the geological equivalent that has produced such vast quantities of oil.

The wells vary from 400 to 1,000 feet in depth. No two of them have the same stratification, and the oil pays come in irregularly. The largest wells found their oil in a loose sand with bowlders of lime concretions. Great quantities of this sand are thrown out with the oil.

Grosni, 500 miles north of Baku; the Goura district, 30 miles north of Batoum, and Kuban, at the extreme west, near the Straits of Kertch, have produced some oil. The specific gravity is high, being 0.970 to 0.985, or 15° to 12° B.

Two distinct statements in regard to the production of Russian crude petroleum are given. One is known as "total production," which includes not only the crude, collected and refined, or sold as fuel oil, but also an estimate of the oil wasted or not collected, as well also as that used for fuel for pumping the wells. The second statement shows "profitable production;" that is, the amount of crude oil put into tanks or reservoirs.

The total production of the Baku oil field in 1896 amounted to 406,000,000 poods, or 39,882,122 barrels; the total exports to 306,723,000 poods, or 30,129,960 barrels (refined reduced to crude equivalent), of which 306,200,000 poods, or 30,078,585 barrels, were illuminating, lubricating, residuum, and crude oil, and the remainder other products. The difference represents the loss and the consumption for fuel purposes at Baku. The loss attending production is not inconsiderable, for from

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the total production but 386,264,782 poods, or 37,943,495 barrels, were marketed. The amount obtained by "bucketing" was 299,277,782 poods, or 29,398,603 barrels; the balance, 86,987,000 poods, or 8,544,892 barrels, from "flowing" wells.

The average price of crude at well for the year 1896 was 7.8 copecks per pood, or about 48 cents per barrel; residuum, 7.7 copecks per pood, or about 47 cents per barrel; illuminating oil, 13.3 copecks per pood (about 81.6 cents per barrel) f. o. b. vessel, or 24.3 copecks per pood (about $1.49 per barrel) f. o. b. cars.

8.18 poods=1 barrel; 100 copecks=1 ruble; 1 ruble=$0.76; 1 copeck=¾ cent.

The total production of crude petroleum in the Apsheron Peninsula and the shipments of the chief petroleum products from Baku from 1880 to 1896 have been as follows:

"Total production" of crude petroleum on the Apsheron Peninsula and shipments of petroleum products from Baku from 1880 to 1896.

[Barrels.]

Year.	Production.	Shipments from Baku.				
		Illuminating.	Lubricating.	Residuum.	Crude oil.	Total.
1880.....	2,455,000	785,000	.....	697,000		1,482,000
1881.....	3,929,000	1,257,000	.....	913,000		2,170,000
1882.....	4,911,000	1,326,000	30,000	1,768,000		3,124,000
1883.....	5,893,000	1,473,000	112,000	1,846,000		3,431,000
1884.....	8,841,000	2,161,000	147,000	2,868,000	.....	5,176,000
1885.....	11,394,000	2,946,000	157,000	3,330,000		6,433,000
1886.....	14,734,000	3,438,000	167,000	3,555,000		7,160,000
1887.....	16,208,000	4,322,000	226,000	4,076,000		8,624,000
1888.....	18,860,000	4,911,000	255,000	5,746,000		10,912,006
1889.....	20,137,000	6,002,000	324,000	8,703,000	413,000	15,442,000
1890.....	23,477,000	6,611,000	452,000	9,538,000	638,500	17,239,500
1891.....	28,290,000	7,269,000	501,000	10,157,000	1,139,509	19,066,500
1892.....	29,273,000	7,730,000	551,000	11,473,000	1,149,300	20,903,300
1893.....	33,104,126	8,438,000	570,000	14,096,267	1,198,400	24,302,667
1894.....	30,383,104	6,994,106	528,684	19,017,682	1,611,000	28,251,472
1895.....	38,339,882	7,956,778	658,153	17,721,022	1,581,532	27,917,485
1896.....	39,882,122	8,526,522	815,324	18,231,827	2,504,912	30,078,585

This table gives the total production and the total shipments from Baku, both to Russian ports and to other countries, and may be regarded as showing the total production of crude oils, refined oils, and residuum for the years named.

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The "profitable production" for the last eight years is shown in the following table:

"Profitable production" of crude petroleum in the Apsheron Peninsula from 1889 to 1896.

[Barrels of 42 gallons.]

Year.	Production.	Year.	Production.
1889	18, 889, 000	1893	31, 894, 000
1890	22, 229, 000	1894	29, 223, 967
1891	26, 974, 000	1895	37, 072, 692
1892	28, 143, 000	1896	37, 943, 495

The divisions of this profitable production among the four subfields on the Apsheron Peninsula are as follows:

"Profitable production" of the several fields of the Apsheron Peninsula from 1889 to 1896.

[Barrels.]

Year.	Balakhany.	Saboontchy.	Romany.	Bibi-Eibat.	Total.
1889	6, 768, 000	10, 373, 000	.....	1, 748, 000	18, 889, 000
1890	6, 218, 000	14, 096, 000	147, 000	1, 768, 000	22, 229, 000
1891	7, 289, 000	16, 060, 000	1, 277, 000	2, 348, 000	26, 974, 000
1892	5, 648, 000	15, 196, 000	4, 027, 000	3, 272, 000	28, 143, 000
1893	5, 677, 000	14, 371, 000	7, 180. 000	4, 666, 000	31, 894, 000
1894	5, 795, 677	14, 047, 151	6, 060, 904	3, 320, 235	29, 223, 967
1895	6, 633, 104	14, 864, 931	10, 945, 482	4, 629, 175	37, 072, 692
1896	8, 413, 278	14, 997, 462	7, 670, 759	6, 861, 996	37, 943. 495

The average stocks for the year 1896 in the four sub-fields on the Apsheron Peninsula were 5,500,000 poods, or 540,275 barrels.

WELLS AND THEIR PRODUCTION.

There are two classes of wells producing oil, flowing and bucketing By bucketing it is understood that, owing to the loose sand that continually comes into the well with the oil, the American system of pumping, with rods, cups, and working barrel, is impracticable, as the sharp sand soon cuts the cups. The substitute is a long pipe or bailer that goes inside of the casing, with a valve in the bottom, and connected to a small wire rope passing over the crown pulley. This rope is also connected with a drum driven by power. The bailer is hoisted to the surface, where the valve is opened automatically and the oil and water are discharged in a trough leading to a reservoir. The bailer is then allowed to descend, to be filled again.

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Flowing wells are the well-known Baku fountains, some of which have given, and continue to give, say, 100,000 poods per day, or about 10,000 barrels; several of these fountains are credited with producing 60,000 barrels per day.

The production of crude petroleum from pumping (bucketing) and flowing wells for the last eight years has been as follows:

Production of crude oil from pumping and flowing wells in Russia from 1889 to 1896.

[Barrels.]

Year.	Pumping.	Flowing.
1889	14,705,000	4,184,000
1890	17,347,000	4,882,000
1891	23,123,000	3,851,000
1892	20,707,000	7,436,000
1893	21,168,000	10,726,000
1894	23,153,240	6,070,727
1895	25,992,141	11,080,550
1896	29,398,603	8,544,892

The greatest number of wells that produced crude petroleum at any time during the years named was as follows:

Number of producing wells on the Apsheron Peninsula from 1889 to 1896.

Year.	Wells.	Year.	Wells.
1889	278	1893	458
1890	356	1894	532
1891	458	1895	622
1892	448	1896	736

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The statement of the number of producing wells from 1893 to 1896, by months, is as follows:

Number of producing wells in Russia from 1893 to 1896, by months.

Month.	Number of wells.			
	1893.	1894.	1895.	1896.
January	322	322	434	501
February	326	337	434	508
March	332	347	437	511
April	323	355	455	536
May	325	366	451	540
June	310	369	450	547
July	307	373	460	566
August	294	400	475	575
September	298	413	496	597
October	310	420	497	606
November	316	425	504	614
December	322	440	500	620
Total	458	532	622	736

It should be understood that these figures represent the average number of wells in operation during any one month, the total representing the greatest number of wells that were operated at any time during the year.

The number of wells drilling during each month from 1892 to 1896 and the number completed during the years 1895 and 1896 are given in the following tables:

Number of wells drilling in Russia from 1892 to 1896, by months.

Month.	1892.	1893.	1894.	1895.	1896.
January	141	62	59	80	137
February	131	57	60	86	141
March	127	69	62	86	145
April	117	64	72	78	150
May	94	69	81	86	152
June	84	73	79	89	159
July	44	69	75	100	152
August	45	64	73	109	152
September	52	58	73	116	164
October	45	59	69	122	194
November	50	58	71	133	200
December	58	59	75	142	208
Total	200	175	204	270	385

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Number of wells completed in Russia in 1895 and 1896.

Month.	1895.	1896.
January	5	13
February	8	11
March	7	7
April	10	8
May	6	6
June	5	14
July	9	11
August	11	10
September	8	16
October	8	16
November	6	10
December	11	11
Total	94	133

In the following table is given a statement of the greatest number of wells drilling at any time during each of the years from 1890 to 1896, together with the total number of wells drilled deeper, and the total length, in sagenes, of all wells drilled:

Total number of wells drilling, number of wells drilled deeper, and length of wells drilled in Russia from 1890 to 1896.

Year.	Total number of wells drilling.	Total number of wells drilled deeper.	Total length, in sagenes, of wells drilled.
1890	231	50	14,810
1891	292	87	19,980
1892	200	111	11,670
1893	175	102	10,984
1894	204	101	12,859
1895	269	133	20,762
1896	385	136	28,125

1 sagene=7 feet.

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EXPORTS OF RUSSIAN OIL.

The exports of petroleum products and crude oil from Baku for 1896 were as follows:

Exports of petroleum products and crude oil from Baku in 1896.

	Barrels of 42 gallons.
Illuminating oil and distillate	8,526,522
Lubricating oil	815,324
Residuum	18,231,827
Crude oil	2,504,912
Total	30,078,585

These different products were exported as follows:

Exports of petroleum products from Baku, by ports, in 1896.

	Barrels.
By way of the Black Sea:	
From Batoum—	
Illuminating oil and distillate	4,616,896
Lubricating oil	402,750
Residuum	726,915
Total	5,746,561
From Novorossisk—	
Illuminating oil and distillate	1,547,300
Lubricating oil	333,500
Residuum	129,300
Total	2,010,100
Total by way of the Black Sea	7,756,661
By way of the Caspian Sea:	
Illuminating oil and distillate	3,860,511
Lubricating oil	422,397
Residuum	17,504,911
Total	21,787,819

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Stocks at Baku at the end of the year 1896 were as follows:

Stocks at Baku at the end of 1896.

	Barrels.
Illuminating oil and distillate	1,149,312
Lubricating oil	166,994
Residuum	2,907,662
Crude oil	4,774,067
Total	8,998,035

PERU.

The petroleum-producing territory of Peru is practically unchanged since it was so well described in Mineral Resources for 1893 and 1895.

Petroleum is produced and marketed at two points in Peru; both are in the department of Piura and separated by a distance of 90 miles. The first district in point of importance is at Negritos, on the hacienda of Lamina Brea, on the seacoast 45 miles north of the port of Payti. The London Pacific Petroleum Company, of London, has drilled some 49 wells at Negritos, 44 of them being producing wells, the field as developed covering an area of about 400 acres. The production of the 44 wells at the close of 1896 was about 250 barrels per day.

The London Pacific Petroleum Company has a refinery at Talara, on Talara Bay, 9 miles from Negritos, with a daily capacity of 1,500 barrels; also a large amount of iron tankage and facilities for loading vessels in bulk. The oil is transported from Negritos to Talara by pipe line. Practically no oil has been refined at Talara for two years, the product being sold for fuel.

It should not be inferred that the present output is the limit of the possibility of the production of the Negritos field. The London Pacific Petroleum Company has been involved in a series of long-continued and expensive lawsuits that have seriously interfered with their business and rendered further exploration impracticable, and it is not probable that there will be much activity at Negritos until a final decision is reached in the suits now pending.

During the years 1894 and 1895 five cargoes of crude oil, amounting to about 100,000 barrels, were shipped by tank steamer from Talara to San Francisco, and used for fuel, but the development of the Los Angeles field made the business unprofitable.

The second producing district is at Zorritos, on the coast, at an inlet of the sea, some 20 miles south of Tumbez. Mr. Faust G. Piaggio, of Lima, Peru, owns 18 wells at Zorritos, being all of the producing wells in the field; he also has a refinery at this point, with which he supplies the demand of the country for low-priced oil, distributing it along the

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coast by sailing vessels. Mr. Piaggio estimates his wells as capable of producing from 400 to 600 barrels per day, but their output is limited to the demands of the country for the grades of oil he manufactures, that being an average of about 100 barrels per day. The producing area of Zorritos as developed covers about 400 acres.

Lately a French company has been making preparations for operating on a large scale in this district, but as yet has not met with much success, and its territory is very limited in extent.

While the actual production is limited to the two districts named, the fields are not in any sense defined by actual exploration, and there are strong indications of the existence of extensive deposits at different points within the oil-bearing zone, which extends along the coast for 250 miles, and inland to the foothills of the Cordilleras.

With the single exception of the hacienda of Lamina Brea, the oil and mineral right in all land in Peru belongs to the Government, and the laws under which they can be operated practically prohibit the oil industry.

The gravity of the oil is 36° to 39° Baumé, and it is of a dark-green color. Mr. Herbert Tweddle, jr., states that "on a large scale distillation will give 25 per cent benzine, 75° to 58° gravity; 15 to 20 per cent of distillate, 58° to 40° gravity fit for refining. The balance is a heavy residuum, generally used for fuel, for which it is admirably suited, having a high calorific value and perfect safety, since its fire test is considerably over 200° F. The distillate, after treatment with acid, has a fire test of 110° and average gravity of 45° to 46° Baumé, and is perfectly colorless. Being very rich in carbon, it does not make a kerosene that burns well in all lamps, since it requires a large supply of air to obtain perfect combustion, but properly regulated its illuminating power is very high."

There are indications of oil deposits in the vicinity of Lake Titicaci, but nothing has been done to prove their existence in quantities of commercial value.

ECUADOR.

In the vicinity of Point St. Helena some oil pits are being worked in a small way. The product is of very low gravity and is reduced to pitch or brea by boiling in open vessels, the pitch being used as a coating for the inside of earthen vessels used as receptacles for fluids.

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APPENDIX.

The considerable variation in the several tables published to show the equivalents of specific gravity and degrees of the Baumé scale, make it advisable to give the correct table below.

Table of Baumé's hydrometer, with corresponding specific gravities.

[Temperature, 60° F.]

Baumé.	Specific gravity.	Baumé.	Specific gravity.	Baumé.	Specific gravity.	Baumé.	Specific gravity.
°		°		°		°	
10	1.0000	31	0.8695	52	0.7692	73	0.6896
11	.9929	32	.8641	53	.7650	74	.6863
12	.9859	33	.8588	54	.7608	75	.6829
13	.9790	34	.8536	55	.7567	76	.6796
14	.9722	35	.8484	56	.7526	77	.6763
15	.9655	36	.8433	57	.7486	78	.6730
16	.9589	37	.8383	58	.7446	79	.6698
17	.9523	38	.8333	59	.7407	80	.6666
18	.9459	39	.8284	60	.7368	81	.6635
19	.9395	40	.8235	61	.7329	82	.6604
20	.9333	41	.8187	62	.7290	83	.6573
21	.9271	42	.8139	63	.7253	84	.6542
22	.9210	43	.8092	64	.7216	85	.6511
23	.9150	44	.8045	65	.7179	86	.6481
24	.9090	45	.8000	66	.7142	87	.6451
25	.9032	46	.7954	67	.7106	88	.6422
26	.8974	47	.7909	68	.7070	89	.6392
27	.8917	48	.7865	69	.7035	90	.6363
28	.8860	49	.7821	70	.7000		
29	.8805	50	.7777	71	.6965		
30	.8750	51	.7734	72	.6930		

The United States gallon of 231 cubic inches of pure water at 60° F. weighs 8.331 pounds. The weight of a gallon at any degree can be found by multiplying 8.331 by the specific gravity corresponding. The weight of an imperial gallon of pure water of 277.27 cubic inches at 60° F. is 10 pounds.

To find the degrees Baumé corresponding to any specific gravity—

$$\frac{140}{\text{sp. gr.}} - 130 = \text{B.}^{\circ}$$

To find the specific gravity corresponding to any degree Baumé—

$$\frac{140}{130 + \text{B.}^{\circ}} = \text{sp. gr.}$$

To reduce United States gallons to cubic feet, divide by 7.5.

To find the pounds in 1 cubic foot of any substance multiply its specific gravity by 62.5.

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NATURAL GAS.

By F. H. Oliphant.

INTRODUCTION.

The difficulty of securing complete returns showing the total amount and value of natural gas consumed and the true condition of the fields that supply it makes this report in a manner incomplete, although nearly all of the large natural-gas companies have furnished satisfactory returns to letters of inquiry. Yet the character of natural gas and the manner of its production and use make the collection of statistics concerning it more difficult and unsatisfactory than the collection of those pertaining to petroleum. Petroleum is of little value at the points of production. It must be sold in the crude state and afterwards transported to the refiner, who separates it into merchantable products. Natural gas, however, needs no process to make it marketable. It is always consumed in its natural condition except in a very few instances. Its consumption begins at the mouth of the well and ends at the last foot of the pipe line. It is often found associated with oil-bearing strata in the higher portions, the gas field forming for miles, as it does in many instances, a border to the oil fields. It is almost indispensable as fuel for drilling wells and pumping them and for operating the pumps that feed the pipe lines. There are a large number of persons associated with the production and transportation of oil and there are numerous farmers who consume large quantities of natural gas without payment, and therefore without record of value. It is probable that if all the natural gas thus consumed were reduced to the value of fuel displaced the total value would be increased at least 30 per cent over the value of that transported and sold by regular pipe-line companies making returns.

The declining pressure throughout the natural-gas districts, as noted year after year, has continued during 1896. No new fields have been opened up, although several of the older ones have been extended. Several of the large companies transporting gas have found their pipes too small, with the reduced pressure, to convey the gas to their consumers, and have added gas-compression pumps to their plants. In some instances the suction at these pumps in the lines leading from

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the wells is below that of the atmosphere. Of late a closer watch has been kept on the condition of the pipe lines, and the numerous small leaks at the joints and elsewhere, that were in former years neglected, are now more carefully repaired.

The natural enemy to the life of a gas well is water, generally salt water. The gas may at first be dry, owing to the heavy pressure holding it back, but as the pressure decreases water becomes noticeable. It may come from the gas rock just below the bottom of the hole, it may come in with the gas, or it may force its way past the packer. In any event, reduced pressure invites it, and this water must be removed or the life of the well is cut short. In former years it was the custom, and is now to a great extent, to exhaust the water by what is known as "blowing the well." This consists in disconnecting the well from the main line and opening the gate at the top of the tubing, allowing the gas to discharge itself into the air. This it does in large volumes. It may be from five to fifteen minutes before the flowing gas by its momentum will break up the column of water sufficiently to entangle it with the gas and sweep it out of the well. The well may stand open for half an hour, until all the water is blown out, and there is probably wasted in this operation more gas than flows from the well into the main line in the next ten or twelve hours. To overcome this waste some of the large companies have in use a pumping engine with a large cylinder operated by the gas coming from the well. As the well pressure is nearly always higher than the line pressure, this in turn operates an inch pipe extending through the tubing to a small working barrel at the bottom, and the water is discharged through this 1-inch pipe, which also answers as a sucker rod.

The general adoption of gas-saving appliances since the introduction of the meter has helped to cheapen natural gas in the household. The manner of consuming natural gas under boilers has been greatly improved in numerous instances. Instead of passing out of the open or perforated end of a pipe, the flow of gas is divided by a number of small openings, each entangling a portion of air before the gas is ignited. The greater the number of these divisions and the lower the pressure, up to a certain limit, the more perfect will be the combustion.

The calorific value of natural gas as compared to artificial gases is generally quite high. Bulk for bulk, it is one-third greater than the ordinary illuminating coal gas and about double that of enriched water gas. Both composition and calorific value vary somewhat from field to field. By calculating the value of the component parts of a number of gases from different fields Prof. F. C. Phillips, of Western University, Allegheny, Pennsylvania, determined the range of from 1,110 to 1,300 pounds of water at the boiling point evaporated by 1,000 cubic feet of natural gas, the average being 1,205. This, multiplied by 966, the number of British heat units required to evaporate 1 pound of water, equals 1,164,030 British heat units in 1,000 cubic

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feet of natural gas of average quality. This high calorific value is of use for comparison, but is not reached in practice, although natural gas, when consumed with care, approaches it much nearer than any other fuel.

The following comparison gives the relative values of the different fuels in general use in boilers properly constructed and proportioned to their work:

Twenty cubic feet or 1 pound of natural gas will evaporate 20 pounds of water at 212°.

Sixteen cubic feet of natural gas or 1 pound of oil will evaporate 16 pounds of water at 212°.

Ten cubic feet of natural gas or 1 pound of coal will evaporate 10 pounds of water at 212°.

Ten cubic feet of natural gas, therefore, equals 1 pound of coal, or 20,000 cubic feet of natural gas equals 2,000 pounds or 1 short ton of coal; 4,800 cubic feet of natural gas equals 300 pounds of oil (1 barrel 34° B.); $4\frac{1}{6}$ barrels of oil equals 1 ton of coal.

The recent improvements in the gas engine adapted for using natural gas have added much to its value, especially where the constant drain on the fields has lessened the production of the gas. The same amount of gas is capable of doing much more work when used in the gas engine than when it is burned under a boiler, as the following table comparing the different types of engines will show:

Fuel per indicated horsepower per hour.

Type of engine.	Eqivalent of gas and coal.	
	Gas.	Coal.
	Cubic feet.	*Pounds.*
Natural-gas engine	13	1.3
Triple expansion condensing	16	1.6
Double expansion condensing	20	2.0
Single cylinder and cut-off	40	4.0
Ordinary high pressure without cut-off	75	7.5

The specific gravity of natural gas varies from 0.55 to 0.60 as compared to dry air at 60° F. and at an atmospheric pressure of 30 inches of mercury. Dry air at the above temperature and pressure weighs 76.5 pounds per 1,000 cubic feet. The composition of nearly all natural gas closely resembles marsh gas, CH_4. In the Appalachian gas the amount of nitrogen varies from 2 to 15 per cent. The paraffin series, whose composition is nearly equivalent to methane or marsh gas (75 per cent of carbon and 25 per cent of hydrogen), constitute 85 to 98 per cent of the whole. The Ohio and Indiana gas has about 0.20 per cent of sulphureted hydrogen in its composition. The amount of air required

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to consume 1,000 cubic feet of natural gas of average composition is slightly less than 11,000 cubic feet, or about one part gas to eleven of air. In practice it is best not to use the full amount necessary for complete combustion, and the proportion of one to ten will give better results.

The use of natural gas in connection with burners using a mantle of alkaline earth (thoria, etc.) has placed it at the head of the cheap illuminants where the gas can be had for 25 cents or less per 1,000 cubic feet, and from 35 to 45 candlepower can be secured by consuming 2½ cubic feet per hour. This natural product has little to fear from the competition of artificial gases or the electric light. Natural gas in an argand burner, with a chimney, consuming 5 cubic feet per hour, furnishes about 12 candlepower, and if consumed in an ordinary tip, using 5 to 6 cubic feet per hour, about 6 candlepower. Some natural gases contain a very slight percentage of the heavier hydrocarbons, which adds considerably to their value as illuminants when used without the mantle.

TESTS.

The following tests of the use of natural gas as a fuel compared with petroleum, made at Roystone, Pennsylvania, and Laketon, Indiana, by the National Transit Company, are of value as showing the relative efficiency of gas and oil. In both these tests the water was carefully weighed and the gas metered through new meters that had been proved just before setting up, so that they are undoubtedly accurate.

TEST OF GAS-PUMPING ENGINE AT ROYSTONE, PENNSYLVANIA.

The type of engine used in this test was a Cross compound engine with one high-pressure and one low-pressure double-acting cylinder with Corliss valves and independent surface condenser. The compressor had one high-pressure and one low-pressure double-acting gas cylinder in line with each steam cylinder. The gas, after being compressed in the low-pressure cylinder, is cooled by passing through a surface cooler constructed of pipe, placed in the bottom of a pond. It then passes into the high-pressure cylinder and from there direct to the mains.

Dimensions of engine and boilers.

	Diameter.	Length of stroke.
Steam cylinder:	*Inches.*	*Inches.*
High pressure	27	60
Low pressure	54	60
Gas cylinder:		
High pressure (2 cylinders, tandem)	16	60
Low pressure (2 cylinders, tandem)	21	60

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Dimensions of engine and boilers—Continued.

Piston rods:

Steam cylinders, 5-inch on crank end and 4-inch on compressor end.

Gas cylinders, high-pressure, one 4-inch and one 3¼-inch each; low-pressure, one 3¼-inch in one end of each.

Boilers:

There were three horizontal tubular boilers 5 feet in diameter and 14 feet in length, each containing 180 tubes 2 inches in diameter.

Performance of engine.

Piston speed in feet, per minute	275.2
Mean pressure of high-pressure cylinder, pounds per square inch	43.975
Mean pressure of low-pressure cylinder, pounds per square inch	12.975
Power from high-pressure cylinder, indicated horse power	204.07
Power from low-pressure cylinder, indicated horse power	246.07
Total indicated horse power	450.14
Horse power developed in compressor	419.35
Per cent of work absorbed in friction of engine	6.84
Water per hour used in operating compressor, pounds	7,052
Pounds water per indicated horse power per hour	15.666
Pounds water per developed horse power per hour	16.817
Steam pressure, engine room	118
Vacuum	25
Jacket water per hour	719
Per cent water used in jackets	10.2

Performance of boilers.

Cubic feet of gas per hour, per meter	8,591
Pounds pressure in meter	1.228
Barometer	14.115
Absolute pressure of gas	15.343
Factor to reduce to atmospheric (14.7 pounds) pressure	1.044
Cubic feet of gas at atmospheric pressure, per hour	8,969
Steam pressure, boiler room	127.5
Temperature, feed water	68.1
Factor of evaporation	1.195
Water evaporated per hour, actual	7,341.6
Water evaporated per hour, equivalent	8,773.2
Cubic feet gas consumed per pound water evaporated	1.022
Water used for other purposes than engine	289.6
Cubic feet gas for other purposes than engine	296
Gas used for pumping purposes, per hour	8,673
Gas pumped per hour	231,216
Gas pumped for cubic foot burned	26.66
Per cent of gas pumped used to operate pump	3.751

PERFORMANCE OF BOILERS BURNING PETROLEUM AS FUEL AT LAKETON, INDIANA.

The following are the results of the evaporation tests made on two boilers at Laketon, Indiana, which supplied steam to a triple-expansion pumping engine:

The fuel used was crude petroleum, burned in a Squire & Towl compressed-air burner.

The boilers were of the horizontal return tubular type, 5 feet diameter, 14 feet long, and containing 180 2-inch tubes.

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The oil burner was located at the front end of the boiler, and the products of combustion passed under the latter, through the tubes, and thence to the chimney.

The water-heating surface of each boiler was 1,320 square feet. There was no superheating surface.

The average evaporation, from and at 212° F., for seven tests, was 16.10 pounds of water per pound of oil.

The quality of the steam, as determined by a superheating calorimeter, was perfectly dry.

The average evaporation per hour per square foot of heating surface was 1.9 pounds, at 150 pounds gauge pressure and 60° temperature of feed water.

VALUE OF NATURAL GAS CONSUMED IN THE UNITED STATES.

The difficulty of securing any statement showing the full value of natural gas consumed has already been discussed. The manner of obtaining statistics and the number of companies reporting remain about the same from year to year, and therefore a comparison by years furnishes a true indication of the value and the conditions of production and sale of this unstable article. The prices have remained very nearly uniform during the years 1895 and 1896, and the value of the product therefore affords an index to the quantity consumed, since a large proportion of the gas during these years was measured by meters. Previous to 1894 the prices were much lower. A great amount was consumed unmeasured, and the money value does not very closely represent the number of cubic feet. It will be noticed that the values for 1895 and 1896 are nearly identical.

In the following table is given the approximate value of natural gas produced in the United States from 1887 to 1896, by States:

Approximate value of natural gas produced in the United States from 1887 to 1896.

State.	1887.	1888.	1889.	1890.	1891.
Pennsylvania ..	$13,749,500	$19,282,375	$11,593,989	$9,551,025	$7,834,016
New York	333,000	332,500	530,026	552,000	280,000
Ohio	1,000,000	1,500,000	5,215,669	4,684,300	3,076,325
West Virginia..	120,000	120,000	12,000	5,400	35,000
Indiana	600,000	1,320,000	2,075,702	2,302,500	3,942,500
Illinois.....	.....	.....	10,615	6,000	6,000
Kentucky	.....	.....	2,580	30,000	38,993
Kansas.....	.....	.....	15,873	12,000	5,500
Missouri	.....	.....	35,687	10,500	1,500
Arkansas.....	.....	.....	375	6,000	250
Texas	.....	.....	1,728		.....
Utah.....	.....	.....	150		.....
South Dakota ..	.....	.....	25		.....
California.....	.....	.....	12,680	33,000	30,000
Other States....	15,000	75,000	1,600,000	1,600,000	250,000
Total	15,817,500	22,629,875	21,107,099	18,792,725	15,500,084

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Approximate value of natural gas produced in the United States, etc.—Continued.

State.	1892.	1893.	1894.	1895.	1896.
Pennsylvania ..	$7,376,281	$6,488,000	$6,279,000	$5,852,000	*a* $5,528,610
New York.....	216,000	210,000	249,000	241,530	256,000
Ohio	2,136,000	1,510,000	1,276,100	1,255,700	1,172,400
West Virginia..	500	123,000	395,000	100,000	*b* 640,000
Indiana	4,716,000	5,718,000	5,437,000	5,203,200	*c* 5,043,635
Illinois.....	12,988	14,000	15,000	7,500	6,375
Kentucky	43,175	68,500	89,200	98,700	99,000
Kansas	40,795	50,000	86,600	112,400	124,750
Missouri	3,775	2,100	4,500	3,500	1,500
Arkansas.....	100	100	100	100	60
Texas	100	50	50	20	.....
Utah.....	.....	500	500	20,000	20,000
Colorado	.....	.....	12,000	7,000	4,500
California.....	55,000	62,000	60,350	55,000	55,682
Other States....	200,000	100,000	50,000	50,000	50,000
Total	14,800,714	14,346,250	13,954,400	13,006,650	13,002,512

a Includes $912,000 worth of gas produced in Pennsylvania but consumed in New York and Ohio.
b Includes $126,000 worth of gas produced in West Virginia, but consumed in Ohio and Pennsylvania.
c Includes value of some gas produced in Indiana but consumed in Ohio and Illinois.

CONSUMPTION AND DISTRIBUTION OF NATURAL GAS.

The following table was compiled from the statements of all companies making full returns in 1895 and 1896. Many gas companies do not keep their accounts in such manner as to be able to furnish all of the information requested. In 1896 full returns were received from 355 companies and individuals—91 in Pennsylvania, 205 in Indiana, and 59 in Ohio, and these are compared with the reports made by the same companies in 1895:

Natural-gas records in 1895 and 1896.

	Pennsylvania.		Indiana.		Ohio.	
	1895.	1896.	1895.	1896.	1895.	1896.
Amount received for sale of gas or value of gas consumed.....	$4,420,258	$4,054,791	$1,639,556	$1,589,276	$834,239	$706,212
Value of coal or wood displaced	$4,796,283	$4,102,845	$2,414,621	$2,208,919	$1,153,258	$788,262
Domestic fires supplied..	182,944	171,104	72,019	62,991	45,537	33,982
Iron and steel works supplied.....	24	29	7	5	0	0

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Natural-gas records in 1895 and 1896—Continued.

	Pennsylvania.		Indiana.		Ohio.	
	1895.	1896.	1895.	1896.	1895.	1896.
Glass works supplied	36	45	21	21	1	0
Other establishments supplied	580	648	414	583	158	198
Total establishments supplied	640	722	442	609	159	198
Total wells producing Jan. 1	1,409	1,522	787	936	310	307
Total producing wells drilled	217	208	189	182	38	39
Total wells producing Dec. 31	1,522	1,629	936	1,042	307	317
Total feet of pipe laid	20,950,905	23,430,836	10,774,780	11,484,329	4,083,050	4,099,864
Total establishments reporting	91	91	205	205	59	59

In Pennsylvania the value of gas consumed by the 91 companies reporting in full was $4,054,791, out of a total for the State of $5,528,610; in Indiana the value reported by the 205 companies was $1,589,276, out of a total value of $5,043,635 for that State; in Ohio the value stated by the 59 companies reporting in full was $788,262, out of a total value of $1,172,400. These facts indicate that the returns from Pennsylvania are much more complete than those of the other States named.

The value of the coal and wood displaced in Pennsylvania is slightly greater than that of the natural gas; in Indiana and Ohio, on the contrary, the value of the gas is shown to be very much less than that of the wood and coal displaced. The gas market of northwestern Ohio and that of the Indiana field extend beyond the coal districts. In Pennsylvania a large proportion of the gas is consumed in the bituminous coal regions. The number of domestic fires shows a falling off in all three States, especially in Ohio. The number of wells drilled in Pennsylvania in 1895 and 1896 are nearly the same.

The following table was compiled from the statements of a large number of companies and individuals making partial returns, which could not be included in the previous table, and shows the amount received from the sale of the gas in the States where it was consumed in 1896. In several instances not all of it was produced in the State where it was consumed, but was brought into it from the adjoining States. Hence these figures will not check with the table showing the production of gas. There were 763 companies and individuals in the several States named that reported, giving the amount received for gas, together with the value of the coal or wood displaced by it.

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Value of natural gas consumed in the United States in 1896, by States, and the value of coal or wood displaced by same, as reported by 763 persons, firms, and corporations.

State.	Companies or individuals reporting.	Amount received for sale of gas, or value of gas consumed.	Value of coal or wood displaced by gas.
Pennsylvania	156	$4,616,386	$4,702,984
Indiana	386	3,604,311	4,688,063
Ohio	130	*a* 1,499,370	1,650,492
New York	36	*b* 1,003,205	1,101,500
West Virginia	7	513,735	616,225
Kansas	10	97,165	149,750
Kentucky	16	79,236	97,512
California	7	31,375	38,043
Utah and Colorado	4	18,500	*c* 20,000
Illinois	7	6,310	6,000
Missouri	3	500	500
Arkansas	1	60	60
Total	763	11,470,153	13,071,129

a Includes $326,978 worth of gas produced in Pennsylvania, Indiana, and West Virginia, but consumed in Ohio.
b Includes $747,386 worth of gas produced in Pennsylvania but consumed in New York.
c Estimated.

The following table shows the principal uses to which natural gas is applied. The amount consumed as an illuminant increases yearly, but in the table it is not separated from that supplying domestic fires. It will be noticed that 763 companies and individuals reported in 1896, as compared with 569 in 1895, which accounts for the general increase in this table. Much gas is also consumed near the wells in the manufacture of a superior article of lampblack, unreported; and a large amount of natural gas of which we have no record is consumed by individuals and companies inside of the gas belts. A number of iron mills and steel works in and about Pittsburg have their own lines extending to the gas fields.

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Uses to which natural gas produced in the United States in 1896 was put, as reported by 763 persons, firms, and corporations.

State.	Companies or individuals reporting.	Domestic fires supplied.	Establishments supplied.				
			Iron mills.	Steel works.	Glass works.	Other establishments.	Total.
Pennsylvania	156	204,447	37	8	51	762	858
Indiana	386	181,385	6	3	53	1,108	1,170
Ohio	130	84,206	0	0	0	337	337
New York	36	29,877	0	0	2	51	53
West Virginia	7	11,350	0	0	3	372	375
Kansas	10	3,924	0	0	0	15	15
Kentucky	16	6,525	0	0	0	4	4
California	7	1,197	0	0	0	1	1
Utah and Colorado	4	1,152	0	0	0	0	0
Illinois	7	305	0	0	0	2	2
Missouri	3	15	0	0	0	0	0
Arkansas	1	2	0	0	0	0	0
Total	763	524,385	43	11	109	2,652	2,815

The following table gives, by States, the number of gas wells at the beginning and close of 1896, the number drilled in 1896, and the total length in feet and miles of pipe in use at the close of that year, as reported by 763 companies and individuals:

Record of wells and amount of pipe line as reported by 763 persons, firms, and corporations in 1896.

State.	Companies or individuals reporting.	Wells.			Total pipe laid to Dec. 31, 1896.	
		Producing Dec. 31, 1895.	Drilled in 1896.	Producing Dec. 31, 1896.	Feet.	Miles.
Pennsylvania	156	1,884	297	2,060	26,811,395	5,078
Indiana	386	1,968	421	2,262	21,265,743	4,028
Ohio	130	643	151	702	8,492,580	1,608
New York	36	217	35	226	1,984,949	376
West Virginia	7	82	21	101	3,824,138	724
Kansas	10	47	18	59	412,270	78
Kentucky	16	60	3	63	320,280	61
California	7	14	1	15	58,100	11
Utah and Colorado	4	11	6	14	194,800	37
Illinois	7	30	4	29	63,180	12
Missouri	3	3	0	3	1,000	0
Arkansas	1	2	0	2	.....	0
Total	763	4,961	957	5,536	63,428,435	12,013

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RECORD BY STATES.

PENNSYLVANIA.

No new gas fields were opened up in 1896, but the deep sands in the southeastern portion of Greene County furnished some fair wells. In nearly all cases gas is found associated with petroleum, generally in the higher portions of the oil-bearing rock. Sometimes a rock holding a large volume of gas is tapped before the oil sand is reached; then again some of the largest gas fields in the State occur in strata that underlie the petroleum sand several hundred feet.

The life of a gas field is often greatly diminished by the development of the petroleum, many millions of cubic feet of gas being allowed to pass into the air in order that the reduction of the pressure may induce the petroleum to come in.

Nearly every gas field has its individual characteristics. At some places large volumes of gas are furnished at low pressures, at others a much smaller quantity of gas at a high pressure, and there are some wells that have large volume and high pressure combined. The best gas well is the one that will produce the most gas at the greatest pressure. The original shut-in rock pressure of 1,100 pounds to the square inch has been measured in the early life of some of the gas wells in Pennsylvania. A few wells have shown an open flow equal to thirty-five to forty million cubic feet in twenty-four hours. The diminished rock pressure has of late years forced many companies to use gas pumps to get sufficient gas to their consumers, and the decrease in volume is being in a measure supplied by an increased number of wells. The rock pressure of wells now in use in Pennsylvania has an estimated range between 1 pound and 750 pounds, the average being placed at 85 pounds.

The amount of gas in the natural reservoirs, which are generally of coarse sandstone blanketed by a slaty covering, continually grows less, in some fields more rapidly than in others. It is safe to say that at least 8 per cent of the gas remaining in these reservoirs in 1895 was drawn out in 1896. As the pressure decreases, less gas can be taken out each year.

The gas-bearing strata in Pennsylvania extend from the Mahoning sandstone to the Kane sand, a vertical distance of over 3,000 feet. The following is a partial list of gas-bearing strata in the descending order: Mahoning sandstone, upper and lower Homewood sandstone, Big Injun sand, Squaw sand, Berea grit, Gantz, One-hundred-foot, Fifty-foot, Second sand, Thirty-foot, Third or Gordon sand, Fourth sand, Fifth sand, Sixth sand, Erie shale, Elizabeth, First Warren, Speechley, Balltown, Sheffield, Bradford, Elk, and Kane sands.

In some instances two or more of these horizons furnish gas in the same well, but generally the main output comes from a single horizon.

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In the following table is given the value of natural gas produced in Pennsylvania in the years from 1885 to 1896:

Value of natural gas produced in Pennsylvania from 1885 to 1896.

Year.	Value.	Year.	Value.
1885	$4,500,000	1891	$7,834,016
1886	9,000,000	1892	7,376,281
1887	13,749,500	1893	6,488,000
1888	19,282,375	1894	6,279,000
1889	11,593,989	1895	5,852,000
1890	9,551,025	1896	5,528,610

OHIO.

No new gas territory was found in 1896; but the Lancaster field has been extended to the southeast, where some new wells have shown a rock pressure about equal to the original field.

The Trenton limestone, the Clinton group, the Berea grit, and the Ohio shale, in ascending order, are still the only horizons so far developed that furnish gas in quantity. The decrease in pressure and production has continued. The average pressure of gas in the Trenton area of northwestern Ohio in 1896 was 45 pounds; the initial pressure in 1888 was 450 pounds, showing that approximately only 10 per cent of the original volume is left in this reservoir, if exhausted to atmospheric pressure. In depth these gas wells vary from 1,100 to 1,150 feet. The elevation of the top of the Trenton limestone in the principal gas areas ranges from 315 to 390 feet below tide. The gas is usually found at or near the top of this limestone.

The extension of the Lancaster field toward the southwest has reenforced the supply, and the prospects indicate a supply for the cities now furnished that will last for some time.

In the southeastern portion of Ohio a large amount of gas has been obtained from the Berea grit, but the supply from this horizon is not of such lasting quantity as that from some others.

The amount of gas furnished by the Ohio shale is quite small, although the formation is scattered over a considerable area in the northeastern portion of the State. The wells are comparatively shallow.

In the following table will be found a statement of the value of the natural gas produced in Ohio from 1885 to 1896. It will be seen that the value for 1894 and 1895 was nearly the same, which is partially accounted for by increase in cost. The year 1896 shows a falling off of $83,300, as compared with 1895.

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Value of natural gas produced in Ohio from 1885 to 1896.

Year.	Value.	Year.	Value.
1885	$100,000	1891	$3,076,325
1886	400,000	1892	2,136,000
1887	1,000,000	1893	1,510,000
1888	1,500,000	1894	1,276,100
1889	5,215,669	1895	1,255,700
1890	4,684,300	1896	1,172,400

INDIANA.

The great broad swell of the Cincinnati arch, as it enters Indiana near the middle of the eastern boundary line and continues in a general northwest direction about halfway across the State, contains an area of gas-bearing Trenton limestone that has been estimated at 2,500 square miles. Originally this gas area was larger, and though the wells farthest down the dip have suffered from the intrusion of salt water, it is still the largest connected gas area discovered. The initial rock pressure over this great district was about 325 pounds to the square inch, this being less by 125 pounds than the general rock pressure in Ohio.

The altitude of the body of Trenton limestone furnishing the gas is generally from 50 to 120 feet below tide level, as compared to about 350 feet below tide in Ohio. In 1896 the average rock pressure was about 220 pounds to the square inch, a decrease of 20 pounds as compared with that of 1895, or 105 pounds less than the original pressure. According to these figures about 32 per cent of the gas in this large reservoir has been drawn out, and an index as to the life of the field is thus afforded.

The following table, showing the comparative pressure in 1895 and 1896, was compiled by Mr. J. C. Leach, State supervisor of natural gas, of Kokomo, Indiana.[1] Mr. Leach states that if there are errors in this statement they occur in figures relating to the outer zone, where many wells are so arranged that they can not be relieved of the presence of the salt water before testing.

[1] Twenty-first Annual Report, Department of Geology and Natural Resources, 1896, p. 444.

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Comparative statement of rock pressure of the Indiana natural-gas field, 1895–96.

	Pounds pressure.	
	1895.	1896.
Blackford County:		
Hartford City	270	240
Hartford City, 5 miles west of town	270	245
Delaware County:		
Muncie, 3 miles north of town	250	230
Royerton	250	232
Daleville, 1 mile west of town	225	190
Selma	230	213
Selma, 3 miles north of town	230	218
Albany, 3 miles north of town	250	230
Grant County:		
Marion, 3 miles southwest of town	255	244
Marion, 3 miles southeast of town	260	235
Jonesboro	270	250
Sweetsers	255	246
Swayzee, 2 miles south of town	260	250
Sims	260	245
Fairmount	270	250
Hamilton County:		
Arcadia, 7 miles east of town	235	218
Noblesville, 2 miles north of town	200	150
Noblesville, 9 miles northeast of town	235	210
Hancock County:		
Greenfield, 3 miles north of town	210	185
Henry County:		
Middletown, 5 miles east of town	220	175
Howard County:		
Greentown	255	235
Guy	255	235
Sycamore, 5 miles northeast of town	245	232
West Liberty	255	237
Jay County:		
Camden	150	100
Dunkirk	225	.....
Redkey, 4 miles southwest of town	250	235
Madison County:		
Alexandria	247	228
Alexandria, 2 miles west of town	255	240
Alexandria, 1 mile north of town	260	240
Anderson, 8 miles northeast of town	240	219

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Comparative statement of rock pressure of the Indiana natural-gas field, 1895–96—Cont'd.

	Pounds pressure.	
	1895.	1896.
Madison County—Continued.		
Elwood	255	221
Elwood, 5 miles east of town	255	235
Elwood, 5 miles northeast of town	255	240
Frankton, 2 miles south of town	245	220
Gilman	255	240
Orestes	255	238
Perkinsville	230	210
Rush County:		
Carthage	150	120
Tipton County:		
Tipton	.....	270
Madison Township	245	220
Prairie Township	205	.....
Wild Cat Township	250	238

The greatest enemy to the life of almost all gas wells is the inflowing salt water as the pressure decreases. Indiana gas wells seem to be particularly subject to the accumulation of salt water, especially those farthest down the dip.

The total value of natural gas produced in Indiana in 1896 was $5,043,635, as compared with $5,203,200 in 1895, showing a slight decrease. A considerable amount of natural gas is consumed outside of the State, in Ohio and Illinois, but the exact proportion could not be obtained.

In the following table will be found a statement of the value of the natural gas produced in Indiana from 1886 to 1896:

Value of natural gas produced in Indiana from 1886 to 1896.

Year.	Value.	Year.	Value.
1886	$300,000	1892	$4,716,000
1887	600,000	1893	5,718,000
1888	1,320,000	1894	5,437,000
1889	2,075,702	1895	5,203,200
1890	2,302,500	1896	5,043,635
1891	3,942,500		

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KENTUCKY.

Meade County at present produces more gas than any other county in Kentucky. The gas area is 35 miles southwest of Louisville, and the gas is piped to that city. It is also found to some extent in Hardin, Jefferson, and Breckinridge counties. It occurs in the Devonian black shale on the western slope of the Cincinnati arch. The wells are from 500 to 700 feet deep and have a shut-in pressure of 40 to 60 pounds. They are quite similar in geological position and other conditions to the gas wells in northeastern Ohio and northwestern Pennsylvania. In southwestern Jefferson County, just west of the outcrop of the shale, in the vicinity of Meadow Lawn, a number of wells supply the farmers of that section with fuel and light. These wells are from 225 to 325 feet deep and are usually drilled through the shale, which is from 85 to 90 feet thick and is the source of the gas. The cost is about $200 per well. There are several wells at West Point, in the northern corner of Hardin County, that supply about 60 fires. The pressure and volume are slowly diminishing, but these shallow wells have produced a remarkable amount of gas.

In eastern Kentucky, some 45 or 50 miles south of Catlettsburg, near Warfield, two large gas wells were drilled about fourteen years ago by Capt. A. Allen. Since that time several other wells in the vicinity have found gas in large quantities. The original source of the gas was the sub-Carboniferous limestone. The wells were afterwards deepened to about 1,780 feet, where a larger supply was found in the Berea grit. A number of wells have since found gas in this vicinity, some of them being on the opposite side of the Tug Fork in West Virginia. A well-developed arch crosses the Tug Fork at this locality and, together with the great thickening of the lower Coal Measure strata, has given considerable dip to the lower rocks and concentrated the gas. The rock pressure is about 285 to 300 pounds. The volume of the old well, now shut in for many years, when tested two years ago appeared to be rather large. A number of companies have at different times proposed to pipe this gas to the Ohio River and supply Huntington, Catlettsburg, Ashland, and Ironton, but so far the project has not been carried out.

The Old Dominion Oil and Gas Company has developed several good gas wells in Floyd County. There is a little gas produced in Barren County, Kentucky.

The following table shows the production of natural gas from 1889 to 1896; it has been nearly the same for 1895 and 1896. The shortage in natural gas may have been supplied, in part, during the cold waves, by manufactured gas.

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Value of natural gas produced in Kentucky from 1889 to 1896.

Year.	Value.	Year.	Value.
1889	$2,580-	1893	$68,500
1890	30,000	1894	89,200
1891	38,993	1895	98,700
1892	43,175	1896	99,000

ILLINOIS.

The gradual decline noted in former years still continues. The localities furnishing natural gas are Lamoille, in Bureau County, and Sparta, in Randolph County. Some of the wells in Lamoille do not show any decrease in pressure since the time they were drilled. They are on an average 135 feet deep, the drill passing through hard clay into a greensand, in which the gas is found. The pressure is from 2½ to 30 pounds. This gas is used for domestic purposes only. There is no petroleum associated with it.

The gas wells at Sparta are gradually failing. The pressure in 1895 was 40 pounds, while in 1896 it was only 25 pounds. No wells were drilled in 1896.

The production of natural gas in Illinois from 1889 to 1896 was as follows:

Value of natural gas produced in Illinois from 1889 to 1896.

Year.	Value.	Year.	Value.
1889	$10,615	1893	$14,000
1890	6,000	1894	15,000
1891	6,000	1895	7,500
1892	12,988	1896	6,375

KANSAS.

The production of natural gas has been steadily increasing for a number of years past, and the prospecting for oil has developed several gas wells.

Natural gas is found in Allen, Miami, Montgomery, Wilson, and Wyandotte counties. The gas is found in Miami County at a depth of from 325 to 450 feet, and the pressure of the gas when struck is about 100 pounds.

In Montgomery County gas was found at 850 feet, free from oil and water. In Allen County the gas is found at a depth of 815 to 960 feet. All the gas in Kansas is singularly free from sulphur.

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The following is an analysis of the natural gas from Iola, Allen County, Kansas, which is very similar to Pennsylvania gas:

Analysis of natural gas from Iola, Kansas.

	Per cent.
Hydrogen (H)	0.00
Oxygen (O)	0.45
Nitrogen (N)	7.76
Carbon monoxide (CO)	1.23
Carbon dioxide (CO_2)	0.90
Ethylene series (C_2H_4)	0.00
Marsh gas (CH_4)	89.66
Total	100.00

The production of natural gas in Kansas from 1889 to 1896 was as follows:

Value of natural gas produced in Kansas from 1889 to 1896.

Year.	Value.	Year.	Value.
1889	$15,873	1893	$50,000
1890	12,000	1894	86,600
1891	5,500	1895	112,400
1892	40,795	1896	124,750

CALIFORNIA.

There seems to be nothing new to report from this State. The pressure of the wells remains about the same as in 1895. One productive well was drilled by the Stockton Gas and Electric Company in 1896. The combined output from eight wells belonging to this company is estimated at 100,000 cubic feet in twenty-four hours. In the spring of 1897 a well at the San Joaquin County Hospital developed considerable gas at 1,100 feet. There are some wells furnishing moderate amounts of gas scattered through the oil fields of Los Angeles, Ventura, and Santa Barbara counties.

The production of natural gas in California from 1889 to 1896 is as follows:

Value of natural gas produced in California from 1889 to 1896.

Year.	Value.	Year.	Value.
1889	$12,680	1893	$62,000
1890	33,000	1894	60,350
1891	30,000	1895	55,000
1892	55,000	1896	55,682

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NEW YORK.

In Chautauqua County there are a few shallow gas wells, from 150 to 350 feet deep, that furnish a supply to families. The gas at Seneca Falls, Seneca County, is from the Medina sandstone at a depth of 1,500 feet. The volume and pressure are remarkably persistent, although the wells are not very large producers. The natural gas at Caledonia, Livingston County, was found at the depth of 1,100 feet in the Medina sandstone. The initial pressure ranges from 210 to 400 pounds. Gas is produced near Sandy Creek, Oswego County, and at Phœnix and Pulaski. The main flow of gas is found at or near the bottom of the Trenton limestone, where pockets are often tapped that have immense pressure, but gradually become exhausted. These wells are about 1,000 feet deep, the top of the Trenton limestone being 600 to 700 feet below the surface. There are a number of gas wells in Erie County which furnish a partial supply to the villages of Getzville, Depew, Clarence, and Alden, the town of North Tonawanda, and a part of Buffalo. At Clarence gas is found in the Medina sandstone at a depth of 875 feet. At Depew, where it is a recent development, gas is found in the Medina sandstone at 1,000 to 1,700 feet. The wells not far from North Tonawanda and Getzville are from 450 to 540 feet deep. At Baldwinsville, Onondaga County, gas is obtained from the Trenton limestone at 2,460 to 2,600 feet in depth. Natural gas has been produced in Allegany County for many years. Near Richburg and Little Genesee the pressure has decreased considerably. In the spring of 1889 the rock pressure was 400 pounds; in 1896 it had declined to 240 pounds. This section is now being actively developed for oil and will no doubt soon show a much lower rock pressure. Oil operations in the vicinity of a gas field soon reduce the rock pressure, owing to the drilling of a number of holes in a limited area and the utter disregard of the waste of gas. The new development for oil in southeastern Cattaraugus County toward the close of 1896 opened up several gas wells with small rock pressure but large volume.

The value of natural gas produced in New York from 1885 to 1896 is given in the following table:

Value of natural gas produced in New York from 1885 to 1896.

Year.	Value.	Year.	Value.
1885	$196,000	1891	$280,000
1886	210,000	1892	216,000
1887	333,000	1893	210,000
1888	332,500	1894	249,000
1889	530,026	1895	241,530
1890	552,000	1896	256,000

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It will be noticed that the production in this State in 1896, amounting approximately to $256,000, was greater than that of any single year since 1891, as shown in a previous table giving the value of natural gas in the United States by States. To this production should be added gas valued at $747,386 produced in Pennsylvania but piped into New York, to obtain the total value of the gas consumed in the State.

WEST VIRGINIA.

The State furnishes natural gas in large quantities to Pennsylvania and Ohio. In the fall of 1894 the Philadelphia Gas Company, of Pittsburg, completed a large gas line from Pittsburg to what is known as the "Big Moses" gas field, on Indian Creek, in Tyler County. The "Big Moses" well at the terminus of this line was probably the largest gas well so far developed. For many months this well forced into the air a volume of gas estimated at from forty to fifty-five million cubic feet each twenty-four hours. The gas from this well comes from the Big Injun sand, at a depth of 1,722 feet. The elevation of the mouth of the well is close to 730 feet above tide. It is near the crown of an axis beginning a few miles southwest of this well, extending northeast, with several depressions and elevations, and crossing the Baltimore and Ohio Railroad a few miles east of Littleton.

The life of the Big Moses gas field was short, as oil in large quantities was being developed near by. Many wells tapped the gas before reaching the pay oil, and in scores of such instances the gas was allowed to exhaust itself, so that the gas streak could be cased off and the drilling carried to the lower oil strata.

North of this pool a number of good "gassers" were found. On Upper Run, a few miles east of Pine Grove, several vigorous wells found gas in the Salt sand, the Big Injun, and the Gordon sands. The rock pressure in the last-named sand was 1,000 pounds.

During the winter of 1895–96 a number of good gas wells were drilled near Cameron, Marshall County, and connected by pipe line with Wheeling. The gas here occurs in what is considered the equivalent of the Gordon sand.

The numerous gentle folds of strata in and around the edges of the deepest portion of the basin bury many of the oil and gas sands so deep that nearly all of them, in one locality or another, hold gas in quantity. In several instances three large gas-producing sands have been tapped in the same well. All of these conditions contribute to make West Virginia one of the largest and possibly one of the most lasting gas-producing regions in the United States.

The approximate value of natural gas produced in this State for 1896 is placed at $640,000. Of this amount $126,000 worth of gas was consumed in Pennsylvania and Ohio.

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COLORADO.

Most of the gas in this State is found in the neighborhood of Florence, and continues to be produced from wells that have ceased to produce petroleum. The pressure is light, and varies in different localities from 3 to 20 pounds. The town of Florence is partially supplied with gas. The larger part of it is consumed in operating the wells, hence there is difficulty in getting at the true value. The value has been estimated at $4,500.

UTAH.

The Salt Lake and Ogden Gas and Electric Light Company report as follows:

During the year 1896 there were in use in Utah from three to eight natural-gas wells, each producing an average supply of 8,480,000 cubic feet of gas per month, as registered by Westinghouse proportional meters. It is difficult to estimate the total value of the gas supplied by our company to consumers, but, roughly speaking, the gross revenues from natural gas in 1896 amounted to not more than $20,000. The gas is used for domestic purposes, chiefly cooking. There are a few furnaces supplied, and during the summer months gas was supplied to one of the electric-light companies for firing boilers, etc.

The size of the gas field is limited. It is evidently only a large pocket in recent sands and shales, and it has hitherto been impossible to supply more than 6,000,000 or 7,000,000 cubic feet per month with any continuity. The gas is produced from a recent formation, being the old bed of Salt Lake. It is found chiefly at a depth of from 400 to 600 feet below the surface, in sandy strata underlying a bed of black, shaly clay. The standing pressure of the wells is from 140 to 250 pounds per square inch, according to depth. No sign of oil has yet been found. The wells are very troublesome to keep open, owing to the sand silting in and choking them. The field is apparently not a large one, covering an area, as at present explored, of not more than 4 square miles. The gas has not been used in large quantities, the maximum ever drawn from the wells in one day being about 500,000 cubic feet.

The wells that supply Salt Lake City are situated 12 miles north of it, near the shore of Salt Lake.

The following analysis of the natural gas, as furnished by the Salt Lake and Ogden Gas and Electric Light Company, is reproduced from the report for 1895:

Analysis of Utah natural gas.

	Per cent.
Hydrogen	16.6
Marsh gas (CH_4)	22.0
Ethane (C_2H_6)	37.8
Ethalene (C_2H_4)	.6
Carbonic oxide	1.2
Carbonic acid	.8
Nitrogen	20.0
Oxygen	1.0
Total	100.0

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MISSOURI, ARKANSAS, AND TEXAS.

The value of the natural gas so far developed in these three States is insignificant. Some of the deep artesian wells in Texas have produced a small amount of gas, but no use has been made of it. The value of natural gas in Missouri has been estimated at $1,500, and that of Arkansas at $60.

CANADA.

The two fields that supply by far the greater portion of gas in Canada are Welland and Essex, counties in the Province of Ontario. The Welland County field is situated at the northeastern end of Lake Erie, and the Essex County field is near the extreme northwestern end of the same lake. The conditions remain very much the same as described in the report for 1895, except that the Essex County field has been extended about 2 miles northeast of Leamington, making the entire field 10 miles long by about 1½ miles wide. The surface is only a few feet above the lake and is almost level. About 30 wells have been drilled in this field. The gas is found in what is considered the equivalent of the Clinton limestone, at a depth of 1,000 to 1,040 feet. The rock pressure is 400 to 405 pounds to the square inch.

There are two companies in this field, the Ontario Natural Gas and Oil Company (Limited), and the Standard Oil and Gas Company of Essex (Limited). The former company has two pipe lines, 30 miles long, furnishing gas to Detroit, Michigan, and to Windsor, Walkersville, Kingsville, and Leamington, Ontario. The last-named place owns its own gas well.

The petroleum field, in Lamberton County, supplies a number of farmers and a few clusters of houses with natural gas, and in Kent and Elgin counties there are many shallow surface wells which furnish a similar provision. There are also a number of shallow gas wells in the northwestern part of Aldborough, Elgin County.

The Provincial Natural Gas Company has about 55 producing wells in Welland County, 12 to 15 miles west of Buffalo, N. Y. The wells are 850 to 900 feet deep, running back from the lake front for 2½ miles. They are connected with Buffalo by a pipe line. The following is a record of the No. 1 well on lot No. 35, concession 3, township of Bertie, Welland County. The elevation of the well is 618 feet above tide and 43 feet above Lake Erie.

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Section of natural-gas well, Welland County, Ontario.

Character of rock.	Depth.	Formation.
	Feet.	
Surface	2	
Dark-gray line	23	Corniferous.
Gray and drab dolomite	390	Onondaga.
Black shale and gypsum		
Gray dolomite	240	Guelph and Niagara.
Black shale	50	Niagara.
White crystalline dolomite, gray toward bottom.	30	Clinton.
Red sandstone	55	Medina.
Red shale	10	
Blue shale	5	
White sandstone	5	
Blue shale	20	
White sandstone "gas rock"	16	
Total	846	

Fresh water was cased off at 284 feet, and salt water at 596 feet. After being shut in in 1889 this well produced 2,050,000 cubic feet in twenty-four hours. There has been considerable decrease in pressure and volume in this field and salt water has sealed up a number of the wells.

A number of deep wells have been drilled in Welland County at different points. One at Thorold was drilled 2,430 feet, probably passing through the Trenton limestone, and near the bottom a very small flow of gas was found.

The following table shows the value of the natural gas produced in Canada from 1892 to 1896:

Value of natural gas produced in Canada from 1892 to 1896.

Year.	Value.
1892	$150,000
1893	366,233
1894	313,754
1895	423,032
1896	450,977

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IMPORTS.

In the following table will be found a statement of the value of the natural gas imported into the United States from 1891, when it was first enumerated:

Value of natural gas imported into the United States from 1891 to 1896.

Calendar year.	Value.
1891 (latter half)	$25,540
1892	74,737
1893	90,653
1894	62,523
1895	89,419
1896	87,446

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ASPHALTUM.

By Edward W. Parker.

PRODUCTION.

Production of asphaltum in 1896 was limited to four States and one Territory: California, Colorado, Utah, Texas, and Indian Territory. Kentucky, which produced 5,383 short tons of bituminous sandstone in 1894, and 2,359 tons in 1895, had no product in 1896. Colorado produced a small amount of gilsonite in 1896. The output of asphaltum includes also bituminous sandstone, asphaltic limestone, and liquid asphaltum, termed sometimes maltha or brea, but does not include petroleum residuum. Conditions in which the product is first sold vary. Part of the output is sold in the raw state, as mined, some is made into mastic, and some is refined. By refined asphalt is meant the hard or gum bitumen extracted from the crude rock by dissolving in benzine, after which the benzine is driven off by evaporation, leaving a residue of practically pure bitumen.

Utah gilsonite is pure bitumen when mined. It does not require any refining process, but is included in the refined hard or gum asphaltum in these reports. As the quantities of material sold in the several conditions vary considerably each year, there is frequently a rather marked difference shown in the production and value. For instance, the product in 1895 was 68,163 short tons, valued at $348,281, whereas in 1896 it was 80,503 short tons, worth $577,563, an increase of only a little more than 12,000 tons in amount, but over $200,000 in value. This comparative increase in value was due to not only an increased production of maltha or liquid asphaltum in California, but to a very pronounced advance in its price. There was also an advance in the price of crude hard asphaltum, mined in Ventura County, which added to the increased total value. In addition to this there was an increase in the amount of Colorado and Utah gilsonite reported in 1896, so that the seemingly surprising advance in value is accounted for.

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The production of asphaltum, bituminous limestone, and bituminous sandstone during 1896, by States, is shown in the following table:

Production of asphaltum, etc., in 1896, by States.

State.	Short tons.	Value.
California	74,471	$492,663
Texas	a 2,862	35,220
Utah and Colorado	3,170	49,680
Total	80,503	577,563

a Includes 12 tons of asphaltum from Indian Territory.

For purposes of comparison the following table, showing the production of asphaltum and bituminous rock in 1894 and 1895, is given:

Production of asphaltum, etc., in 1894 and 1895, by States.

State.	1894.		1895.	
	Short tons.	Value.	Short tons.	Value.
California	51,187	$251,991	64,046	$284,086
Kentucky	5,383	21,409	2,359	11,795
Texas	3,000	45,000	1,058	29,900
Utah	1,000	35,000	700	22,500
Total	60,570	353,400	68,163	348,281

It must be remembered that the term "bituminous rock" is used to include limestone and sandstone impregnated with bitumen, and called bituminous (or asphaltic) limestone and bituminous sandstone. Practically all of the bituminous rock produced in Texas and Utah are of the limestone varieties. Texas produced 2 tons of hard and 10 tons of liquid asphalt in 1896 from bituminous sandstone. All of the Kentucky product is bituminous sandstone, and all but a small part of the California "bituminous rock" product is sandstone. There are large deposits of bituminous sandstone in Uvalde County, Texas, only a few miles from the present working mines of bituminous limestone, but they have not been developed. These deposits are described later in this article in a paper by Mr. T. Wayland Vaughan, of the United States Geological Survey, who has recently been making a study of that region.

The varieties of asphaltum may be said to be about as numerous as the localities in which they occur. Such forms as gilsonite, elaterite, uintaite, grahamite, wurtzilite, etc., are hard and brittle at ordinary temperatures, and from these they vary down to viscous, semifluid maltha and to a liquid form, occurring chiefly in California, which, while

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having asphaltum and not paraffin for a base, yields illuminating and other petroleum products. Some occur in a comparatively pure state and others as sandstone or limestone impregnated with bitumen. These are known, respectivley, as bituminous sandstone or bituminous limestone, and are classed together as bituminous rock. An interesting table is given below, in which is shown the amount and value of the different asphaltum products obtained in 1896. All the varieties of refined or gum asphaltum are combined. These include "hard" from California, "gilsonite" from Colorado and Utah, and "litho-carbon" from Texas. The values are given for the condition of the product in which it was first sold:

Varieties of asphaltum, etc., produced in 1896.

Variety.	Short tons.	Value.
Crude asphaltum	6,500	$78,000
Bituminous sandstone	56,971	170,913
Bituminous limestone (a)	4,300	21,500
Mastic	100	900
Hard, refined, or gum	3,122	92,240
Liquid or maltha	9,510	214,010
Total	80,503	577,563

a Not including mastic or refined asphaltum made from bituminous limestone.

The following table shows the annual production of asphaltum and bituminous rock in the United States since 1882:

Production of asphaltum and bituminous rock from 1882 to 1896.

Year.	Short tons.	Value.	Year.	Short tons.	Value.
1882	3,000	$10,500	1890	40,841	$190,416
1883	3,000	10,500	1891	45,054	242,264
1884	3,000	10,500	1892	87,680	445,375
1885	3,000	10,500	1893	47,779	372,232
1886	3,500	14,000	1894	60,570	353,400
1887	4,000	16,000	1895	68,163	348,281
1888	50,450	187,500	1896	80,503	577,563
1889	51,735	171,537			

On November 24, 1896, fire broke out in the gilsonite mines of the Gilson Asphaltum Company at Fort Duchesne, Utah, and, despite the most strenuous efforts made to extinguish it, burned fiercely for six days. On the night of November 29 one of the shafts caved in, cutting off a portion of the draft which fed the flames, and by noon the next day the fire was extinguished. While it lasted, the fire burned out a

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gilsonite vein 700 feet in length and 100 feet in depth. The old workings were entirely ruined, and it is not probable that the company will ever be able to repair them. The disaster is supposed to have been caused by a small fire started by some of the miners in the workings. The heat from this fire caused an explosion of asphaltic dust in the shaft, and this in turn started the conflagration. Several lives were lost in the explosion and subsequent fire, and a large number of men were injured. Before the fire had been fairly extinguished, the superintendent, Mr. Bert Seaboldt, with a gang of men, was at work on a new shaft, and before the 1st of December gilsonite was being shipped from the new opening.

IMPORTS.

The imports of asphaltum into the United States include hard asphaltum from Cuba, Trinidad asphaltum from the island of Trinidad, off the coast of Venezuela, South America, and bituminous limestone from Neufchatel and Val de Travers, in Switzerland, and Seyssel, in France.

The following table shows the imports of crude asphaltum since 1867:

Crude asphaltum imported into the United States from 1867 to 1896.

Year ended—	Quantity.	Value.	Year ended—	Quantity.	Value.
	Long tons.			*Long tons.*	
June 30, 1867..	.....	$6,268	June 30, 1882..	15,015	$102,698
1868..	185	5,632	1883..	33,116	149,999
1869..	203	10,559	1884..	36,078	145,571
1870..	488	13,072	1885..	18,407	88,087
1871..	1,301	14,760	Dec. 31, 1886..	32,565	108,528
1872..	1,474	35,533	1887..	30,808	95,735
1873..	2,314	38,298	1888..	36,494	84,045
1874..	1,183	17,710	1889..	61,952	138,163
1875..	1,171	26,006	1890..	73,861	223,368
1876..	807	23,818	1891..	102,433	299,350
1877..	4,532	36,550	1892..	120,255	336,868
1878..	5,476	35,932	1893..	74,774	196,314
1879..	8,084	39,635	1894..	102,505	313,680
1880..	11,830	87,889	*a* 1895..	79,557	210,556
1881..	12,883	95,410	1896..	96,192	304,596

a In addition to the crude asphaltum imported in 1895 there was some manufactured or refined gum asphaltum, valued at $30,664. The quantity was not reported.

ASPHALT FROM PETROLEUM.[1]

By a modification in the final process of distilling the heavier fractions (tar) of petroleum, F. H. Byerley has succeeded in obtaining as residue various grades of asphalt instead of the coke usually produced.

[1] Extract from a paper by C. F. Mabery and F. H. Byerley in the Journal of the Society of Chemical Industry.

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The process consists in introducing a current of air through a number of pipes into the liquid, the decomposing action of the air being minimized by lowering the rate of distillation, which is prolonged to about four or five days. The temperature is first raised to 450° F. and later to 650° F., at which point it is maintained throughout. The distillates are divided into two portions, both of which are refined for burning oils after removal, by steaming, of the sulphur they contain (0.04 to 0.15 per cent).

The air appears to act mechanically by preserving the tar from coking on the walls of the still, and chemically by oxidizing sulphur and hydrogen rather than by forming oxygen compounds in the oil.

Four chief products are formed—liquid asphalt, roofing asphalt, paving asphalt, and varnish asphalt. In percentage composition they differ but little from each other, the carbon content ranging from 86.22 in the first named to 87.44 in the varnish asphalt. Sulphur is present to the extent of from 0.3 to 0.4 per cent, hydrogen between 10.90 and 9.30 per cent, and oxygen from 1.90 to 2.40 per cent.

The varnish asphalt resembles the natural bitumen (gilsonite), and is suitable for the same industrial purposes. It softens at 230° and begins to flow at 260° F. In carbon bisulphide it is completely soluble, but less so (62.45 per cent) in petroleum spirit, 75° to 110°, and petroleum distillate (53.37 per cent) 200° to 250°.

PRODUCTION BY STATES.

CALIFORNIA.

The production of asphaltum and its allied minerals on a commercial scale began in 1888. The product in that year consisted entirely of bituminous sandstone, which was used for street paving. In the following year considerable attention was paid to the refining of some of the natural product for the manufacture of varnishes, insulators, and protective covering for wharf piling and timbers, wood conduits, etc. During these first two years of the asphaltum industry in California the business was somewhat overdone and a reaction set in. The conditions were not ripe for a revolution in the system of street paving, and it is for this purpose that the bituminous sandstones of California are especially adapted. Moreover, those who had engaged in the enterprise had done so without sufficient knowledge. It is now well known that asphalt pavements are serviceable and enduring only when proper attention has been given to preparation of the foundation, laying of the base, and technical treatment and laying of the asphalt itself. More than this, owing to the great differences in the qualities of various asphaltums and bituminous rocks, each must be studied for itself in order to obtain the best results. Because one asphaltum, treated by the same process to which another has been subjected, does not give as satisfactory results, it is not necessarily a reflection on the quality of the

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former. It may be really better than the other. The trouble has been with the preparation. To the lack of technical knowledge in regard to the California asphaltums may be attributed the unsatisfactory result from their earlier applications and the collapse of several companies which engaged in the business. More intelligent application has corrected this error, and the superior qualities claimed for the California asphaltums have not only been demonstrated at home, but have secured for them recognition and markets abroad. The increased production in the last four years, and particularly the largely increased value in the product for 1896, are ample evidences of this fact.

In the earlier years of the industry the consumption of California bitumens for street paving and other purposes was confined to a few of the larger cities of the State, San Francisco, Sacramento, Los Angeles, San Luis Obispo, etc. They are now being shipped to the Eastern cities and to Europe. Mr. Charles G. Yale is authority for the statement that San Francisco is not now considered a market to any extent for the liquid asphaltum produced at the Las Conchas mine and the solid asphaltum produced at La Patera mine, both in Santa Barbara County. The mining company is now filling a contract with Glasgow, Scotland, and has been shipping some material to Paris. The railroad companies encourage the industry by giving favorable freight rates.

The following table gives the annual production of asphaltum and bituminous rock in California since 1888:

Annual production of asphaltum, etc., in California since 1888.

Year.	Bituminous rock.	Hard asphaltum.	Maltha.	Total.	Total value.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	
1888	49,300	.....	.....	49,300	$152,500
1889	47,968	.....	.....	47,968	126,885
1890	.....	.....	.....	(a)	(a)
1891	39,962	.....	.....	39,962	154,164
1892	24,000	6,250	1,300	31,550	188,350
1893	33,000	b 9,650	.....	42,650	275,662
1894	45,397	b 5,790	.....	51,187	251,991
1895	38,921	21,375	3,750	64,046	284,086
1896	56,971	c 8,000	9,500	74,471	492,663

a Not reported by States.
b Includes maltha or liquid asphaltum.
c Includes solid crude asphaltum and refined gum.

In regard to the bituminous sandstones of Santa Cruz and San Luis Obispo counties, Mr. J. H. Swift, vice-president of the Consolidated Bituminous Rock Company, of San Francisco, reports that the former contains about 75 per cent quartz sand, 20 per cent bitumen, and about

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5 per cent carbonate of lime, and that the latter contains from 82 to 83 per cent quartz sand, and yields, when separated, about 18 per cent of hard, elastic, and very pure bitumen. The rock is sold in San Francisco at $4.50 per ton, and is worth $3 per ton at the mines. This material, Mr. Swift says, needs only to be treated with hot water and steam for about twenty minutes and it is ready for spreading. It is then rolled smooth with hot rollers and becomes a hard and lasting pavement. It is not slippery and is not affected by the extremes of warm or cold weather to which it is subjected in the cities of the Pacific Coast. Mr. Swift states that this bituminous rock has been used for pavements in cities where the temperature reaches 105° to 115° F. for several weeks at a time, and after eight years of use has caused no expense in the way of repairs. It has also been in use on eight blocks at Salt Lake City for five years, where the climate is very cold in winter, the streets being covered with snow and ice for several months. No repairs have been made on this work.

One ton of crude bituminous rock is calculated to cover 100 square feet of surface 2 inches thick. Following are analyses of the Santa Cruz and San Luis Obispo bitumens:

Analyses of California bituminous rocks.

Constituents.	Santa Cruz.	San Luis Obispo.
	Per cent.	*Per cent.*
Bitumen	20.04	16.77
Silica	74.45	82.60
Carbonate of lime	4.75	None.
Water	.76	.63
Total	100.00	100.00

The Santa Cruz material is preferred for streets where there is heavy travel, and the San Luis Obispo for those with light traffic.

BITUMINOUS DEPOSITS IN SANTA BARBARA COUNTY, CALIFORNIA.

The following description of the bituminous deposits of Santa Barbara County is abstracted from a recently issued publication of the California State Mining Bureau.[1]

The Punta Gorda asphalt mine is about a mile east of Rincon Creek, less than a quarter of a mile north of the Southern Pacific Railroad, and at about 150 feet altitude. The workings consist of a tunnel about 140 feet long and a 100-foot shaft. The tunnel cuts through a vein of asphaltum which has a strike of N. 20° W. The vein in the tunnel varies from 10 inches to 2 feet in thickness, and dips S. 60° E. at an angle of about 75°. The wall rock is bituminous shale. At the mouth of the

[1] Bulletin No. 11, California State Mining Bureau: Oil and Gas Yielding Formations of Los Angeles, Ventura, and Santa Barbara Counties, 1896.

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tunnel the shale is much disturbed, and in the tunnel it shows a dip of S. 30° W. at an angle of about 70°. The prevailing dip of the formation north of the tunnel is N. 10° E., at an angle of about 80°. The shaft has been sunk on the vein, which shows about 13 feet maximum thickness at this point. The asphaltum is a uniformly black mass, which exhibits a slightly granular structure. The following assays of asphaltum obtained in the Punta Gorda mine are from the records of the company:

Analysis of asphaltum from Punta Gorda mine, 40-foot level.

[By Prof. George E. Colby, University of California, Berkeley.]

Constituents.		Per cent.
Loss at 212° F.		0.83
Hydrocarbons	Equal 28.50 per cent bitumen	18.06
Fixed carbon		10.44
Ash		70.67
Total		100.00

The asphaltum contains 28.06 per cent fixed carbon.

Analysis of asphaltum from Punta Gorda mine, 60-foot level.

[By C. A. Ogden, chemist.]

Constituents.	Per cent.
Bitumen	28.53
Silica	51.64
Clay	4.76
Calcium sulphate	2.45
Calcium carbonate	11.96
Magnesium carbonate	0.55
Not determined	0.11
Total	100.00

The pure bitumen showed the following condition when treated at various temperatures:

Constituents.	Per cent.
Loss of oils at 212° F.	2.65
Loss of oils at 212° to 480° F.	6.95
Above 480° F.	40.72
Carbon	49.68
Total	100.00

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Analysis of asphaltum from Punta Gorda mine, 85-foot level.

[By Prof. George E. Colby.]

Constituents.		Per cent.
Loss at 212° F		0.71
Hydrocarbons	Equal 29.91 per cent bitumen	18.72
Fixed carbon		11.19
Ash		69.38
Total		100.00

The asphaltum contains 37.30 per cent fixed carbon.

The Rincon asphaltum mine.—This mine is situated on the Rincon ranch, about 1 mile northeast of the Punta Gorda mine, and at about 900 feet altitude. At this point soft Pliocene sandstones rest nonconformably on the Miocene shales. The workings consist of a tunnel and an open cut. The tunnel has been run N. 80° E. and cuts through a body of sand which is impregnated with heavy oil, and about 4 feet in thickness. The walls of the tunnel are soft sandstone, containing a few fossils. Thirteen specimens were obtained from this formation and classified. They show the following range:

Living, Quaternary	2
Living, Quaternary, Pliocene	7
Living, Quaternary, Pliocene, Miocene	4
Pliocene	1

About 50 feet S. 30° E. from the mouth of the tunnel there is an open cut about 10 feet deep, which shows a body of impure asphaltum, and appears to be an extension of the body of oil-soaked sand and asphaltum material which has been cut through by the tunnel.

In the railroad cut near the mouth of Rincon Creek a soft, bituminous sand is exposed, which contains a few fossils, and dips to the north at an angle of about 30°. This sand is several feet in thickness, but the lighter oils have almost entirely evaporated from it, leaving it dry and pulverulent.

The Las Conchas mine and asphaltum works are situated on the seashore at Carpenteria. The mine consists of a body of bituminized sand which covers about 75 acres, and which has been estimated by boring to be more than 25 feet in average thickness. The sand is soaked with maltha, derived from the bituminous shale on which it rests. The prevailing dip of these shales is N. 10° W. and the angle of inclination is for the most part 70° or more. The bituminous sands appear to be horizontal, as they dip to the northwest at a very slight angle. The process of mining is as follows: The surface soil, consisting of 6 to 8 feet of loam, is removed by hydraulic washing; a thin stratum of yellow clay overlying the bituminous sand is then stripped off; the sand is

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mined with hot spades and conveyed by cars, which are hauled by a cable up an incline track to the upper floor of the asphaltum refinery, where it is dumped into a "mixer," consisting of a steam-jacketed cylinder, in which revolving arms break the lumps. From the mixer the sand falls into vats of boiling water; the maltha floats and the sand sinks to the bottom, where revolving "worms" carry the sand to a hopper, feeding a "bucket conveyor," which conducts the sand through a flume to the point of discharge. When each bucket reaches the point of discharge it is played on by a jet of water to free it from the sand. The maltha, called "crude flux," flows from the surface of the water through a flume to a tank, whence it is pumped into a storage tank at a higher elevation. From the storage tank the "crude flux" runs by gravity into two refining kettles of 15 tons capacity each, where it is subjected for twenty hours to a high temperature, commencing at 100° F. and finishing at 240° F. In this process aqueous vapor and the lighter oils are driven off. The "refined flux" is carried by steam-jacketed pipes to the mixing department, where it is used as a flux for treating asphaltum from the La Patera mine. This treatment consists of adding the refined flux to the crude asphaltum and revolving the mass in drums of five tons' capacity and at a temperature of about 350° F. The amount of flux added depends on the degree of hardness required in the refined asphaltum. In about five hours the charge is run into a settling kettle, wherein the impurities settle, and from the bottom of which they are removed by a worm and used as fuel. The refined asphaltum is conducted by a steam-jacketed pipe to the "barreling tank," from which it is drawn into a traveling kettle, running on an overhead gear, and discharging the asphaltum into barrels. During all these processes the asphaltum is kept in a state of fluidity to admit of its being handled with celerity. The process of separating the maltha from the sand and refining the "crude flux" is a continuous one; the manufacture of the refined asphaltum is intermittent. The capacity of these works is 75 tons in twenty-four hours.

There is little doubt that the petroleum in the bituminous sand at the Las Conchas mine is derived from fissures in the Miocene shales; still there are no productive wells in the shales themselves. In 1894 Mr. P. C. Higgins, of Carpenteria, dug a 4 by 6 foot well 354 feet deep at a point on the seashore about half a mile west of the Alcatraz refinery. The well proved unproductive. The formation penetrated is a purple-colored bituminous shale, containing a few specimens of *Pecten peckhami*, and bleaching almost white on exposure to the air. The dip of this shale is a little east of north. Eastward along the coast line the exposed rocks are principally bleached shales, which at some places are much disturbed and contorted, and there are numerous faults. The prevailing dip is to the north, but in a few places the rocks dip southerly. This bleached shale is well exposed on the east side of Rincon Creek, at the base of Mount Hoar. As before men-

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tioned, the bleaching of the shale appears to be due to solfataric action or to some chemical process allied thereto. East of Carpenteria Creek, and for a distance of about 1 mile from the ocean, flowing water is obtained at less than 150 feet depth. In this area the formations penetrated by artesian wells consist of irregular strata of sand and clay. East of this artesian area the land surface rises, and the Miocene shale is struck about 30 feet in depth. Westward from Carpenteria, toward Serena, oil and water have been struck in shallow wells which penetrate the alluvial formations. This was the case on the Follinsbee ranch at Serena, about 100 feet north of the railroad track. Also, on the Cheeseborough ranch, adjoining the Follinsbee ranch on the south, oil and water were found at 25 feet depth. Also, on the Martin ranch, in a well about 1,000 feet southwest of the well on the Follinsbee ranch, oil and water were struck at 100 feet depth. It is said that at low tide an oil spring is exposed on the seashore about a quarter of a mile southwest of the Martin ranch.

KENTUCKY.

Kentucky did not produce any bituminous sandstone in 1896. The first production was reported in 1891, and operations were suspended in 1895. The product during the five years, 1891 to 1895, was as follows:

Annual production of bituminous sandstone in Kentucky from 1891 to 1895.

Year.	Short tons.	Value.
1891	3,000	$6,000
1892	2,680	10,525
1893	1,929	6,570
1894	5,383	21,409
1895	2,359	11,795

OKLAHOMA TERRITORY.

Mr. George F. Devereux, general manager of the Oklahoma Oil and Asphalt Company, Oklahoma City, reports large and valuable bituminous deposits in the Territory, but the business depression of the past few years has prevented development. With an improvement in business conditions, Mr. Devereux hopes to be able to place the material on the market.

TEXAS.

Asphaltum in various forms occurs in several localities in Texas, but the bituminous limestone deposits at Cline, in Uvalde County, continue to furnish practically all of the commercial product. The output here in 1896 was 5,000 tons of crude rock, 2,300 tons of which was sold crude, 100 tons made into mastic for paving, the remainder being refined and yielding 450 tons of gum or "litho-carbon."

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Not far from this deposit and in the same county, near the town of Uvalde, is an extensive deposit of bituminous sandstone, but no attempts have been made to develop it. The deposits in Montague County mentioned in the preceding report produced a few tons in 1896.

The following statement shows the production of crude rock at Cline since operations were begun in 1894:

Production of crude bituminous limestone at Cline, Texas, since 1894.

Year.	Short tons.
1894	3,000
1895	3,500
1896	5,000

THE ASPHALT DEPOSITS OF WESTERN TEXAS.[1]

By T. Wayland Vaughan.

The asphalt deposits of western Texas lie in Uvalde County, within the areas designated by the United States Geological Survey as the Brackett[2] and Uvalde[3] quadrangles of the Geologic Atlas of the United States. There are two different areas of asphalt-bearing rock, whose relations to each other will be explained later. The first area is in the extreme western portion of Uvalde County, south of the Southern Pacific Railroad, and lies along the courses of Turkey, Gato, and Olmos creeks. The second occurs farther east, on the same side of the Southern Pacific Railroad, along the Nueces River. The topography of the region is that of a plain broken by hills that rise abruptly to a height of 100 to 400 feet above the general level of the surrounding country. The climate is semiarid. The rainfall is spasmodic, but at times very heavy. The vegetation consists mostly of cactus and mesquite trees.[4]

The Turkey Creek-Gato Creek deposit.—These localities lie in the vicinity of the Brackett quadrangle near its eastern margin. The mines of the Litho-Carbon Rubber Company are situated at Carbonville, about 6 miles southeast of Cline Station, on the Southern Pacific Railroad, along the eastern side of Turkey Creek. Other exposures of asphalt-bearing rock occur $2\frac{3}{4}$ miles west of south of Carbonville in the valley of Gato Creek, on its western side. Farther down this creek, about half a mile below the crossing of the road from Nunn's ranch

[1] The data upon which this paper is based were accumulated during the field season of 1895 by Mr. R. T. Hill and the author, while mapping the geology of the Brackett quadrangle, and by the author during the summer of 1896, while doing additional work on the Brackett quadrangle and mapping the geology of the Uvalde quadrangle, under the direction of Mr. Hill.

[2] Bounded by parallels 29° and 29° 30′, meridians 100° and 100° 30′.

[3] Bounded by parallels 29° and 29° 30′, meridians 99° 30′ and 100°.

[4] The general features of the region are described in considerable detail in a paper on the Edwards Plateau and the Rio Grande Plain, in Part IV of this annual report.

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to Beasley's ranch, a well was sunk into the asphalt rock, according to Mr. Thomas Nunn, of Uvalde, through a thickness of 200 feet. There is another exposure of the same rock about half a mile farther west, on the west side of Olmos Creek, south of the Nunn-Beasley ranch road. These data seem to indicate that there is here a continuous area of the asphalt-bearing rock about 4½ miles long from north to south and half a mile or more in width.

The asphalt occurs as an impregnation of a porous limestone. The stratigraphic position of the limestone is slightly above the middle of the Upper Cretaceous. Stated more specifically, the horizon of the asphalt is in the upper portion of the Anacacho formation.[1] The structure of the area is that of a shallow synclinal basin, plunging gently to the southward. The dips are very gentle, rarely or never exceeding 5° or 6°.

Condition of working.—The asphalt at present is being worked only at Carbonville (litho-carbon) on Turkey Creek. Mr. Parker[2] has published the following account:

> The deposit is large and easily mined, as very little overburden has to be removed before the material can be stripped off the surface. Extensive works have been erected for treating the asphalt, which is prepared and sold in two conditions—as mastic and gum. The preparation of the mastic is a simple operation, consisting merely of grinding the crude rock to a desired fineness, after which it is heated and run into molds and it is ready for shipment. This is used for street paving, etc., the other necessary ingredients, sand and petroleum residuum, being added at the place where used. The city of Houston, Texas, has paved a number of streets with asphalt sheets made from the Cline mastic.
>
> The more valuable condition in which the material is sold is that of refined or gum asphaltum. The owners have given this the name of "litho-carbon." It is prepared by dissolving the bitumen out of the rock by benzine. The benzine is distilled off, recondensed, and used over and over again with very little loss. The bitumen is obtained in a very pure state, and is worth $50 per ton free on board at New York. In 1895 450 tons of litho-carbon were shipped, and with the increased facilities in the way of new machinery, etc., which were placed on the ground early in the present year, it is calculated that an output of 6,000 tons of litho-carbon may be produced in a year. The mastic plant is capable of turning out 20 tons a day.

Mr. R. T. Rokeby, vice-president of the Litho-Carbon Rubber Company, has kindly furnished the following data on the chemistry of the material mined near Cline:

> The following are analyses of two samples of the rock made by an expert in Philadelphia. The first sample was probably a little richer in bitumen than the average rock mined, and the second a little poorer. Taken generally, the average of the rock mined yields 15 or 16 per cent of bitumen.
>
> The analysis of sample No. 1 was as follows:
>
> The rock is made up in large part of fossil-shell remains filled in and partly replaced by bitumen.
>
> A qualitative analysis of the mineral matter showed it to be carbonate of lime and magnesia, with no silica, clay, or earthy oxides.

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[1] These beds are defined in the paper in Part IV, of this Annual Report.

[2] Seventeenth Ann. Rept. U. S. Geol. Survey, 1895-1896, Part III, p. 754.

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A representative analysis of a carefully made average sample gave the following composition:

Analyses of average samples of asphaltum from near Cline, Texas.

Constituents.	Per cent.
Total bitumen	25.18
Organic nonbitumen	1.46
Mineral residue	73.36
Total	100.00

Analysis of No. 2 is as follows:

Constituents.	Per cent.
Bitumen extracted by petroleum naphtha (petrolene)	6.40
Bitumen extracted by chloroform (so-called asphaltene)	2.63
	9.03
Organic nonbitumen	None.
Mineral residue	90.97
Total	100.00

It will be seen that 70.87 per cent of the total bitumen is of the petrolene character and 29.13 per cent the so-called asphaltene, an excellent ratio if the material is to be used for paving purposes.

The mineral residue was found to be carbonate of lime, with quite an appreciable amount of oxide of iron. There was no silica to speak of and only a trace of magnesia.

The outcrops at other places, as those in the valleys of Gato and Olmos creeks, are very promising, but have not been developed. Mr. Thomas Nunn, of Uvalde, blasted out a considerable quantity of the rock from the west bank of Olmos Creek, crushed it, and heated it. He paved his walk with the material. In two years the pavement has shown no signs of wear, the original uneven surface being still preserved. The bituminous limestone is easily mined, as there is very little overburden. The transportation facilities are good, as all the deposits are within 12 miles of the main line of the Southern Pacific Railroad, and a branch road about 6 miles long has been built from Cline to the mine of the Litho Carbon Rubber Company.

The deposits along the Nueces River.—The asphalt-impregnated rock found along the Nueces River is a soft, bituminous sandstone. Asphalt was found in a well about 9 miles west of south of the Southern Pacific Railroad bridge over the Nueces River, and about 3 miles west of the

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crossing of the Eagle Pass-Uvalde road over the same stream, along a trail going to Nunu's ranch. About half a mile below the crossing of the Eagle Pass-Uvalde road other outcrops of the asphalt-bearing sandstone are seen. There are outcrops of the same from place to place along the river to Pulliam's ranch, about 5 miles farther down the river. A few hundred yards above this ranch are the Waxy or Asphalt Falls. This is the best exposure that was seen, and as it was studied rather carefully a somewhat detailed description will be given.

Section from top of bluff on the west side of the Nueces River, Texas, to bed of stream.

	Ft.	In.
11. Flint gravel capping lower rocks	8	0
10. Coarse-grained laminated and cross-bedded yellow sandstone.	2	0
9. Soft, yellow sandstone and clay	5	0
8. Ledge of oysters (*Ostrea cortex*) in slightly consolidated yellow clay	2	0
7. Yellow, laminated, sandy clay	3	6
6. Soft ledge of mass of fragments of oyster shells or small oysters.	1	0
5. Soft, laminated, yellow, sandy clay	3	0
4. Hard layer of sandstone	0	6
3. Soft, fine-grained sandstone, frequently cross-bedded; contains some asphalt	10	0
2. Soft, fine-grained sandstone, containing great quantities of asphalt—so much that under the influence of the heat of the sun it oozes out over the surface	5	0
1. Bluish clay to waters' edge	1	0

The dip of the rocks is about 8 feet to the hundred to the northwest, upstream, producing several small falls. The upper fall is over the oyster ledge; the lower one over the asphalt-bearing sandstone. It is well to note here that the relations between the asphalt-impregnated sandstone and the oyster ledge were found to be constant throughout an area several miles long. The latter occurs between 15 and 18 feet above the asphalt horizon. No attempt was made to estimate the amount of the asphalt-bearing rock of Waxy Falls. The area is quite large and the impregnated stratum over 5 feet thick.

About 100 yards below Pulliam ranch is another exposure of the same bituminous sandstone. The section is as follows:

	Feet.
3. Massive sandstone containing asphalt, about	5
2. Shaly stratum	5
1. Indurated argillaceous sandstone	4

The area underlain by asphalt-bearing sandstones extends from a point on the Nueces River, 9 miles below the Southern Pacific Railroad bridge, for more than 3 miles down the river, measured in a straight line. The width can not be ascertained from observations on the surface, as there are extensive superficial fluvial deposits that obscure the older geologic formations. The geologic horizon of this asphalt deposit is somewhat higher than that of the Turkey Creek-Gato Creek deposit. The sandstone in which it occurs is very near the base of the arenaceous

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division of the Upper Cretaceous, known in the region as the Eagle Pass beds. The geologic structure is that of a shallow synclinal basin. There are local irregularities in the dips along the Nueces River.

The bituminous sandstone has not been mined at all. Some blasts have been put in the outcrops at Waxy Falls, but so far no capital seems to have been interested in the property. The area is quite extensive, and parts of it seem very promising. It can not be stated at present how much of the area is workable, because so large a portion of the deposit is concealed by the old fluvial deposits, and good exposures are not frequent. The material at Waxy Falls can be mined easily, as there is no overburden.

Mr. George H. Clapp, of Pittsburg, Pennsylvania, has examined this locality, and has made determinations of the amount of asphalt in the rock, and has kindly allowed the publication of the same, viz:

Amount of asphalt in sandstone from near Waxy Falls, Texas.

	Per cent.
1. Outcrop: Asphalt	13.24
2. Two feet below surface:	
Asphalt	15.03
Sand	74.03
Oxides of iron and alumina	7.76
Organic matter, water, and undetermined	3.18
3. Four feet from surface: Asphalt	12.36

Transportation facilities are very good, as the main line of the Southern Pacific Railroad is only 12 miles distant. The intervening country is very level and easily traversed.

Outcrops of bituminous limestone have been verbally reported as occurring near the Nueces. These would necessarily be north of the area of bituminous sandstone, i. e., within the area of the Anacacho formation, which is to the north. The writer has not seen these outcrops.

Suggestions concerning the origin of the asphalt deposits.—In the preceding discussion two facts have been stated bearing upon the probable origin of the deposits. They are: (1) The asphalt is an impregnation of a porous limestone or soft sandstone; (2) the bituminous impregnations occur in the bottoms of shallow synclines. The significance of these facts will be shown in the following discussion.

The marine sedimentary formations occurring in the vicinity of the asphalt deposits are the Austin chalk, which underlies the Anacacho formation, and the Eagle Pass formation which overlies the Anacacho. The Austin chalk is composed very largely of the remains of marine organisms—foraminifera, mollusks, etc. The Anacacho formation also is largely of organic origin, the limestone ledges that it contains often

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being shell breccias. The Eagle Pass beds are composed mostly of sands and clays, with some ledges of oyster shells.

The region has been subjected to considerable igneous disturbance There are laccolites, bosses, sills, and dikes of basalt[1] of a considerable number of varieties. There is a large laccolitic mass about 2 miles south of the Southern Pacific Railroad, extending west for a little more than 5 miles. The greatest distance from north to south across this mass is 3¾ miles. In the narrowest place the distance across is only half a mile. The highest hills in the area of the laccolite, as indicated above, such as Sulphur or Copperas Peak, are bosses of basalt standing above the general level of the laccolite. The eastern limb of the syncline, in which the Turkey Creek-Gato Creek deposit occurs, rests against the western side of the large basalt mass. The northern end of the syncline, in which the Neuces River deposit occurs, approaches near to the southern surface exposure of the laccolite. There are small areas of basalt, probably originally sills (laterally intruded sheets), now usually capping the hills on both sides of the river south of the main laccolitic mass. Therefore both deposits are associated with the igneous rocks. The facts above presented may be summarized as follows:

1. The asphalt is in shallow synclinal basins.
2. It is an impregnation of porous rock.
3. The associated sedimentary formations are largely of organic origin.
4. There has been much igneous disturbance, and the asphalt is clearly associated with the igneous rocks.

These facts have suggested the conclusion that the heat of the basalt intrusions has acted upon the organic limestone, driving out the asphalt or bitumen, which has accumulated in the synclinal basins as impregnations of the porous beds.

UTAH AND COLORADO.

Gilsonite, a very pure form of asphaltum, is mined in Uintah and Wasatch counties, Utah, and just across the line from the former, in Clear Creek County, Colorado. Producers of gilsonite have furnished statements of their production to the Survey, but they have done so with the understanding that the statements shall be maintained confidential. As there was but one company operating in Colorado and two in Utah, the production of the two States in 1896 has been combined. In addition to the output of gilsonite, Utah produces a considerable amount of asphaltic limestone, which is used in the manufacture of paving and roofing material. It is shipped principally to Chicago and other central cities. There is nothing to add to what has been previously said in regard to the Utah ozocerite. The market is still supplied by the Galician product, and the Utah deposits are not

[1] The details of the occurrence of these rocks and their petrographic characters will be described soon in an article by Mr. C. Whitman Cross and the author.

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worked. The production of asphaltum, etc., in Utah from 1891 to 1895 and in Utah and Colorado in 1896 is shown in the following table:

Annual production of asphaltum, etc., in Utah since 1891.

Year.	Short tons.	Value.
1891	1,732	$82,100
1892	2,700	93,500
1893	*a* 3,200	90,000
1894	1,000	35,000
1895	700	22,500
1896	*b* 3,170	49,680

a Including 100 tons of ozocerite. *b* Including Colorado gilsonite.

The asphaltum deposits of Utah have been thoroughly described in previous volumes of Mineral Resources and in a report by Mr. George H. Eldridge in Part I of the Seventeenth Annual Report of the Survey. In view of the disastrous explosion and fire which occurred at the gilsonite mines of the Gilson Asphaltum Company in November, 1896, it is not amiss to quote from Mr. Eldridge's report. He said: "Normally it is of absolutely homogeneous texture and has a coarsely conchoidal fracture. In mining it gives off a fine chocolate-colored dust, which is not only very penetrating to the skin and lungs, but also, when mixed in certain proportions of air, highly explosive." The explosion in November was due to the ignition of this explosive mixture of air and dust from a fire carelessly started by some of the workmen underground. This fire (mentioned previously in this report) occurred so late in the year that it did not materially affect the output for the year. Moreover, before the fire was fairly extinguished a new opening had been made, and within ten days after the fire started ore was being shipped.

Early in 1897 a new company was formed at Provo for the purpose of mining gilsonite on property claimed to be outside of the Uintah Indian Reservation and not within previously preempted claims. The new undertaking has developed litigation, to which the Gilson Asphaltum Company and the Indian agent of the reservation, Col. J. F. Randlett, are made parties. The outcome of the litigation will be the settlement of the boundary line of the reservation, the Gilson Company claiming that its property extends to the reservation line, and mining within the reservation being prohibited.

In Mineral Resources for 1894 a report was made by Dr. William C. Day on the chemical properties of the asphaltum found in Park County, Montana. Dr. Day has continued his work by a study of Utah gilsonite and has embodied the result of his work in a paper read before

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the chemical section of the Franklin Institute,[1] which is abstracted below:

THE CHEMISTRY OF GILSONITE.

A study of the literature of asphalt and allied bitumens reveals but few publications which throw light upon the true nature of these bodies or of the classes of hydrocarbons which, in intimate mixture, appear to constitute them.

Boussingault studied the bitumen of Bechelbronn with reference to the action of solvents upon it, and also the products resulting from distillation under the ordinary atmospheric pressure. By heating the material in an oil bath to the temperature of 230° C. for a long time (i. e., a number of days) he obtained a distillate to which he gave the name "petrolene," while the undistilled residue he called "asphaltene." The distilled "petrolene" showed a brown color, which was regarded as due to asphaltene mechanically carried over. After drying over calcium chloride the petrolene was rectified and described then as being in a state of purity, having a pale yellow color and an odor like bitumen. Its density was given as 0.891 at 21° C., and its boiling point 280° C. It was slightly soluble in alcohol, and much more so in ether. In a note he says that it is impossible to determine the proportions of asphaltene and petrolene by the heating method, since the petrolene oxidizes and becomes converted into asphaltene. On the basis of combustions of asphalt purified by ether, he gives the proportions of asphaltene and petrolene as 85.4 per cent and 14.6 per cent, respectively.

An elementary analysis of the asphalt gave the following figures:

Elementary analysis of asphalt from Bechelbronn.

	Per cent.
Carbon	85.90
Hydrogen	11.25
Oxygen	2.85
Total	100.00

It is noteworthy that in this analysis no mention is made of nitrogen or sulphur.

Volckel investigated the mineral tar from Dax. Of this he found 50 per cent soluble in ether. The ethereal solution becomes turbid upon the addition of absolute alcohol, precipitating a blackish-brown mass. Using a large excess of alcohol, only a small amount of oil remains undissolved in the mixture of alcohol and ether. The material left behind on evaporating the ethereal solution he regards as identical with the asphaltene of Boussingault.

By distilling asphalt rock in iron cylinders a peculiar volatile oil is obtained, having an odor like mineral tar, and a faint taste. It is insoluble in water and alcohol, but readily soluble in ether. The distillate, when distilled by itself or with water, always shows a yellowish color. This yellow color is ascribed to a small amount of yellow oil, which, in the distillation of a number of resins, particularly copal, is obtained in greater quantity. The raw asphalt oil was shaken with a concentrated solution of caustic potash, then distilled with steam, dried over calcium chloride, and finally distilled by itself from a retort provided with a thermometer. The oil begins to boil at 90° C., but the boiling point rapidly rises to 120° C. The greater part of the oil distills at 200° C.; a smaller part from 200° to 250°. At the latter temperature there remains a small quantity of thick, strongly colored oil as a residue.

[1] Journal of the Franklin Institute, Vol. CLX. p. 221.

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The following quantitative results are given. The portion boiling between 90° and 200° showed, at 15° C., a specific gravity of 0.817, and, by combustion, the following percentage composition:

Analysis of asphalt oil boiling between 90° and 200° C.

	Per cent.
Carbon	87.37
Hydrogen	11.65
Oxygen	0.98
Total	100.00

That boiling between 200° and 250° showed a specific gravity of 0.868, and the following percentage composition:

Analysis of asphalt oil boiling between 200° and 250° C.

	Per cent.
Carbon	87.55
Hydrogen	11.56
Oxygen	0.89
Total	100.00

Asphalt oil has exactly the same composition as amber oil obtained by distilling amber, and these oils are also similar in general conduct.

By the action of dilute nitric acid asphalt oil is colored brown at ordinary temperatures; by heating it changes into a yellow, gummy mass, which smells like musk and oil of bitter almonds. Concentrated nitric acid works in the same way, but more violently. Concentrated sulphuric acid dissolves, with evolution of heat, a part of the asphalt oil, while another part collects upon the surface of the thick, red-colored sulphuric acid solution. The separated oil was again treated with sulphuric acid and then with alkali, and finally distilled with steam. The distillate thus obtained possesses a faint, pleasant odor, entirely different from the oil not treated with sulphuric acid. After dehydration by long contact with chloride of calcium, the oil was distilled; it began to boil at 90° C., but very little went over below 120°. The following fractions were separated: 90–120°; 120–150°; 150–180°; 180–200°; 200–220°; 220–250°. All these fractions were analyzed with practically the same results—C., 87.50 per cent; H., 12.50 per cent. The part of asphalt oil not taken up by sulphuric acid shows, therefore, the formula N (C_8H_5). These oils are insoluble in water, but easily soluble in alcohol or ether. They are only slightly attacked by concentrated sulphuric acid, and do not dissolve in concentrated nitric acid. By heating with nitric acid, only a small part is changed into a heavy yellow oil, which, by distillation with steam, is obtained colorless. In chemical constitution these oils agree with the volatile oils which separate on treating amber oil with concentrated sulphuric acid.

R. Kayser, in 1879, published the results of an investigation upon the products obtained from a number of asphalts of different sources by the action of the solvents alcohol and ether, and also of products obtained by destructive distillation of the original asphalts. Kayser made quite a large number of elementary analyses of asphalts and of products obtained from them by the action of alcohol and ether,

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and by destructive distillation. In his analyses were included determinations of carbon, hydrogen, sulphur, nitrogen, and ash. In the older investigations the presence of sulphur appears to have been overlooked or ignored. In many of them nitrogen also was undetermined.

In Kayser's paper formulas for the product analyzed were proposed in accordance with the requirements of the analytical results. Bodies "of constant boiling point" were obtained by fractional distillation of the products obtained from the destructive distillation of the original material. The asphalts included in this investigation were taken from Syria, Trinidad, Bechelbronn, Maracaibo, and Barbadoes. The following table shows the results obtained by Kayser in his elementary analyses of the various asphalts studied by him:

Analyses of various asphalts by Kayser.

	Syria.	Trinidad.	Bechelbronn.	Maracaibo.	Barbadoes.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Carbon	80.00	78.80	86.60	81.65	87.04
Hydrogen	9.00	9.30	11.40	9.59	9.56
Sulphur	10.00	10.00	1.40	8.03	2.67
Ash	.60	.50	.50	.34	.24
Nitrogen	.40	1.40	.30	.....	.....
Oxygen	.....	.....	.40	.....	.....
Total	100.00	100.00	100.60	99.61	99.51

In the first three cases the figures are the averages of a number of well-agreeing determinations; in the two others (Maracaibo and Barbadoes) the figures are the results of single determinations.

Although Kayser claims to have obtained pure substances as the result of fractional distillation of the Syrian asphalt oil, and gives to these bodies definite formulas as the results of elementary analysis, the evidence given by him of their purity is hardly satisfactory, since he does not, in any case, give the exact range of boiling point, but gives the boiling points in round numbers. Furthermore, he describes a number of them as yellow and brownish yellow in color, the first one only (boiling ot 96°) being described as water-white.

Although there are in print many articles of value on the commercial applications of asphalt, and some giving the results of elementary analysis, I have failed to find any publications other than the ones already considered and an important paper by Peckham, to be referred to later, which throw light upon the real nature of the asphalts or which definitely describe pure products obtained from them.

The present investigation of gilsonite had for its object the isolation of such single hydrocarbons, or classes of hydrocarbons or their derivatives, as would give some information as to the nature of the material itself.

Although this object has not yet been fully attained, such progress toward that end has been made as to indicate that definite results are near at hand. As the work must be interrupted for a few months, I have thought best to give an account of the results thus far obtained.

Gilsonite is a black, brittle material pulverizing readily to a dark brown powder, which is inclined to stick to the sides of the mortar when finely divided. It is lighter than water and entirely soluble in carbon bisulphide.

Absolute alcohol dissolves 54.6 per cent, if repeatedly treated with the hot liquid until no further action is noticeable. The following figures, showing the solubility

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in alcohol, were obtained: 2.2298 grams of gilsonite gave 1.2178 grams of insoluble residue, while the dissolved matter weighed 1.01 grams.

Ether does not dissolve gilsonite entirely, as shown by two successive treatments of a small quantity of gilsonite with a large excess of ether. The solution obtained is red in color, with a greenish fluorescence. Absolute alcohol added to the ether solution gives a precipitate. Petroleum ether, glacial acetic acid, and chloroform are partial solvents.

The residue obtained by evaporating the petroleum ether is black in color, hard, brittle, and differs markedly from the material soluble in alcohol. It resembles the original gilsonite quite closely. Only a small percentage of gilsonite remains undissolved in petroleum ether after twenty-eight successive treatments with the solvent. This insoluble residue is black and very easily pulverized.

The residue obtained by evaporating the alcoholic solution is reddish-brown in color, solid at ordinary temperatures, but soft enough to be easily cut with the finger nail. On being heated on the water bath it becomes softer, and at 100° is liquid enough to flow.

The residue, insoluble in alcohol, is a black, brittle substance, becoming brownish in color on pulverizing, and resembling in appearance the original gilsonite.

Analysis of gilsonite.—To determine the volatile matter, fixed residue, and ash, weighed quantities of gilsonite were heated in a platinum crucible, first covered, and afterwards, when all volatile matter had been expelled, uncovered; 0.2391 gram gilsonite gave 0.1041 gram fixed residue and 0.0003 gram ash. These figures show that gilsonite yields:

Analysis showing volatile matter, fixed residue, and ash of gilsonite.

	Per cent.
Volatile matter	56.46
Fixed residue	43.43
Ash	.10
Total	99.99

Working on a larger scale, and distilling a weighed quantity of gilsonite from a retort, the following result was obtained: 136.1 grams of gilsonite gave 76.1 grams of distillate. The percentage of volatile matter is thus 55.9. Comparing this result with that above, it is evident that all the volatile matter is condensable.

Combustions were made with lead chromate in a current of oxygen. The percentages of carbon and hydrogen found:

Analysis showing amount of carbon and hydrogen in gilsonite.

	I.	II.
Carbon	87.99	88.61
Hydrogen	10.03	9.89

The determination of sulphur in gilsonite proved to be a matter of some difficulty, and before success was finally attained all the various methods of determining sulphur in organic compounds were tried.

Sauer's method of burning in oxygen and passing the products of combustion into a hydrochloric-acid solution of bromine was found inapplicable, on account of the great difficulty of securing steady vaporization of the volatile constituents of the

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gilsonite. Owing to the tendency which at certain stages of its distillation gilsonite shows to foam or volatilize very rapidly some of this vapor almost inevitably escapes combustion in the oxygen. The writer has used this method with success in the case of volatile petroleums, and is therefore sure that the difficulties which stand in the way of its application to gilsonite are inherent in the substance, as above described.

Good results in the determination of sulphur were finally secured by a combination of the Carius method of oxidizing with nitric acid in an open vessel and then heating the unoxidized solid material with magnesia in a platinum crucible, as recommended by Eschka in determining sulphur in coals. The sulphur is finally weighed as $BaSO_4$. When gilsonite is treated with a large excess of concentrated nitric acid, under the influence of heat in an open vessel, brown fumes are abundantly given off, and after a time the gilsonite entirely dissolves, giving a dark-red solution, which becomes constantly lighter as the heating is continued. If at the point when the gilsonite is just completely dissolved the solution is poured into cold water, a reddish-brown precipitate, closely resembling ferric hydroxide, is immediately thrown down. This precipitate contains practically all the sulphur, only traces having been converted into sulphuric acid by the oxidizing action of the nitric acid. This precipitate was washed with water, dried, then mixed with magnesia, and the sulphur determined as already described.

(I) 1.30215 grams gilsonite gave 0.1231 gram $BaSO_4$.

(II) 0.9581 gram gilsonite gave 0.09414 gram $BaSO_4$.

Percentage of sulphur from I, 1.29; percentage of sulphur from II, 1.34.

The results obtained by other methods did not show sufficiently close agreement, ranging, however, only between the limits 0.93 and 1.59 per cent.

The percentage composition of gilsonite, therefore, appears to be:

Analysis showing percentage composition of gilsonite.

	Per cent.
Carbon	88.30
Hydrogen	9.96
Sulphur	1.32
Ash	.10
Oxygen and nitrogen (undetermined)	.32
Total	100.00

Dry distillation of gilsonite.—Before undertaking the direct distillation some of the finely powdered gilsonite was subjected to distillation with steam. The receiver showed a slight film of colorless oil, of pleasant odor, floating upon the water. The amount of oil was so small that nothing further could be done with it.

In the dry distillation, the material was first distilled from a tubulated retort, provided with a thermometer, the bulb of which was in the liquid. Distillation began at 150° C., but very little came over; the temperature rose quite rapidly; but before the distillation was fairly under way, the thermometer had to be removed, as the temperature rose above 300° C. The first drops of oil coming over were light yellow; this color became darker as the distillation progressed. The operation could not be carried to completion on account of the softening of the glass, although with a hard glass retort on another occasion the distillation was continued until nothing but coke was left. Glass retorts were finally replaced by one made of 6-inch iron pipe, capped at both ends, and connected with a smaller pipe to serve as a condenser. Energetic foaming takes place at two different stages; this fact necessitates the greatest care in the regulation of the heating flame, and it is a very difficult matter to avoid the carrying over of undistilled matter, particularly when using an iron

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retort. Toward the end of the distillation, ammonia is quite freely evolved. The distillate is lighter than water, is of a reddish-brown color, and shows a greenish fluorescence; the odor is highly unpleasant. It was distilled with steam. This treatment separates the oil into a portion readily volatile with water vapor, and of a yellow color, and a thick, black, tarry-looking oil which remains in the distilling flask.

The volatile portion was distilled again with steam, becoming, as a result, much lighter in color, but on standing it changes from a lemon-yellow to a reddish tint. The odor is suggestive of sulphur compounds. The oil, after drying over calcium chloride, was next treated with concentrated sulphuric acid, the two liquids being placed in a round-bottomed flask and thoroughly shaken together; the acid became very dark red, almost black in color, sulphur dioxide was freely evolved, and so much heat was produced that the flask became too hot to handle. This treatment, using afterwards fuming sulphuric acid instead of ordinary concentrated acid, was repeated, until, after 25 or 30 treatments with fresh acid each time, no further action could be detected. The oil at this stage, after washing with alkali and water and drying over calcium chloride, is water white, of a pleasant odor much like that of highly-refined petroleum after repeated distillations over metallic sodium.

Concentrated nitric acid and a mixture of concentrated nitric and fuming sulphuric acids have no effect upon it, even after prolonged heating on the water bath. It dissolves bromine, but without chemical action or evolution of hydrobromic acid. The washed and dried oil, subjected to distillation, begins to boil at 125°, and, with the exception of a few remaining drops, is entirely distilled when the temperature reaches 263° C. After standing for six months over calcium chloride the oil is still perfectly water white. The total bulk of the oil so treated with sulphuric acid is very much reduced; perhaps less than 10 per cent survives the action of the acid. The chemical inertness of this oil shows that it belongs to the paraffin series. Judging from the regular and uniform rise of temperature in distilling, the oil is just as complicated a mixture of different hydrocarbons as is highly refined petroleum.

The sulphuric acid used in treating this oil was preserved for subsequent investigation. The action of sulphuric acid was apparently largely of an oxidizing character, judging from the copious evolution of sulphur dioxide, which was so vigorous at times that the liquid almost foamed out of the flask. A part of this spent acid was diluted with water; a turbidity was produced, and on warming and allowing to stand a green oil rose to the surface. This oil has an odor something like that of pennyroyal. The dilute acid was neutralized with precipitated chalk, the resulting gypsum filtered off, and the solution evaporated. A sticky, gummy substance separated when nearly all the water was driven off; when perfectly dry the material became a pulverizable solid, light in color, deliquescent, very easily soluble in water, and entirely insoluble in ether.

The oil which rises to the surface on diluting the spent sulphuric acid becomes, on standing, a thick, tenacious, black tar, of such consistency that on being stirred it takes a long time to spread again over the surface of the water. This was skimmed off and heated with water on the water bath; it seems to dissolve entirely in hot water. On standing over night a small amount of oil was found floating on the surface; this was skimmed off; on pouring off the aqueous solution a heavy oil, small in amount, was found at the bottom. The aqueous solution was transparent and greenish in color. On evaporating off the water a thick, dark green, almost black, oily-looking liquid was left behind; this dissolves readily and quickly in cold water. It is entirely soluble in alcohol, but only partly soluble in ether and carbon bisulphide. The alcoholic solution is green, and looks like the aqueous solution. Ether becomes yellow in color, but does not dissolve much; carbon bisulphide acts much like ether. The aqueous solution was extracted with ether until the latter was no longer colored. The aqueous solution was then treated with barium carbonate, to neutralize a small amount of sulphuric acid, and the barium sulphate filtered off. This neutralization caused the green color to change from green to reddish brown. On evaporation a mass remains which is black and sticky before complete dryness, but when dry is a brown powder, easily soluble in cold water.

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Prof. S. F. Peckham, in an article entitled "Nitrogen content of California bitumen," has shown that the crude petroleums of California contain esters made up of basic oils in combination with an exceedingly viscous, feebly acid, tar. He says when the crude oils are treated with dilute acid this acid radical forms a hydrate which produces, with the other constituents of the petroleum, an emulsion, from which the aqueous acid solution of the basic oils is separated with much difficulty. In the case of distillates of high specific gravity, the acid radical, or its hydrate, does not dissolve in the oil, so that the acid solution of the bases, the acid hydrate and the oil not acted on by the dilute acid form three distinct layers in the containing vessel. Peckham states that the basic oils belong to the pyridine and quinoline series. He has shown also that by removing these basic oils and the tarry, viscous acid hydrates with which the basic oils were previously combined, the burning and lubricating oils afterwards produced by refining are much superior to those obtained when the above-mentioned bodies are not removed.

If, in the case of the oil volatile with steam, dilute sulphuric acid is used and warmed for a time on the water bath, shaking frequently, the dilute acid becomes colored yellowish red from it; by the addition of sodium hydroxide solution a yellowish-white precipitate is obtained. On standing, a brown oil rises to the surface. It has an odor which reminds me of quinoline rather than pyridine.

From the general similarity between the bodies obtained by Peckham and those resulting from my treatment of oil volatile with steam, I feel no hesitation in expressing the conviction that the bodies obtained from this oil correspond entirely with those obtained by Peckham from the California bitumens. The existence of these basic oils in the California petroleums and in gilsonite is evidence both of their relationship and of their animal origin. Since gilsonite is a hard, brittle solid, and thus removed as far as possible from the petroleum from which it may have been derived by oxidizing agencies, it is a matter of some general interest to note the resemblance in constitution, as shown by these basic compounds. According to the result of analysis of gilsonite, which I have submitted, there appears to be not more than 0.5 per cent of nitrogen in it, while in the California petroleums the amount exceeds 1 per cent. In general, the percentage of nitrogen is less in the asphalts than in the petroleums, according to the analytical results thus far obtained. I propose to continue the study of the nitrogen compounds from gilsonite during the present year.

After removal from the water-distilling flask this oil appeared thick, black, and tarry. It was dried by standing for two weeks over calcium chloride. The first distillation was conducted in a 250 c. c. retort. The boiling began at about 175° C., rising quite rapidly to 230° C., after which the rise was more gradual. The distillate was divided arbitrarily into five fractions. On distilling again the first or most volatile fraction, the boiling began at 175°, rising quite rapidly to 230°, and from that more slowly to 300° C., when only a few drops remained. The distillate was reddish in color, but lighter than it was before the second distillation. There was not much evidence of cracking in this distillation. The remaining fractions are thus evidently liquids boiling at points above 300° C. No solid body separated in the course of any distillation, but the distillates were, in all cases, liquids of various degrees of consistency.

Action of nitric acid.—The highest boiling fraction was subjected to the action of concentrated nitric acid. The weight taken amounted to nearly 100 grams. Violent action took place with abundant evolution of red fumes, accompanied by occasional slight explosions, producing vortex rings in the red vapor and a popping sound. The flask became too hot to touch. After cooling, a quantity of semisolid oil remained on the surface; the acid was then poured off into cold water. This produced a yellow precipitate of a solid body, which, when collected and pressed into a lump, took a purple color. This, after being pulverized in a mortar, proved to be nearly insoluble in ether, but readily soluble in absolute alcohol; it would not crystallize from this solution. Subjected to the slow action of somewhat diluted nitric acid, the oil, after heating on the water bath for a number of days, gradually

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becomes thicker until finally it reaches the solid condition, appearing then as a purple solid, having a musk-like odor. It is soluble in ether and alcohol, somewhat more so in the latter. Alkalies slowly dissolve most of it, but some oily-looking matter remains undissolved. The investigation of this material will be continued.

At first gilsonite was treated with dilute nitric acid, the former in large excess. No definite results were reached in this way. Finally, the nitric acid was employed in concentrated condition, and in large excess, when it was found that after about twenty-four hours' continuous heating, during which time brown fumes were continually given off, the gilsonite had entirely dissolved, giving a dark-red solution. When this solution is poured into water a flocculent brown precipitate is produced, looking almost exactly like freshly precipitated ferric hydroxide. This was washed repeatedly with water until all nitric acid had been removed, and then dried on the water bath. Alcohol dissolves most of this substance, leaving undissolved a small quantity of dark-colored material. On evaporation, a dark, brittle substance is left. This is soluble in concentrated nitric acid; on pouring into water a precipitate like the original is produced. Ether dissolves less of the material than alcohol, the greater part being insoluble in ether. The ether solution is yellow in color, and on evaporation leaves a hard, shiny, reddish-yellow, varnish-like residue, which may be ground to a fine powder. It dissolves readily in concentrated nitric acid, and on reprecipitating by the addition of water, appears as a light-yellow, almost white, precipitate of flocculent character. On heating with water this precipitate melts, shrinks very much, and becomes, on cooling, a hard, brittle substance. It was redissolved in nitric acid and reprecipitated with water a number of times, but no perceptible change in it resulted from this treatment. Alkalies and ammonium hydroxide dissolve it readily. From the solutions thus obtained the substance is reprecipitated, apparently unchanged, by dilute acids. The material thus appears to be an organic acid in apparently quite pure condition. The original precipitate from nitric acid, on being heated in a dry test tube, swells up, giving off a dense white smoke and distilling off a colorless oil, heavier than water. A sort of deflagration takes place, which continues after the removal of the heat. This deflagration appears also with the material dissolved by alcohol, but not at all in the case of that dissolved by ether. From this it appears that the original brown precipitate produced by pouring the nitric acid solution into water is a mixture of different substances, one or more of which, as indicated by the deflagrating action, are nitro compounds easily decomposed by heat, with attendant rapid oxidation. Another ingredient of the mixture is an acid insoluble in water, and probably a single chemical compound, which is to be made the subject of further study.

The filtrate obtained on removing the brown precipitate is of a reddish color. This was evaporated upon the water bath, removing the excess of acid and leaving finally a sticky, dark-red, gummy mass, soluble in water. As the oxidizing action of the nitric acid in the course of this evaporation appeared to be quite considerable, it was thought best in other cases to neutralize the acid filtrate first with ammonia and then evaporate, thus avoiding further oxidation. The mixture of organic matter and ammonium nitrate thus obtained was first tested as to solubility in ether, but this had very little action in dissolving anything. Absolute alcohol was then tried, with the result of dissolving quite a considerable quantity of organic material, together with some ammonium nitrate. The treatment with alcohol was continued until it came through nearly colorless, being at first dark red. The alcohol was distilled off on the water bath, and the residue, which was liquid when hot, became crystalline on cooling, due, probably, to the separation of ammonium nitrate. It was dissolved in water. On adding lead acetate to this, a light-yellow precipitate was formed at once. This was washed, and on treating with hot water and hydrochloric acid it was all dissolved. On cooling, lead chloride settled out; this was filtered off, and hydrogen sulphide passed through the filtrate to secure the complete removal of lead. No lead sulphide was, however, obtained. Upon evaporating again, a reddish liquid was left behind, together with some crystals of a substance readily soluble in water and in ether, and giving a strong acid reaction.

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The material remaining undissolved by the absolute alcohol above referred to was dissolved in water; lead acetate was added to this, and a heavy greenish-gray precipitate was thrown down. This was filtered and washed with hot water, and then hydrochloric acid was added, which caused the solution of nearly the whole. On filtering this, the solution, coming through at first clear, soon separated material looking like the original, and not at all crystalline. The investigation of this material will be continued.

The alkali salts of all the acids obtained are readily soluble, and, on shaking, the solutions give a lather reminding one of soap solutions, although they do not appear soapy to the touch. The lead salts are all insoluble in cold water. None of the salts appeared to be crystallizable.

Hell and Medinger have described an acid occurring in Wallachian petroleum. This, in the conduct and general character of its salts, is quite similar to some of the acids referred to in this paper. The authors just named purified the acid by conversion into the methyl and ethyl esters and fractioning, and afterwards obtaining the pure acid.

As a result of the present investigation a method of obtaining from gilsonite a number of acids has been outlined. By further study of those acids and their derivatives a knowledge of the hydrocarbons present in the mineral may be gained. The distillation experiments have shown that a number of radically different series of hydrocarbons is obtained, and that the paraffin series is one of them, and very probably, also, the naphthene series is another. No aromatic hydrocarbons appear to be present, or, at most, only in small quantity, as in no part of the work have derivatives of these bodies suggested themselves. Conclusions drawn from distillation products of a mineral hydrocarbon as to the constitution of the latter are necessarily unsafe, on account of the decompositions which take place during the distillation. Much safer conclusions may be drawn from products obtained without distillation from the original material directly by the action of reagents, such as nitric and sulphuric acids.

Markownikoff, who isolated aromatic hydrocarbons in petroleum from Baku, condemns the use of bromine or nitric acid to detect aromatic hydrocarbons, since, he says, these reagents are liable to give aromatic derivatives from the naphthenes. He prefers, on this account, to use sulphuric acid, obtaining the sulphonic acid, and from this to pass to the hydrocarbons by distilling with lime from an iron retort. The action of concentrated sulphuric acid upon gilsonite is now under investigation, but as yet without definite or even promising results.

PRODUCTION OF ASPHALTUM IN FRANCE.

The Statistique de L'industrie Minerale gives the following as the output of asphaltum in France for four years, with the value of the product. For convenience and for comparison the quantities are expressed in metric tons and short tons, and the value both in francs and dollars:

Production of asphaltum in France from 1892 to 1895.

Year.	Production.		Value.	
	Metric tons.	Short tons.	Francs.	Dollars.
1892	224,000	246,848	1,678,000	323,854
1893	222,000	244,644	1,612,000	311,116
1894	231,000	254,562	1,758,000	339,294
1895	267,000	294,234	1,843,000	355,700

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PRODUCTION OF ASPHALTUM IN GERMANY.

The production of asphaltum in the German Empire for the years 1886 to 1895, according to the official report Die Bergwerke, Salinen und Hütten im Deutschen Reich und Luxemburg is shown in the following table. Metric tons are converted into short tons, and marks into dollars:

Production of asphaltum in Germany from 1886 to 1895.

Year.	Production.		Value.	
	Metric tons.	Short tons.	Marks.	Dollars.
1886	42,894	47,270	216,075	51,426
1887	34,483	38,000	186,125	44,298
1888	41,534	45,770	255,250	60,749
1889	43,496	47,933	325,246	77,408
1890	51,144	56,361	377,987	89,961
1891	49,150	54,163	375,712	89,419
1892	53,279	58,713	418,850	99,686
1893	47,238	52,056	356,982	84,962
1894	55,981	61,691	451,049	107,350
1895	59,563	65,638	454,424	108,153

PRODUCTION OF OZOCERITE IN GALICIA.

The production of ozocerite, or mineral wax, in Galicia, Austria, for six years, as near as can be ascertained, has been as follows:

Production of ozocerite in Galicia from 1891 to 1896.

Year.	Metric tons.	Short tons.
1891	6,158.6	6,787.0
1892	5,637.6	6,213.0
1893	5,624.8	6,198.5
1894	6,743.1	7,431.0
1895	6,644 5	7,322.0
1896	7,210.0	7,945.0

STATISTICS OF TRINIDAD ASPHALTUM.

Mr. O. E. Thurber, treasurer of the Trinidad Asphalt Company, of New York City, has kindly furnished the following statements showing the exports of Pitch Lake asphaltum from 1881 to 1896; also the exports

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of land asphaltum from 1886 to 1896, and the total exports of all asphaltum (stated in tons of crude or equivalent) from 1886 to 1896.

The shipments of Trinidad asphaltum to countries other than the United States and Europe have been so comparatively insignificant that they have been included under one caption.

Exports of Pitch Lake asphalt from Trinidad, 1881 to 1896, inclusive.

Year.	To United States.			To Europe.			To other countries.			Grand total of exports in crude equivalent.
	Crude.	Dried.	Total equivalent in crude.	Crude.	Épuré and dried.	Total equivalent in crude.	Crude.	Épuré and dried.	Total equivalent in crude.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1881	5,600	.....	5,600	10,656	6,174	16,917	.....	.....	.....	25,517
1882	12,710	.....	12,710	24,712	12,007	42,722	.....	.....	.....	55,432
1883	22,885	.....	22,885	11,744	4,668	18,746	.....	.....	.....	41,631
1884	17,885	.....	17,885	15,910	6,561	25,751	.....	.....	.....	43,636
1885	15,505	.....	15,505	12,135	7,636	23,589	.....	.....	.....	39,094
1886	22,225	.....	22,225	5,130	5,394	18,221	.....	.....	.....	35,446
1887	21,915	.....	21,915	10,205	5,771	18,861	.....	.....	.....	40,776
1888	24,321	.....	24,321	8,445	8,248	20,817	.....	.....	.....	45,138
1889	45,410	.....	45,410	9,378	9,581	23,750	.....	.....	.....	69,160
1890	39,907	.....	39,907	11,755	9,951	26,681	668	.....	*a* 668	67,256
1891	52,510	.....	52,510	9,984	9,969	24,937	901	.....	*a* 901	78,348
1892	70,806	.....	70,806	11,596	9,458	25,783	1,076	.....	*a* 1,076	97,665
1893	65,436	.....	65,436	10,640	6,650	20,615	.....	.....	.....	86,051
1894	71,860	.....	71,860	8,967	9,413	23,086	.....	.....	.....	94,946
1895	61,702	2,256	64,976	5,058	7,365	16,104	.....	.....	.....	81,080
1896	60,637	.....	60,637	8,320	8,052	20,391	.....	1,300	*b* 1,918	82,946

a Australia. *b* Argentina and Mexico.

Exports of land asphalt from Trinidad, 1886 to 1896, inclusive.

Year.	To United States.			To Europe.			To other countries.			Grand total of exports in crude equivalent.
	Crude.	Épuré.	Total equivalent in crude.	Crude.	Épuré.	Total equivalent in crude.	Crude.	Épuré.	Total equivalent in crude.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1886	2,297	.....	2,297	.....	.....	.....	.....	.....	.....	2,297
1887	1,195	2,100	4,345	220	.....	220	.....	.....	.....	4,565
1888	5,316	1,536	7,620	619	.....	619	.....	.....	.....	8,239
1889	10,490	2,052	13,568	.....	.....	.....	833	.....	*a* 833	14,401
1890	15,406	1,341	17,417	.....	.....	.....	.....	.....	.....	17,417
1891	20,507	7	20,517	139	.....	139	40	.....	*b* 40	20,696
1892	17,406	.....	17,406	699	.....	699	.....	.....	.....	18,105
1893	3,450	.....	3,450	2,432	1,862	5,225	110	178	*b* 377	9,052
1894	3,365	325	3,853	2,200	4,699	9,249	13	94	*b* 154	13,256
1895	4,445	199	4,744	1,770	2,368	5,322	.....	169	*b* 254	10,320
1896	11,943	71	12,049	842	1,988	3,824	.....	.....	.....	15,873

a Australia. *b* Canada, Venezuela, and West Indies.

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Total exports of all asphalt from Trinidad, 1886 to 1896, inclusive.

Year.	To United States.			To Europe.			To other countries.			Grand total.
	Lake.	Land.	Total.	Lake.	Land.	Total.	Lake.	Land.	Total.	
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
1886.....	22,225	2,297	24,522	13,221	.....	13,221	.....	.....	.....	37,743
1887.....	21,915	4,345	26,260	18,861	220	19,081	.....	.....	.....	45,341
1888.....	24,321	7,620	31,941	20,817	619	21,436	.....	.....	.....	53,377
1889.....	45,410	13,568	58,978	23,750	.....	23,750	.....	833	833	83,561
1890.....	39,907	17,417	57,324	26,681	.....	26,681	668	.....	668	84,673
1891.....	52,510	20,517	73,027	24,937	139	25,076	901	40	941	99,044
1892.....	70,806	17,406	88,212	25,783	699	26,482	1,076	.....	1,076	115,770
1893.....	65,436	3,450	68,886	20,615	5,225	25,840	.....	377	377	95,103
1894.....	71,860	3,853	75,713	23,086	9,249	32,335	.....	154	154	108,202
1895.....	64,976	4,744	69,720	16,104	5,322	21,426	.....	254	254	91,400
1896.....	60,637	12,049	72,686	20,391	3,824	24,215	1,918	.....	1,918	98,819
Total .	540,003	107,266	647,269	234,246	25,297	259,543	4,563	1,658	6,221	913,033

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Value of the various kinds of stone produced in 1896, by States—Continued.

State.	Granite.	Sandstone.	Slate.	Marble.	Limestone.	Total.
Ohio	.....	$1,679,265	.....	.....	$1,399,412	$3,078,677
Oregon	$2,449	.....	.....	.....	1,600	4,049
Pennsylvania	159,317	$446,926	$1,726,318	$31,522	2,104,774	4,468,857
Rhode Island	746,277	.....	.....	.....	11,589	757,866
South Carolina	55,320	.....	.....	.....	26,000	81,320
South Dakota	199,977	37,077	.....	.....	3,126	240,180
Tennessee	.....	4,100	1,420	381,373	157,176	544,069
Texas	.....	36,000	.....	.....	77,252	113,252
Utah	886	7,860	.....	.....	9,358	18,104
Vermont	895,516	.....	609,596	1,101,557	147,138	2,753,807
Virginia	95,040	.....	107,863	.....	182,640	385,543
Washington	.....	11,090	.....	.....	83,742	94,832
West Virginia	.....	24,693	.....	.....	59,113	83,806
Wisconsin	126,639	65,017	.....	.....	552,921	744,577
Wyoming	.....	16,465	.....	.....	.....	16,465
Totals	7,944,994	4,023,199	2,746,205	2,859,136	13,022,637	30,596,171

GRANITE.

The following table shows the value of the granite output in 1896, by States:

Value of granite product in 1896, by States.

State.	Value.	State.	Value.
California	$215,883	New York	$161,167
Colorado	36,517	North Carolina	40,017
Connecticut	794,325	Oregon	2,449
Delaware	67,775	Pennsylvania	159,317
Georgia	274,734	Rhode Island	746,277
Idaho	3,037	South Carolina	55,320
Maine	1,195,491	South Dakota	199,977
Maryland	251,108	Utah	886
Massachusetts	1,656,973	Vermont	895,516
Minnesota	155,297	Virginia	95,040
Missouri	107,710	Wisconsin	126,639
Nevada	1,250	Total	7,944,994
New Hampshire	497,966		
New Jersey	204,323		

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Value of granite paving blocks made in 1895 and 1896, by States.

State.	1895.	1896.
California	$34,079	$73,390
Connecticut	46,830	32,592
Delaware	16,556	17,074
Georgia	232,041	94,390
Maine	636,063	344,101
Maryland	2,633	33,933
Massachusetts	496,544	324,784
Minnesota	4,800	.....
Missouri	22,014	27,911
New Hampshire	16,823	26,353
New Jersey	39,389	14,847
New York	16,443	24,389
North Carolina	1,320	1,554
Oregon	.....	210
Pennsylvania	69,503	65,580
Rhode Island	49,255	50,851
South Carolina	12,505	4,644
South Dakota	20,800	28,326
Vermont	30,702	30,990
Virginia	8,028	10,129
Wisconsin	17,000	25,688
Total	1,773,328	1,231,736

The value of the total granite output in the United States in 1896 falls below that of 1895 by $949,334. This is not so great a difference as that between the figures of 1895 and 1894, but it is nevertheless a serious falling off, due, as heretofore, only to the general depression. It would be a very serious mistake to ascribe the decline in granite output to anything else than hard times, for never before was it put to a larger number of uses than at present, and its popularity for monumental and cemetery work is steadily increasing. It is being used more and more in the form of polished pillars and slabs in our public buildings, while even houses built in blocks for renting in some of our large cities, notably Philadelphia, are to be seen with polished granite pillars supporting the roof covering front porticos. The enduring qualities of granite are sure to appeal to good judgment in building, and where expense is not too serious a consideration granite will have preference over a number of other kinds of building and ornamental stone. The expense attached to the use of granite is largely a consequence of the difficulties in cutting, polishing, and ornamenting it. The price of crude granite for monumental use runs from 70 cents to $1.50 per cubic foot, while the price of crude marble for the same kind of use runs from $2.25 to $12 per foot.

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While marble costs more to quarry, since it has to be cut out by channeling machines and drills, it is more easily cut, polished, and ornamented, owing to its greater softness, and hence such work costs less than the same applied to the comparatively very hard granite.

Improvements in machinery for handling granite and also for cutting, polishing, and ornamenting tend to reduce the cost of manufacture to some extent, although prices for finished granite monumental stock are quite firmly maintained in spite of reduced cost of working it.

The table on the next page shows the condition of the granite industry in the various producing States for all years since 1889.

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VALUE OF THE GRANITE PRODUCT, BY STATES, FROM 1890 TO 1896.

The following table gives the value of the granite output, by States, for the years 1890 to 1896:

State.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
Arkansas	(a)	$65,000	$40,000		$28,100		
California	$1,329,018	1,300,000	1,000,000	$531,322	307,000	$348,806	$215,883
Colorado	314,673	300,000	100,000	77,182	49,302	35,000	36,517
Connecticut	1,061,202	1,167,000	700,000	652,459	504,390	779,361	794,325
Delaware	211,194	210,000	250,000	215,964	173,805	73,138	67,775
Georgia	752,481	790,000	700,000	476,387	511,804	508,481	274,734
Idaho						14,560	3,037
Maine	2,225,839	2,200,000	2,300,000	1,274,954	1,551,036	1,400,000	1,195,491
Maryland	447,489	450,000	450,000	260,855	308,966	276,020	251,108
Massachusetts	2,503,503	2,600,000	2,200,000	1,631,204	1,994,830	1,918,894	1,656,973
Minnesota	356,782		360,000	270.296	153,936	148,596	155,297
Missouri	500,642	400,000	325,000	388,803	98,757	128,987	107,710
Montana	(a)	51,000	36,000	1,000	5,800		
Nevada	(a)			3,000	1,600	3,200	1,250
New Hampshire	727,531	750,000	725,000	442,424	724,702	480,000	497,966
New Jersey	425,673	400,000	400,000	373,147	310,965	151,343	204,323
New York	222,773	225,000	200,000	181,449	140,618	68,474	161,167
North Carolina	146,627		150,000	122,707	108,993	75,000	40,017
Oregon	44,150	3,000	6,000	11,255	4,993	1,728	2,449
Pennsylvania	623,252	575,000	550,000	206,493	600,000	300,000	159,317
Rhode Island	931,216	750,000	600,000	509,799	1,211,439	968,473	746,277
South Carolina	47,614	50,000	60,000	95,443	45,899	22,083	55,320
South Dakota	304,673	100,000	50,000	27,828	8,806	33,279	199,977
Texas	22,550	75,000	50,000	38,991			
Utah	8,700		15,000	590			886
Vermont	581,870	700,000	675,000	778,459	893,956	1,007,718	895,516
Virginia	332,548	300,000	300,000	103,703	123,361	70,426	95,040
Washington	(a)						
Wisconsin	266,095	406,000	400,000	133,220	166,098	80,761	126,639
Total	14,464,095	13,867,000	12,642,000	8,808,934	10,029,156	8,894,328	7,944,994

a Granite valued at $76,000 was produced in Arkansas, Montana, Nevada, and Washington together, and this amount is included in the total.

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The table on the next page shows the purposes for which the granite was sold by the quarrymen. The column headed "Sold in rough state" shows how much stone was sold in rough condition without any special squaring up or dressing. The purposes which such stone ultimately served is a matter of question, as it was disposed of by the quarrymen to builders, monument and tombstone cutters, and to others for uses which could not be ascertained from the quarrymen. In spite of the difficulty thus indicated, however, the table will probably be found of interest in showing, for example, just how far the quarrymen go in preparing their product for immediate consumption without the intervention of others.

Granite production in the United States in 1896, by States and uses.

State.	Sold in rough state.	Building purposes.	Monumental and cemetery purposes.	Paving blocks.	Macadamizing purposes.	Other.	Total.
California	$27,200	$79,225	$16,003	$73,390	$9,814	$10,251	$215,883
Colorado	3,743	30,802	1,972				36,517
Connecticut	512,352	120,080	91,121	32,592	35,580	2,600	794,325
Delaware	38,190	10,461	500	17,074		1,550	67,775
Georgia	29,127	64,093	11,900	94,390	11,634	a 63,590	274,734
Idaho	3,037						3,037
Maine	187,855	470,838	80,564	344,101	7,300	b 104,833	1,195,491
Maryland	68,671	129,927	5,073	33,933		c 13,504	251,108
Massachusetts	538,907	569,829	185,987	324,784		d 37,466	1,656,973
Minnesota	10,431	113,113	29,153			a 2,600	155,297
Missouri	7,120	32,190	12,928	27,911	25,356	a 2,205	107,710
Nevada		500	750				1,250
New Hampshire	151,975	194,926	119,460	26,355		e 5,250	497,966
New Jersey	11,016	27,255		14,847	151,205		204,323
New York	20,539	71,672	14,613	24,389	28,298	a 1,656	161,167
North Carolina	2,583	6,281	72	1,554		a 29,527	40,017
Oregon	78		51	210	1,876	234	2,449
Pennsylvania	66,427	12,683	565	65,580	12,487	a 1,575	159,317
Rhode Island	90,219	199,487	366,840	50,851	30,000	a 8,880	746,277
South Carolina	692		12,375	4,644		f 37,609	55,320
South Dakota	4,951	9,000	7,700	28,326	150,000		199,977
Utah	516	296	74				886
Vermont	431,928	28,200	404,398	30,990			895,516
Virginia	15,706	46,686	17,887	10,120		a 4,641	95,040
Wisconsin	9,419	14,533	57,079	25,688	13,500	a 6,420	126,639
Total	2,232,682	2,232,077	1,437,065	1,231,729	477,050	334,391	7,944,994

a All curbing; b $70,433 for curbing, $34,400 for bridge work; c $3,680 for bridge work, $3,924 for curbing, $5,000 for riprap; d $23,745 for curbing, $9,000 for building; e $4,700 for curbing, f $37,500 for ballast.

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ELECTRICITY IN STONE QUARRIES AND YARDS.

The following is an abstract of an article in Stone for July, 1896:

The transmission of power through the agency of electricity has been tried at a number of European stone quarries, and notably by the Hainaut quarries, at Soignies, Belgium. By the present process of transmitting power by steam there is much loss by condensation of steam in passing through long pipes, particularly in cold weather. By the use of electricity this is of course avoided, and the number of employees needed is reduced. The quantity of fuel necessary is much smaller, while the ease with which speed is controlled in electrical apparatus does away with objections made to steam apparatus because of its sudden, jerky action, and naturally reduces the expense for repairs. At the plant above-mentioned a single Sulzer compound engine of 300 horsepower moves saws and runs two generators for mixed service, such as lighting, running pumps, capstans, and cranes, etc. Immense blocks of stone are handled by a traveling crane of 60 tons capacity run by an electric motor.

The success which has attended the innovations of the Hainaut company is attested by the fact that in 1894 substantial additions to the original plant were made.

PNEUMATIC TOOLS AND COMPRESSED AIR.

Pneumatic tools,[1] at first crude and complicated, have been so improved that they now deliver 20,000 blows per minute at a pressure of 80 pounds per square inch. The painful recoil has been done away with by the use of an air cushion. A machine is used for surfacing granite, and a larger tool is employed, mounted on a radial arm supported on a post; these are capable of surfacing 60 square feet of granite per day. Compressed air, as a means of transmitting power for other machines, seems to be rapidly replacing steam, which, owing to leakage and loss of heat, is decidedly less economical than compressed air.

THE GRANITE INDUSTRY IN INDIVIDUAL STATES.

California.—Production declined from a valuation of $348,806 in 1895 to $215,883 in 1896. The granite industry in this State is at a low ebb. This is the almost unanimous verdict of the producers, and recuperation is not expected for several years.

Colorado.—Production increased very slightly, but there has been no radical improvement, and quarrymen say they can not see how the industry could be in any worse condition than at present.

Connecticut.—The output of granite in 1896 was valued at $794,325; business showed considerable improvement, and the value of the output increased from $779,361 in 1895 to the figure named above for 1896.

[1] Stone, September, 1896.

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The following gives the results of investigation of a trap rock at Meriden. The stone is used chiefly for road making and was quarried by the Byxbee-De Peyster Trap Rock Company, of Meriden. The mechanical test was made with testing machine at Watertown Arsenal, Massachusetts, by Maj. J. W. Reilly.

Crushing test of trap rock from Meriden, Connecticut.

Test number.	Sectional area.	First crack.	Ultimate strength.	Per square inch.
	Sq. in.	*Pounds.*	*Pounds.*	*Pounds.*
8175	9.61	163,000	335,600	34,920

The following analysis was made at the mineralogical laboratory of Yale University, at New Haven, Connecticut, by Mr. J. H. Pratt, chemist.

Analysis of sample of trap rock from Meriden, Connecticut.

	Per cent.
Silica, SiO_2	52.37
Aluminum oxide, Al_2O_3	15.06
Ferric oxide, Fe_2O_3	2.34
Ferrous oxide, FeO	9.82
Titanium oxide, TiO_2	.21
Manganous oxide, MnO	.32
Magnesium oxide, MgO	5.38
Calcium oxide, CaO	7.33
Potassium oxide, K_2O	.92
Sodium oxide, Na_2O	4.04
Water, H_2O	2.24
Total	100.03

Specific gravity = 2.965.

Granite from a quarry at Greenwich showed a crushing strength of 18,330 pounds and 25,030 pounds to the square inch, and a modulus of rupture of 3,645 and 3,757. The latter test was made by placing a slab 18 inches long, 1 inch wide, and 1 inch thick on the two supports 15 inches apart and adding to a load in the middle until the slab yielded. The load applied in one case was 162 pounds, in another 167, thus giving the moduli of rupture mentioned above.

In regard to the granite quarried by the Columbia Granite Company from a quarry recently developed near the narrows of the Connecticut River, 4 miles southeast of Middletown, the following data have been obtained: The granite is of two varieties, about equal in amount. One is a coarse-grained stone of reddish cast from the flesh-colored feldspar; it contains a finely divided black mica in moderate quantity; it

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takes a good polish. The other is a fine-grained light-gray stone of compact and uniform structure; it takes a good polish and is well adapted to monumental purposes. Tests were made by Mr. Ira H. Woolson, M. E.

Crushing tests of granite from Middletown, Connecticut; coarse-grained variety.

[Pounds per square inch.]

NINE SAMPLES FROM NORTHWEST END OF LEDGE.

Bed	23,000	Bed	22,525	Bed	23,542
Edge	21,450	Bed	22,475		
Edge	21,019	Bed	23,525	Average	23,029
Edge	24,278	Edge	25,450		

SEVEN SAMPLES FROM MIDDLE OF LEDGE.

Bed	21,460	Bed	21,921	Edge	20,470
Bed	22,058	Edge	22,797		
Bed	24,753	Edge	21,831	Average	22,184

Final average, 22,600 pounds per square inch.

Crushing tests of granite from Middletown, Connecticut; fine-grained gray variety.

[Pounds per square inch.]

Bed	32,525	Bed	32,500	Bed	34,075
Bed	31,019	Bed	32,562	Edge	32,050
Bed	32,700	Bed	30,000	Edge	30,888
Edge	30,050	Bed	29,400	Bed	32,150

The following tabular statement shows the details involved in making the tests. The pieces used were all cubes:

Tests of granite from Middletown, Connecticut.

COARSE-GRAINED GRANITE.

[Mark: "N. W. end of ledge."]

Test number.	How tested.	Length or height.	Diameter or breadth.	Thickness.	Area.	First crack.	Stress in pounds compression; maximum.	
							On specimen.	Per square inch.
		Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*
1045	Bed	2.004	2.00	2.00	4.00	91,600	92,000	23,000
1046	Edge	2.002	2.00	2.00	4.00	84,000	85,800	21,450
1047	Edge	1.994	2.01	2.00	4.02	83,800	84,500	21,019
1048	Edge	2.005	2.01	2.00	4.02	97,500	97,600	24,278
1049	Bed	2.002	2.00	2.00	4.00	.....	90,100	22,525
1050	Bed	2.001	2.00	2.00	4.00	.....	94,100	23,525
1051	Bed	2.001	2.00	2.00	4.00	89,000	89,900	22,475
1052	Edge	2.001	2.00	2.00	4.00	101,000	101,800	25,450
1053	Bed	2.010	1.99	2.00	3.98	85,000	93,700	23,542

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Tests of granite from Middletown, Connecticut—Continued.

FINE-GRAINED GRAY GRANITE.

[Mark: "South end B."]

Test number.	How tested.	Length or height.	Diameter or breadth.	Thickness.	Area.	First crack.	Stress in pounds compression; maximum.	
							On specimen.	Per square inch.
1054	Bed...	2.007	2.00	2.00	4.00	126,500	130,100	32,525
1055	Bed...	2.002	2.00	2.01	4.02	95,500	124,700	31,019
1056	Bed...	2.007	2.00	2.00	4.00	129,000	130,800	32,700
1057	Edge..	2.001	2.00	2.00	4.00	119,000	120,200	30,050
1058	Bed...	2.000	2.00	2.00	4.00	.....	130,000	32,500
1059	Bed...	2.002	1.99	2.00	3.98	128,900	129,600	32,562
1060	Bed...	2.007	2.01	2.00	4.02	110,000	120,600	30,000
1061	Bed...	2.001	2.00	2.00	4.00	.....	117,600	29,400
1062	Bed...	1.998	2.00	2.00	4.00	135,000	136,300	34,075
1063	Edge..	2.001	2.00	2.00	4.00	127,800	128,200	32,050
1064	Edge..	1.999	1.99	1.99	3.94	.....	121,700	30,888
1065	Bed...	2.004	2.00	2.00	4.00	128,000	128,600	32,150

COARSE-GRAINED GRANITE.

[Mark: "Middle ledge B."]

1066	Bed...	2.026	2.01	2.01	4.04	85,000	86,700	21,460
1067	Bed...	2.025	2.02	2.02	4.08	89,000	90,000	22,058
1068	Bed...	2.007	2.01	2.02	4.06	100,000	100,500	24,753
1069	Bed...	2.011	2.01	2.02	4.06	.....	89,000	21,921
1070	Edge..	2.013	2.00	2.02	4.04	91,000	92,100	22,797
1071	Edge..	2.027	2.01	2.01	4.04	76,000	88,200	21,831
1072	Edge..	2.016	2.01	2.01	4.04	81,000	82,700	20,470

Delaware.—The industry in this State fell off slightly. Although operations for the entire State are not large, quarrying methods are advanced and well conducted. Improvement in the magnitude of business will follow the advent of the expected prosperity.

Georgia.—Production in 1896 fell off very markedly, namely, from a valuation of $508,481 in 1895 to $274,734 in 1896. No improvement is expected until the general conditions of trade become better. Maj. J. W. Reilly, of the Watertown Arsenal, found for the Stone Mountain granite a crushing strength of 25,630 and 28,130 pounds per square inch, both on bed; for Lithonia stone, 30,320, 28,290, and 28,250, all on bed. Results of another series of tests of Lithonia granite are as follows. Tests made by Mr. John Bradley.

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Crushing tests of granite from Lithonia, Georgia.

[Pounds per square inch.]

No.		No.	
1	31,260	5	30,690
2	31,690	6	33,750
3	28,980	Average	31,816
4	34,530		

Maine.—The value of the product in 1895 was $1,400,000; in 1896 the corresponding figure was $1,195,491. The producers have made many complaints of trade depression, but most of them are hopeful of better things in 1897.

The late Prof. J. S. Newberry, of the School of Mines, Columbia College, New York, made the following report concerning granite from Pleasant River, Maine:

Properly speaking the stone is a diorite, being composed of black hornblende and albite or white feldspar as essentials, a small amount of quartz, and the usual accessories. The hornblende, owing to its toughness, gives the stone a superior cleavage, while albite is one of the hardest and most durable of the feldspars. The stone is very strong, homogeneous, and handsome, and is quite unlike any other building or ornamental stone now in use in this country. It will not rust on exposure, and, as hornblende is substituted for mica in its composition, it takes a fine polish, which will be permanent. The hammer-dressed surfaces are light gray, almost white, and the strong contrast between this and the dark color of the polished surfaces is a very desirable feature, as it brings out strongly any ornamental designs or lettering that may be placed upon it. It withstood a pressure of 22,410 pounds to the square inch.

Though the stone somewhat resembles in appearance some varieties of dark serpentine now in use, it has a totally different composition, and will resist exposure to the weather, as the serpentines and verd antiques will not. It is well adapted to building and monumental purposes, and will be prized by architects as affording a new, attractive, and excellent element for combination with contrasting materials for decorative designs.

Tests of granite quarried at North Jay, Franklin County, Maine.

Sectional area	square inch..	36.36
Weight	pounds..	20¼
Tested between flat steel plates.		
Ultimate strength	pounds..	459,000
Ultimate strength	pounds per square inch..	12,624
Snapping sound heard at	pounds..	190,000
No cracks in sight.		
Corner along one edge split off	pounds..	260,000
Block suddenly flew into fragments when maximum strain was reached.		
Test at Watertown Arsenal, May 6, 1882.		

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The following statements by Mr. F. L. Bartlett, of the Maine State assay office, have been made relative to the granite at Freeport, Cumberland County, quarried by Mr. E. B. Mallet, jr.:

Characteristics of granite from Freeport, Maine.

Specific gravity	2.627
Hardness	Medium
Iron in form of pyrite	None
Iron in form of oxide, in combination	1.872
Percentage insoluble in strong acids (quartz)	95.2
Percentage soluble in dilute acids	None
Absorption in water	None appreciable

The examination of this granite, as shown by the above tests, indicates that it contains an excess of silica, and that it contains no sulphides of iron or lime; that it is compact and insoluble in water; all of which proves that the stone is suitable for monumental purposes, and will stand under either salt or fresh water. Its composition is silica, black mica, and feldspar. The silica predominates; consequently it would be called quartzose granite.

The Chase Granite Company, operating quarries at Blue Hill, Hancock County, submit the following analysis of the granite quarried by them. The analysis was made in May, 1896, by Messrs. Ricketts and Banks, chemists, of New York City:

Analysis of granite from Blue Hill, Maine.

	Per cent.
Silica	73.02
Protoxide of iron	2.59
Alumina	16.22
Protoxide of manganese	Trace.
Lime	.94
Magnesia	Trace.
Potash	3.42
Soda	3.60
Sulphur	None.
Loss and undetermined	.21
Total	100.00

Maryland.—The output of granite in 1895 was valued at $276,020; in 1896 the figure was $251,108. This of course indicates a slight falling off, but not a serious one, and it is entirely due to the continued financial depression. Producers generally anticipate much improvement in the industry as soon as the hard times have passed. The following data relative to the Port Deposit granite are submitted. The analysis was made by Mr. William Bromwell, under the supervision of

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Dr. H. N. Morse, professor of analytical chemistry in the Johns Hopkins University. The stone is quarried by Messrs. McClenahan & Bro., of Port Deposit.

Analysis of granite from Port Deposit, Maryland.

	Per cent.
Silica, SiO_2	73.690
Alumina, Al_2O_3	12.891
Ferric iron, Fe_2O_3	1.023
Ferrous oxide, FeO	2.585
Lime, CaO	3.737
Magnesia, MgO	.498
Potash, K_2O	1.481
Soda, Na_2O	2.811
Water, H_2O	1.060
Total	99.776

The rock also contains a small percentage of titanium (TiO_2), which was not accurately determined, but which is probably about 0.50 per cent. There are also traces of cerium, strontium, barium, manganese, lithium, and phosphoric acid.

The following mineralogical description of the Port Deposit granite was prepared by Prof. G. P. Grimsley, of the Johns Hopkins University:

The proportionate mineral composition of this Port Deposit rock was calculated from the chemical analysis made by Mr. William Bromwell. Such a calculation could be only an approximation for two reasons: First, because the exact composition of the individual minerals in the rock is not known; second, because certain of the bases enter into two or more of the silicates. Although a little secondary muscovite occurs in the feldspar, this was ignored, and the proportion of orthoclase was first calculated, it being assumed that all the potash was contained in this mineral. The soda was in like manner referred to the albite molecule in the plagioclase. The magnesia was regarded as being confined entirely to the biotite. A small proportion of the lime (1 per cent) was arbitrarily assumed to represent approximately the epidote, which is small in amount as seen from this section, while the remainder was referred to the anorthite molecule of the feldspar. The residual silica represents the quartz.

For those minerals which have a definite composition, like orthoclase, albite, anorthite, and quartz, the theoretical proportions of the constituents were used as given in E. S. Dana's System of Mineralogy (edition of 1893). From such a calculation, taken in connection with a mechanical separation in a heavy solution and a study of the relative

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areas occupied by these minerals in the thin sections, the following percentages are thought to fairly represent the rock:

Mineral composition of granite from Port Deposit, Maryland.

		Per cent.		
	Biotite (mica)	9.7		
	Orthoclase (potash-feldspar)	9.0		46.4
Feldspar (oligoclase)	Albite	23.8	37.4	
	Anorthite	13.6		
	Quartz	40.0		
	Epidote	3.9		
	Total	100.0		

This represents an acid soda-granite of true igneous origin which has subsequently been foliated through pressure.

The following physical tests of Port Deposit granite were made by Messrs. Booth, Garrett, and Blair, of Philadelphia, on a 2-inch cube: Crushing strength, 84,730 pounds for 2 inches; equivalent to 21,180 pounds per square inch.

Massachusetts.—The output of 1895 was valued at $1,918,894; in 1896 the corresponding figure was $1,656,973. There has been evidently a decrease in product. Many producers speak in a decidedly discouraged tone, but feel that as the situation can hardly become worse there must soon be a change for the better.

The following data relative to the character of granite in different localities have been obtained:

Granite from near Westford, Middlesex County, quarried by Messrs. H. E. Fletcher & Co., showed a crushing test of 16,091 pounds to the square inch. Size of specimen, 4.10 by 4.04 by 3.97 inches. First crack occurred at 116,000 pounds. Ultimate strength, 258,100 pounds, equal to 16,091 pounds to the square inch. The test was made at the Watertown Arsenal.

The W. N. Flynt Granite Company, of Monson, report the following facts relative to trap rock quarried by them: The Highway Commissioner of Massachusetts determined what is known as the "coefficient of wear" to be 22.13. The following analysis of same is credited to the Watertown Arsenal:

Analysis of granite from Monson, Massachusetts.

	Per cent.
Silica	52.59
Ferric oxide	14.55
Alumina	23.42
Lime	9.05
Magnesia	.28
Manganous oxide	.09
Total	99.98

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The following facts as to Chester granite, quarried at Chester, Hampden County, were submitted by the Hudson and Chester Granite Company:

Prof. B. K. Emerson, of Amherst College, makes the following statements relative to this granite: Its color is a clear gray. It is of fine and even grain, and has strength abundantly sufficient for all architectural demands. A microscopical examination detects no constituents which can impair its durability or cause it to tarnish under the influence of the weather. Pyrite is present in minute quantity, but it shows no tendency to rust. The evenness of the color and grain and the absence of all banding and blotching are all that could be desired, and this enables the quarry to furnish a stone which will meet all architectural demands, and will satisfy the more exacting requirements of the higher classes of monumental work.

Prof. J. F. Kemp, of Columbia College, New York, states that the granite has a gray or bluish-gray color of a medium shade and is very pleasing in its appearance. It is very homogeneous and of moderately fine grain, and has a texture well adapted to tool treatment.

The minerals entering into the stone are quartz, orthoclase and plagioclase feldspar, green biotite and colorless muscovite (i. e., dark and light colored mica), a little magnetite, and a few rare accessory minerals. The several sections failed to show pyrite, and although the chemical analysis indicates it in a very small amount, it is quite insignificant, and need not be feared, either as a source of weakness or of stains.

The chemical analysis gave the following results:

Analysis of granite from Chester, Massachusetts.

	Per cent.
Moisture yielded at 110° C	0.08
Further loss on ignition	0.74
Silica (SiO_2)	69.465
Ferric oxide (Fe_2O_3)	2.30
Alumina (Al_2O_3)	17.50
Manganous oxide (MnO)	Trace.
Lime (CaO)	2.57
Magnesia (MgO)	0.305
Potash (K_2O)	4.07
Soda (Na_2O)	3.01
Sulphur (S)	0.04
Total	100.080

This analysis indicates a granite with a medium percentage of silica, and with nothing of unusual or deleterious character in its composition.

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The sulphur, which is present as pyrite (the sulphide of iron), is practically insignificant. A few minute specks are the only signs of it to the eye. The amount of iron is quite low.

Minnesota.—Production in 1895 amounted in value to $148,596; in 1896 the corresponding figure was $155,297, showing an increase of nearly $7,000. Under prosperous conditions the granite industry would probably progress regularly. In 1892 the value of the output was $360,000, showing what can be done under flourishing conditions.

Missouri.—Production fell off from a valuation of $128,987 in 1895 to $107,710 in 1896. The following is an abstract of a paper by Prof. Charles R. Keyes, State geologist of Missouri:

The granites are confined to the southeastern part of the State, where they occur in irregular masses and isolated hills extending over an area of 3,000 square miles. Granites and porphyries are the principal types, with several varieties of dark trappean rocks, chiefly diabase, occurring in the form of dikes. They are the most ancient rocks of the State.

The approximate center of the crystalline district is Pilot Knob, Iron County. For a distance of perhaps 12 miles in all directions from this point the massive crystallines form the greater portion of the surface rock, while in an easterly direction they are practically continuous for more than twice as far. To the north the exposures do not reach much beyond Bismarck, St. Francois County. Northeastward they are found in St. Genevieve County, 30 miles from Pilot Knob. On the east, hills of similar rock are abundant as far as Castor Creek, in Madison County. To the south they stretch away in large masses for many miles, with occasional outcrops as far as the boundary line of Butler County. To the northwest they extend into Shannon County, and perhaps even beyond. They stretch out to the west almost unbrokenly to the east fork of Black River, while numerous scattered hills continue even beyond the middle fork of the same stream. Toward the north similar rocks occur at short intervals as far as Little Pilot Knob, in Washington County. The stone has been used in Dallas, Kansas City, Omaha, St. Louis, Des Moines, Minneapolis, New Orleans, Chicago, Indianapolis, Cincinnati, Cleveland, and Baltimore.

It has been demonstrated that apparent lines of sedimentation in this rock are really pseudo-stratification planes, and that they have been developed in a way that is widespread among rocks that have cooled from molten magmas. The continuity of the massive rocks is interrupted by numerous lines. The porphyry appears to be the surface facies of the coarse grained granite, and seems to graduate downward into the latter. The numerous lines of fracture are most of them merely joint planes; many are slight fault lines, while still others have the walls spread apart, the space being filled with basic material which often forms dikes, sometimes of considerable breadth.

Dikes of basic rock occur rather abundantly. They range from a few

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inches to 50 yards or more in width, and cut the granites and porphyries alike. Nowhere have they been observed to penetrate the overlying sedimentaries. Their number and wide distribution, the great weight and black color of the rock composing them, and their peculiarities in weathering cause them to attract much attention.

There are four principal kinds of rock that are suitable and available for quarry stones. These are:

1. Granite (biotite-granite or granitite).
2. Syenite (granite-syenite).
3. Porphyry (felsite).
4. Black granite (diabase-greenstone).

Typical granite constitutes about one-fifth part of all the crystallines in the district under consideration. In color the stone is a warm red to pink, in places merging into gray. Though usually a coarse-grained rock, fine-grained varieties are of frequent occurrence. The rocks consist almost entirely of a granular aggregate of quartz and feldspar; white mica is entirely absent. The black mica (biotite) present, which is usually one of three essential constituents and a mineral which is the first of the principal components in most granites to break down under meteoric influences, is reduced to minimum, and in many cases it is almost entirely absent. The feldspar is for the most part orthoclase, the most durable of feldspathic minerals. Accessory components liable to decomposition are wanting.

The porphyry is close grained, glassy, of various colors—pink, red, purple, green, brown, and black in many shades. It polishes brilliantly, is hard and rather brittle. It is not suited to dimension work on account of difficulty of working. The groundmass is dense and fine grained, though there are scattered large crystals of quartz and feldspar.

The black granites are greenstones or diabases; they occur in dikes, cutting the granite and porphyry; are heavy, tough, and admit of fine polish; are not desirable for building, but are unsurpassed for paving blocks, decaying fast enough not to become slippery.

The following table shows the results of chemical analyses:

Analyses of granite from the region of Graniteville, Missouri.

Locality.	Loss at 100°C.	Loss on ignition.	SiO_2.	Al_2O_3.	F_2O_3.	FeO.	NiO.	MnO.	CaO.	MgO.	K_2O.	Na_2O.	P_2O_5.	TiO_2.	Totals.	Authority.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Graniteville	.....	0.52	77.05	11.77	2.33	.....	.....	.....	2.21	.....	3.88	2.90	0.023	.....	100.68	Melville.
Ironton, 6 miles E	0.14	.85	69.94	15.19	1.88	0.60	.....	0.03	1.15	0.92	4.29	3.95	.13	0.25	90.32	Do.
Silver Mine, 2 miles W	.....	.....	73.98	14.32	.....	.....	.....	.....	1.04	.....	3.32	4.56	.....	.....	.....	St. L. Samp. Works.
Middlebrook, 5 miles E	.....	.....	77.04	12.29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Do.
Hogan, 7 miles E	.....	.....	74.06	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Melville.
Do	.....	.....	77.38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Do.
Ironton, 6 miles E	.22	.54	72.35	13.78	1.87	.36	0.20	.06	.87	.42	4.49	4.14	.13	.44	90.87	Do.
Skrainka	.....	.....	69.51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Bradford.

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The granite is a mixture of quartz and feldspar, with some biotite as an essential component. Accessory constituents are apatite, zircon, and magnetite. Biotite and hornblende are comparatively rare. Biotite is an important constituent in only a few cases. It is unevenly distributed, so that at some points the rock is quite mottled, though only a short distance away the mica is entirely absent. Hornblende has been observed in a few instances, and then only very sparingly. The feldspars show little indication of decomposition, which is a very favorable point in determining the value of a rock for building purposes.

The rock is jointed in such a way as to make quarrying both easy and economical. The space between the fractures varies at different points. In some cases they are close enough together to permit paving blocks to be taken out with the greatest facility; in other places monoliths of any practical size may be readily obtained perfectly free from seams and defects. Very little stripping is required.

The Syenite Granite Company, of Graniteville, submits the following facts, ascertained by Prof. J. B. Johnson, of the department of civil engineering of Washington University: The two specimens of granite which were sent were ground down on their top and bottom faces to true parallel planes, leaving prisms which were 3.85 square inches and 3.87 square inches in area, respectively. These specimens broke, the former at 93,100 pounds, or 24,200 pounds per square inch, and the latter at 95,700 pounds, or 26,400 pounds per square inch.

Nevada.—Very little granite is produced at present. The following is a statement of the results of analysis of granite produced in Washoe County by Mr. John Barrett. The analysis was made by Prof. J. W. Phillips, chemist:

Analysis of granite from Washoe County, Nevada.

	Per cent.
Silica, SiO_2	58.67
Alumina, Al_2O_3	14.89
Manganese, MnO_2	1.00
Ferric oxide, Fe_2O_3	7.56
Lime, CaO	5.68
Magnesia, MgO	1.79
Soda, Na_2O	7.69
Potash, K_2O	2.69
Loss by ignition	.57
Total	100.54

New Hampshire.—New Hampshire is one of the very few States to show a gain in output during 1896. Production advanced from $480,000 in 1895 to $497,966 in 1896.

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New Jersey.—Much of the stone output of New Jersey is trap rock, which has a well-established reputation for use as macadam. Most of it is devoted to this purpose.

The value of the output in 1895 was $151,343; in 1896 the figure was $204,323. Thus, there has been a considerable gain in production in spite of the general depression in trade.

New York.—There was a quite decided gain in the output of granite in New York, as will be seen by consulting the tables of production, but the total is still much below what has been done in former years.

North Carolina.—A falling off in output from a valuation of $75,000 in 1895 to $40,017 in 1896 shows the extent to which depression has gone. Demand has been very light. Expectations for much improvement in 1897 are expressed by some of the quarrymen.

The following facts relative to North Carolina granite have been submitted by the Mount Airy Granite Company. Tests of Mount Airy granite by Messrs. Riehle Bros., of Philadelphia, on cubic-inch samples showed the crushing strength to be about 20,000 pounds to the square inch.

Prof. J. A. Holmes, State geologist of North Carolina, makes the following statements relative to the granite quarried by the Mount Airy Granite Company:

A chemical analysis of a sample of granite from the Mount Airy quarry made in the survey laboratory shows only 0.50 per cent of sulphur and 1.94 per cent of iron. The former probably occurred in the form of small pyrite crystals, and the latter comes in part from this source and in part from the biotite-mica. Both occur in such small quantities that they can not prove in any way injurious to the stone, and I have been unable to find any other injurious ingredients. The stone is a medium-grain, light-colored biotite-granite, of marked uniformity in color and texture, and, as shown by actual tests, it stands a crushing strain of 18,000 to 20,000 pounds per square inch. It is an excellent stone for general architectural purposes and for Belgian blocks.

The following analysis of Mount Airy granite quarried at Greensboro was made by Prof. C. M. Cresson, of Philadelphia:

Analysis of Mount Airy granite, North Carolina.

	Per cent.
Silica, SiO_2	71.56
Alumina, Al_2O_3	16.79
Oxide of iron, Fe_2O_3	1.87
Lime, CaO	2.93
Magnesia, MgO	.30
Soda, Na_2O	11.96
Sulphuric acid in combination, SO_3	.33
Total	105.74

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This granite is well adapted for buildings, possessing sufficient strength and toughness to carry the loads which are ordinarily required for such purposes. The large masses in which the individual components are aggregated give the stone a peculiar brilliancy of appearance. It is beautifully bright, calculated to make handsome buildings, in strong contrast with the somber cast which usually accompanies granite facings. The absence of the deleterious elements which frequently occur in granite, causing strain and disintegration, adds to the value of this stone.

Oregon.—Very little quarrying has been done in Oregon during the past year. That there is plenty of material of desirable quality, both as to strength and beauty, is well shown by the following account of rocks of economic interest and importance in Oregon, by Mr. J. S. Diller, of the United States Geological Survey:

The rocks of the Coast Range of Oregon are chiefly sandstone, shales, and basalts. Although widely distributed, they are not all of economic importance. The shales are of but little use. The calcareous nodules which they contain, abundantly in some places, have been burned to lime, but the amount is very limited.

The sandstones are quarried in many places for building purposes. Those near the coast are generally soft and used chiefly in the construction of jetties. At Tillamook Bay and Coos Bay they are quarried for this purpose within easy reach of tide water.

The principal sandstone quarry of western Oregon is the one at Pioneer, on the Yaquina River, in Lincoln County. At that place the sandstone occurs in massive beds and affords an excellent building stone. Being soft, it is easily shaped and yet is durable, with a good gray color. The heavy beds allow it to be quarried in large pieces, in some cases 10 feet thick. It is carried by the railroad from the quarry to tide water, then towed on barges down the bay. The rock dips gently and a great mass of it is exposed, so that it will evidently furnish material for some time to come.

About 5 miles south of Forest Grove, in Washington County, at Boose's quarry, a solid dark-gray sandstone is taken for building purposes, and is quite extensively used in the surrounding country. The rock contains numerous Miocene fossils.

At several points a few miles south of Corvallis, and at Monroe, still farther south, in Benton County, considerable sandstone has been quarried, but for local use only.

About 2 miles from Jefferson, Marion County, a sandstone has been quarried and used, by Mr. F. Wood, of Albany, in the construction of monuments. It is a dark-gray sandstone, easily cut, and occasionally shows, upon a fresh fracture, irregular areas of bright reflections from the calcareous cement which holds the sand together. The rock being fine grained receives delicate carvings and was used for the ornamental memorial stone from Oregon in the Washington Monument, at the national capital. Small cubes of this sandstone are said to have been

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tested and to have shown not only a high crushing strength but to stand fire well. This would be expected from the nature of the sand, which is made up largely of volcanic material. Characteristic fossils occur in this region, as well as near Corvallis and at Monroe, showing that the sandstone belongs to the Eocene formation and may be older than the sandstone at Pioneer and the Coast Range, farther northward.

Sandstones are especially abundant in the Coast Range south of the latitude of Eugene City, and are well exposed along the Umpqua and Coos rivers and the forks of the Coquille. A great bluff of sandstone forms the eastern escarpment of the range from Tyee Mountain and Coles Valley to Camas. The same rock continues farther southward, lapping over the older strata, but in places gets coarser grained, and rising higher in the mountains is less available. Along the coast, however, it is much more easily reached. Near Port Oxford, and perhaps other points south of the district embraced in this reconnoissance, the sandstones have been quarried for the San Francisco market.

It is well known from the publications of Mr. Herbert Lang that limestone, sometimes in the form of marble, occurs in a number of places in the Klamath Mountains of southwestern Oregon, as, for example, near Rocky Point, in Jackson County, and on Williams Creek, in Josephine County. Farther northward, upon the borders of the Willamette Valley, shell limestone is said to occur in Marion and Polk counties.

There is also an interesting occurrence in Douglas County, less than a dozen miles southeast of Roseburg. The narrow belt in which the lenticular masses of limestone crop out here and there crosses the south fork of the Umpqua between Dillard and Ruckles, extending northeast toward Peel, for a distance of at least 20 miles. The outcrops best known are at Cooper's and Flint's, and at the quarry of the Variety Marble Company, of Roseburg. At the first two localities it has been burned for lime. At the last locality a mill was erected to saw the marble into slabs. The mill was not running in the summer of 1895. The marble is one of remarkable beauty, being handsomely variegated with red, yellow, gray, and white. Much of the rock is mottled gray, with a multitude of white veins, while other portions are brecciated with brilliant shades of red and yellow, veined with white and irregular areas of gray. The marble when well polished is one of the most beautiful variegated marbles of this country. It appears, however, that different portions of the mass vary considerably in hardness, and this renders it somewhat difficult to work. Furthermore, the quantity exposed at the quarry is quite limited, although farther southward, in the same belt larger lenticular masses are exposed.

Under the head of basalt are included the modern lavas so extensively used for road metal at many places. At Portland they form a portion of the heights, and occur at many points throughout western Oregon. This rock forms the falls of the Willamette at Oregon City, and many of the hills throughout the Great Valley, whose fertility is largely due to the

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rich soil which the lavas furnish by alteration and disintegration. It is well known that this rock is among the very best material it is possible to obtain anywhere for road construction. In large cities it is sometimes used in the form of paving blocks, but it is also utilized in the form of fine stones for macadamizing. It is thus employed quite extensively in Portland.

One mile south of Dilley, in Washington County, is the county stone quarry for road metal, in this sort of rock. A crusher is located here and the crushed stone is hauled a long way. The good roads of that region show the wisdom of such a provision.

Basalt is one of the most solid and enduring rocks of Oregon, but its hardness and tenacity render it comparatively difficult to trim. On account of its somber color it is little used for building purposes, excepting for foundations. For this purpose it has a wide application. It frequently possesses a columnar jointing that cuts it up into pieces too small for building purposes. Occasionally the columns are sufficiently regular to be used for fence posts without further trimming. This is especially the case along the Rhine, in Germany.

According to the report[1] concerning the stone industry for 1894, granite is quarried in Jackson and Columbia counties, diabase in Lynn County, basalt in Clackimas and Lynn counties, and andesite in Multnomah County. The value of the granite quarried in Oregon in 1890 was $44,150; in 1891, $3,000; in 1892, $6,000; in 1893, $11,255; in 1894, $4,993. The rocks classed above as granite, diabase, basalt, and andesite are all of igneous origin.

Pennsylvania.—The output in 1896 shows a very decided falling off—i. e., from $300,000 in 1895 to $159,317 in 1896. More than half the product is used for paving blocks, and the substitution of asphalt for paving blocks in Philadelphia has very noticeably affected the paving-block industry in Pennsylvania. The use of paving bricks is also considerable. A number of quarrymen ceased operations entirely for the year. The following is a statement of the results of an analysis of granite from Lackawanna County. The analysis was made by Mr. D. W. Humphrey, chemist, of Scranton.

Analysis of granite from Lackawanna County, Pennsylvania.

	Per cent.
Silica, SiO_2	94.16
Oxide of iron, Fe_2O_3	1.16
Alumina, Al_2O_3	3.60
Magnesia, MgO	.....
Lime, CaO	.....
Soda and potash	.25
Loss by ignition	.80
Total	99.97

[1] Sixteenth Ann. Rept. U. S. Geol. Survey, Part IV, 1895, pp. 444 and 461.

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Rhode Island.—The value of the output in 1896 fell below that of 1895 by $222,196. This State generally stands first in the United States for the annual value of monumental stock turned out, but in 1896 Vermont takes first place in this regard. More than half of the value of the output for 1896 was that of monumental stock.

The granite quarried at Westerly has a high reputation for its adaptability to the finest kind of ornamental work and carving.

South Carolina.—A considerable increase in production characterized the year 1896 in this State, namely, from $22,083 in 1895 to $55,320 in 1896. The need of more capital for the working of some of the quarries is felt by the operators.

South Dakota.—Owing to the increased operations of two firms the output of granite in South Dakota increased from $33,279 in 1895 to $199,977 in 1896. Most of the product was used for macadam, and a considerably smaller amount for paving blocks. The productive quarries are in Minnehaha County.

Vermont.—While the output of granite in Vermont fell off from a valuation of $1,007,718 in 1895 to $895,516 in 1896, still the general tone of encouragement expressed by producers is quite different from that which comes from some other granite-producing sections of the country. Barre particularly shows up very well, and, all things considered, the past year may be called a prosperous one for this important locality.

Virginia.—Production in Virginia increased from $70,426 in 1895 to $95,040 in 1896. There is granite of very fine quality in the vicinity of Richmond, and its popularity is attested by a production which amounted in value to $332,548 in 1890. The recent hard times have, however, caused suspension of operations by a number of important firms; hence the decline in output.

Investigation of granite from Henrico County, quarried by Mr. Peter Copeland, showed, as the result of tests at the Watertown Arsenal, the following results:

Tests of granite from Henrico County, Virginia.

Number of specimen.	Height.	Surface.	First crack.	Ultimate total.	Strength in pounds per square inch.
	Inches.	*Sq. in.*	*Pounds.*		
1	1.90	4.00	93,000	102,080	25,520
2	1.90	4.00	103,000	114,500	28,625

Wisconsin.—A stride forward was made in the granite industry in 1896. Production increased from $80,761 in 1895 to $126,639 in 1896.

The following is a statement of the results of an analysis of the granite quarried in Waushara County by the Milwaukee Monument Company.

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Analysis of granite from Waushara County, Wisconsin.

	Per cent.
Silica, SiO_2	76.62
Alumina, Al_2O_3	13.02
Ferric oxide, Fe_2O_3	1.01
Lime, CaO	.51
Magnesia, MgO	.05
Soda, Na_2O	2.24
Potash, K_2O	6.38
Total	99.83

MARBLE.

VALUE OF THE MARBLE PRODUCT, BY STATES.

The following table shows the value of the marble produced in the United States during the year 1896, by States:

Value of the marble product for the year 1896, by States.

State.	Value.	State.	Value.
California	$4,000	New York	$484,160
Georgia	617,380	Pennsylvania	31,522
Idaho	5,500	Tennessee	381,373
Iowa	39,740	Vermont	1,101,557
Maryland	110,000		
Massachusetts	83,904	Total	2,859,136

Comparing the product of 1896 with that of 1895 it appears that there has been a gain of $33,417. This increase is not great, but in view of the financial conditions that have prevailed generally it is somewhat surprising that there should have been any advance whatever. The gain in output in New York State is the most noteworthy and has been such as to more than offset a decrease in several other States.

The following table shows the various uses to which the marble quarried in 1896 was put:

Distribution of output in 1896 among various uses.

	Value.
Sold by producers in rough state	$583,690
Sold for outside building	1,036,163
Ornamental purposes	65,365
Cemetery work (monuments and tombstones)	813,146
Interior decoration in buildings	329,804
Other scattering uses	30,968
Total	2,859,136

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Inspection of this table shows that the largest single item is "outside building," to which use $1,036,163 worth of marble was applied, or, in other words, 36.2 per cent of the whole.

The uses to which the stone "sold by producers in rough state" is actually put could not be certainly ascertained. It is bought by builders, stonecutters, and finishing mills. Supposing it to be divided equally between "outside building," "cemetery work," and "interior decoration," this would increase these items by $194,563 in each case, making the amount devoted to outside building, $1,230,726; cemetery work, $1,007,709; interior decoration, $524,367. On this basis 43 per cent went for outside building, 35 per cent for cemetery work, and 18 per cent for interior decoration; the remaining 4 per cent went for ornamental purposes and scattering uses, such as small ornaments, statuettes, etc.

Of the amount known to have been devoted to cemetery work, Vermont produced 81 per cent, but on the assumption that the total devoted to cemetery work was the increased figure, $1,007,709, then Vermont's percentage becomes 65.

New York supplies the largest amount for "outside building," Georgia second, Vermont third, Maryland fourth.

For interior decoration in buildings (i. e., wainscoting, tiling, mantels, washstands, etc.) Tennessee yields 57 per cent, producing three times as much for this purpose as any other one State.

There has been during the past few years a tendency in a number of marble producing States to extend the sales of marble for outside building purposes, thus creating a larger volume of business and bringing marble more definitely into competition with other kinds of stone, which for the greater part are used only for building. In times of financial distress indulgence in luxuries naturally decreases with the use of stone, as elsewhere. This brings about lower prices and reduces margins of profit. Many producers have therefore sought to offset loss of trade and profit in decorative, monumental, and cemetery products by increased sales of stone in the rough at reduced prices for structural building rather than stop quarrying altogether. This statement applies particularly to the more enterprising and determined producers, while others with less capital invested have ceased operations altogether, in some cases permanently and in others with the intention of resuming when financial conditions shall be more favorable. These statements apply with much less force to the marble industry in Vermont than to that of any other State. The great bulk of the marble output of Vermont goes into cemetery products—monuments and tombstones—and this branch of the business has grown to such proportions in the State and is of such long standing, while the stone is so well adapted to this use, that the present period of depression has simply had the effect of reducing the value of the output without compelling the leading producers to seek other uses for their product.

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There is, however, another reason to explain the falling off in the total value of cemetery products, and that is the increasing competition of granite. The beauty and durability of granite, its susceptibility to fine effects in carving and polishing, and the fact that the cost of cutting, ornamenting, and polishing has become somewhat lower than formerly, are causes which have made it a formidable competitor of marble in the cemetery.

While the cost of manufacturing crude granite into monumental and ornamental stock is decidedly greater than that of producing the same effects in marble, it should be remembered that the cost of the rough granite is less also than that of such marble as is suitable for these uses. Furthermore, there is, as a rule, less elaboration in granite monuments than is expected in marble. Thus causes are at work to bring these two kinds of stone to the same plane of competition.

The popularity of marble for cemetery purposes is more pronounced in the Southern States than in the New England, Middle, and Western States. This is accounted for by a climate in the south more favorable for preservation of the stone.

Prices of Vermont marble suitable for cemetery decorative work range from $2.25 up to $12 per cubic foot, the last-named price being that for the grade known as statuary marble. There is a wide difference in price between crude marble and crude granite suitable for monumental work. The prices for marble have already been given. The range for crude granite for monumental work is from 70 cents to $1.50 per cubic foot, while for building granite the prices are from 25 to 40 cents per cubic foot.

Georgia marble for building purposes costs $1 to $1.25 per cubic foot.

The following table shows the purposes for which the marble of the various productive States was sold by the quarrymen:

Value of the marble product, by uses and States.

States.	Rough.	Building.	Ornamental.	Cemetery.	Interior.	Other.	Total.
California	$4,000	.....	.....	.....	.....	.....	$4,000
Georgia	171,644	$258,886	.....	$98,200	$63,650	$25,000	617,380
Idaho	1,500	.....	.....	4,000	.....	.....	5,500
Iowa	23,460	10,080	$6,200	.....	.....	.....	39,740
Maryland	.....	109,000	.....	.....	1,000	.....	110,000
Massachusetts	14,763	56,641	.....	8,000	3,000	1,500	83,904
New York	69,072	365,737	.....	41,682	4,471	3,198	484,160
Pennsylvania	3,022	28,500	.....	.....	.....	.....	31,522
Tennessee	190,103	.....	.....	.....	190,000	1,270	381,373
Vermont	106,126	207,319	59,165	661,264	67,683	.....	1,101,557
Total	583,690	1,036,163	65,365	813,146	329,804	30,968	2,859,136

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The following table gives the production of marble, by States, for the years 1890 to 1896, both inclusive:

Value of marble, by States, from 1890 to 1896.

State.	1890.	1891.	1892.	1893.
California	$87,030	$100,000	$115,000	$10,000
Georgia	196,250	275,000	280,000	261,666
Idaho				4,500
Iowa				
Maryland	139,816	100,000	105,000	130,000
Massachusetts			100,000	
New York	354,197	390,000	380,000	206,926
Pennsylvania		45,000	50,000	27,000
Tennessee	419,467	400,000	350,000	150,000
Vermont	2,169,560	2,200,000	2,275,000	1,621,000
Scattering	121,850	100,000	50,000	
Total	3,488,170	3,610,000	3,705,000	2,411,092

State.	1894.	1895.	1896.
California	$13,420	$22,000	$4,000
Georgia	724,385	689,229	617,380
Idaho	3,000	2,250	5,500
Iowa		13,750	39,740
Maryland	175,000	145,000	110,000
Massachusetts		2,000	83,904
New York	501,585	207,828	484,160
Pennsylvania	50,000	59,787	31,522
Tennessee	231,796	362,277	381,373
Vermont	1,500,399	1,321,598	1,101,557
Total	3,199,585	2,825,719	2,859,136

The following is a consideration of the marble industry in each individual productive State:

California.—Although there is much fine marble in California, of great variety as to color and fineness of grain and suitable for all the purposes to which marble is put, it was in 1896 almost entirely left where nature placed it. Some concerns did a little business with stock left over from former years, but there was practically no occasion for the removal of any more from the quarries. The construction of the city hall in San Francisco called for a small amount for use in interior decoration. Some of the producers predict better conditions for 1897.

Colorado.—At the present time (March, 1897) Colorado is engaged in producing marble for use in a new public building in Denver.

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Operations have been going on for some little time, but it is doubtful if any considerable amount was taken out in 1896. An interesting paper on Colorado marble, by Prof. Arthur Lakes, appeared in the August (1895) number of Stone, of which the following is a brief abstract:

The most important deposits of marble are found at the head of Yule Creek, in Gunnison County, 8 miles from the present terminus of a branch line of the Rio Grande Railroad to the anthracite coal mines, 12 miles from Crested Butte, and 32 miles from Gunnison. At the head of Yule Creek, and also on Crystal River, the Paleozoic limestones have been crystallized into white and variegated marbles. The following is the section of the marble from top to bottom of the mountain in which it occurs:

Vertical section of marble beds on Yule Creek, Colorado.

[Top, quartzites and porphyry several hundreds of feet thick.]

	Feet.
1. Pure white coarse-grained marble, very similar to but finer than that of Georgia	125
2. Pure white fine-grained statuary marble	100
3. White, with blue spots, both fine and coarse grained and soft	30
4. Pale chocolate, with green stripes, porphyry bed 8 feet thick	100
5. Dark bluish-black	40
6. White, with blue veins (like the Italian)	40
7. Delicate flesh or roseate color, with dark-green veins	10
8. Same, with dark-green blotches	2
9. Blue-gray, hard, fine grained	9
10. Flesh color or roseate and light green, mottled	30
11. Pure white statuary, very fine-grained, of Carrara quality	7
12. Variegated, a combination of many of those colors	200
13. Grass green or light green serpentine	30
Total of marbles and serpentine	723–750

The slope of débris conceals most of the underlying formations of the lower part of the mountain to its base. Here and there, however, outcrops of marble and quartzite are visible, and at the base fundamental granite, on which all these formations rest.

A remarkable feature of these marble beds is their fineness and solidity at the surface. In most districts marble is of little commercial value till a depth of several feet has been attained and the rotten superficial crust removed.

These deposits are not wholly confined to the head of Yule Creek, though the thickest and finest deposits appear to be there, but after sloping down gradually to the level of the valley and passing for awhile out of sight, the same belt reappears along Crystal River some miles distant.

No discoveries of marble in the United States have been made in recent years which disclose at once so much in favor of the material as do those in Colorado. The operations of quarrying this marble will be watched with much interest, particularly with reference to the conditions found after the surface has been well removed and the interior of the mass comes to view.

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Georgia.—The marble industry of Georgia, as is evident from the table of production for different years, has developed with remarkable rapidity within the past few years. The value of the output reached its maximum in 1894 at $724,385. In 1895 this declined to $689,229, and in 1896 to $617,380. This decline is, of course, simply due to the general causes which have produced a falling off in almost every industry and is in no way to be ascribed to decline in popularity of the material. The value of the product in 1896 devoted to building is $430,530. The remainder went for cemetery use and interior decoration. In 1890 the total value of the output was $196,250, most of which was devoted to ornamental work and interior decoration. It is evident, then, that the growth of the industry in Georgia has been due to the rapidly increasing application of the material to structural or outside building rather than to increased use for interior decoration, tombstones, or ornamental products. This change in the nature of the uses to which marble is applied is not confined to Georgia, but it is characteristic of the industry in other States as well. In short, marble of certain grades is less of a luxury than it used to be. Prices have come down so that this beautiful material is within the reach of builders of all classes. Hard times have done much toward this end by curtailing, in the first place, demand for interior ornamentation, thus causing a drop in prices. This decline in price soon brought certain grades of marble to a figure which permitted a more liberal use for outside building. Producers have met the changed conditions by pushing vigorously forward in the production of building marble and in advertising its claims for recognition and adoption as a building stone in competition with other less ornamental materials. This increased use of marble for outside building constitutes what is really a new industry, and while marble will, of course, continue to be used for interior decoration and cemetery work, and in increasing amount as commercial prosperity returns, these uses will probably never again appropriate so large a proportion of the total output as formerly.

For the very best classes of marble stock, prices have been quite firmly maintained, but producers are at the same time vigorously pushing marble to the front as a building stone, and this is made possible only by reducing the price of such stone to a figure which will admit it to competition with the established building stones of the country.

Idaho.—The output of marble in Cassia County increased slightly. Most of it was used for cemetery work.

Iowa.—Production in Iowa increased to about three times the output of 1895. Most of it was sold in the rough for building purposes; none for cemetery work or interior decoration. Some of it was used for ornamental purposes.

Maryland.—The output in Maryland declined somewhat in 1896, owing to the general depression of trade.

Massachusetts.—The output in Massachusetts increased quite decidedly in 1896. This was largely due to the operations of a number

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of new firms which began quarrying during the year. The marble of this State has an established reputation for building, to which purpose most of the product is devoted. The reader's attention is called to a description of Westfield serpentine marble under the heading "New discoveries" in this report.

New York.—The value of the marble quarried in 1896 was $484,160, a figure more than twice as large as that for 1895. Most of the product was used for building purposes and came from Westchester County, although smaller amounts were obtained in St. Lawrence, Dutchess, Warren, Columbia, and Madison counties. New York produced more marble for outside building in 1896 than any other State; most of the increase was due to larger operations at Tuckahoe.

Pennsylvania.—Montgomery and Chester counties yielded an output valued at $31,522; much of the product is used for outside building; operations in Chester County have extended but little beyond the initial stages. This stone (Avondale marble) is a hard dolomite, not quarried with ease, but highly serviceable on account of its hardness and capability of withstanding the actions of acids. This marble has been described in a former report. The marble from Montgomery County is well known to the trade and has been quarried for many years.

Tennessee.—It is evident from the table of "uses to which marble is put," already given, that in the amount of marble devoted to interior decoration in buildings, Tennessee stands far in the lead of any other State. In the past this application of the marble output of the State has been the leading one ever since the use of marble in the manufacture of furniture, table tops, etc., went out of fashion. Now, however, the grade of stone designated "Knox pink" is becoming known as building material, and its merits for such use are claiming considerable attention from consumers of building marble. During 1894 and 1895 an investigation of Tennessee marble with special reference to its use as an outside building material was made at the engineering laboratory of the University of Tennessee. Crushing strength tests were made upon 1-inch cubes, sawed and sand-rubbed and placed between hard cardboard cushions. The table on the next page gives the results of these tests. No difference could be detected in crushing strength when the load was applied perpendicular to the bedding and when parallel to it.

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Physical tests of Tennessee marble.

No. of sample.	Description of marble.	Number of samples broken.	Crushing load.	Remarks.
			Lbs. per sq. in.	
1	A light pink marble, with few traces of fossils, and nearly white when tool-dressed or sand-rubbed.	4	16,500	
2	Dark-pink marble from same quarry as No. 1, but taken from a higher stratum.	2	13,750	A fair sample of a grade of marble suitable only for interior decoration.
3	Light-gray marble with dark-blue lines nearly free from fossils.	5	17,000	A fair sample of a well-known marble.
4	Dark variegated marble, of chocolate color, with fossils well defined and abundant.	6	17,600	A much higher test than can be expected from the dark variegated marbles as a class.
5	A dark variegated marble but recently opened.	4	16,150	This was the only sample tested that showed any well-defined bedding.
6	An average sample of dark variegated marble so much used for interior work a few years ago.	4	14,400	
7	A light-colored marble, gray and pink, uniform in color, fossils well defined and abundant.	8	18,100	

The following tests to determine absorptive capacity were made. The samples were first weighed when they came to the laboratory as a check to subsequent work. They were then heated to a temperature ranging from 212° F. to 275° F. and weighed each day until the weight became constant. They were then placed in water and weighed daily until the weights again became constant.

The following table gives the results of absorption tests:

Absorption tests of Tennessee marble.

No. of sample.	Weight dry, in grams.	Weight after immersion.	Gain in weight.	Parts by weight of stone for 1 part of water absorbed.	Per cent of gain.	Remarks.
1	42.70	42.735	.035	1 in 122 ...	0.00082	
2	44.20	44.275	.075	1 in 600 ...	.0017	This result is so far from the average that it seems hardly credible.
3	43.54	43.57	.03	1 in 1,240..	.0008	
4	43.15	43.19	.04	1 in 1,100..	.00093	
5	46.53	46.53	.00	Less than 1 in 8,000.	.0000	This result also seems hardly credible.
6	53.48	53.525	.045	1 in 1,070..	.00093	
7	44.63	44.655	.025	1 in 1,480..	.00069	

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The following table gives the results of an analysis of an average sample from four large blocks of Hawkins County variegated marble by Dr. Albert L. Colby, of the School of Mines, New York City:

Analysis of Hawkins County marble.

	Per cent.
Moisture	0.125
Silica, SiO_2	.125
Sesquioxide of iron, Fe_2O_3	.260
Alumina, Al_2O_3	Trace.
Lime, CaO	55.320
Magnesia, MgO	.021
Carbon dioxide, CO_2	43.510
Sulphur	.005
Organic matter and loss	.634
Total	100.000

This analysis shows the stone to be a very pure carbonate of calcium.

The following table gives the results of an independent set of tests of crushing strength, made by the Riehle Bros. Testing Machine Company, of Philadelphia, in May, 1895:

Crushing-strength tests of Tennessee marble.

Name of sample.	Size in inches.	Broke at pressure in pounds.
Pink Tennessee	2.011 x 2.009 x 2.011	63,160
White Tennessee	2.013 x 2.014 x 2.012	68,850
Do	2.013 x 2.003 x 2.013	65,400
Do	2.014 x 2.015 x 2.013	59,250

The low absorption shown by Tennessee marble shows that it is not liable to stain from coloring matters brought into contact with it.

There is a wide difference in price between the marble devoted to building purposes and that suitable for fine interior work or monumental purposes.

Material which is taken out in blocks too small to saw goes to the dump unless utilized for building, burning into lime, road metal, or railroad ballast. These blocks are just as well adapted to outside building as any of the material taken from the quarry, and consequently building marble may be sold at a low figure and is thus able to compete on the basis of price with comparatively inferior kinds of stone. There seems to be no good reason why Tennessee marble should not achieve success in its application as a building stone in competition with marble from other localities which devote the bulk of their output to outside building.

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Production in 1896 amounted to a valuation of $381,373; this figure is a gain of $19,096 over 1895. About half of this valuation represents stone sold in the rough. The purposes for which the stone thus sold was used can not be certainly ascertained, but doubtless much of it was applied to building. It seems reasonable to expect that in the course of a few years Tennessee marble will have become generally known as a building stone.

Vermont.—The value of the marble output in 1896 was $1,101,557; the figure for 1895 was $1,321,598. It is evident that there has been a decline, but as decrease in production of almost everything in the line of mineral products for the last few years has been the rule, this result in the case of marble will cause no surprise.

Of the total output, 60 per cent was devoted to cemetery work, while the remainder was divided between what was sold "in the rough," for "building," for "interior decoration," and for "ornamental work."

The marble of Vermont covers a wide range of qualities, from fine statuary marble to grades sold only for outside building. That produced at West Rutland and in its vicinity is as yet without a peer in the United States for the finest uses to which marble is applied, and it supplies a large proportion of the stock used for cemetery work in the United States. Much is said from time to time in regard to new discoveries of "fine statuary marble" in one locality or another in the United States, but to find an outcropping of good white marble is one thing, and to prove that the marble is obtainable in large quantities, free from serious flaws, and susceptible of fairly economical quarrying, is another. Marble can hardly be said to have been discovered until much money has been spent in opening it up so as to reveal the character of that beneath the surface as well as its probable extent and accessibility. To make a success of marble quarrying means compliance with a variety of conditions, many of which are problematical at the outset and can only be ascertained at the expense of time and money.

Vermont is likely to remain in first place for production of fine marble for many years to come in spite of claims to superior product which are occasionally made in connection with new discoveries elsewhere. Fine white marble will always be in demand and will always command a high price, both on account of its beauty and its rarity. The increasing use of granite in cemetery work and its competition with marble in this application is discussed elsewhere in this report.

The following tabular statement shows the nature of the successive layers of marble in a quarry at West Rutland:

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Section in marble quarry at West Rutland, Vermont.

	Feet.
Top, blue	20
Top, white	
Green stripe	2
Thin statuary	3–6
Striped monument	2–6
Statuary	3–6
Average layer, half green, half white	4
Brocadilla	2.6–3
Crinkly (siliceous; half light, half dark)	2–3
Light, Smith / Mottled, Smith — Light; nearly pure white.	4–6
Jackman layer (6 in. green striped, 2 ft. 6 in. white)	3
Sherman (half dark green, half white)	3–6
Italian blue	15–20
Mottled limestone, of no value	

The following analyses show the composition of marble quarried at West Rutland and Proctor:

Analyses of marble from West Rutland, Vermont.

	Blue.	White.	Statuary.
	Per cent.	*Per cent.*	*Per cent.*
Insoluble	0.28	0.40	0.70
Carbon dioxide	43.82	43.66	43.65
Lime	55.27	55.26	55.50
Magnesia	.28	.15	Trace.
Iron and alumina	.30	.20	.15
Total	99.95	99.67	100.00

It is interesting to note the slight difference that there is between the blue and the white. The following two additional analyses were made by Mr. J. N. Harris:

Additional analyses of marble from West Rutland, Vermont.

	Blue.	White
	Per cent.	*Per cent.*
Silicate of alumina	0.22	0.62
Carbon dioxide	44.00	43.80
Lime	55.15	54.95
Magnesia	.57	.59
Organic matter	.05	.....
Total	99.99	99.96

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Analysis of marble from Proctor, Vermont.

	Per cent.
Insoluble	0.35
Carbon dioxide	44.02
Lime	55.00
Magnesia	.25
Iron and alumina	.20
Total	99.82

Additional analyses of marble from Proctor, Vermont.

	Light.	Dark.
	Per cent.	*Per cent.*
Calcium carbonate	96.30	98.37
Magnesium carbonate	3.06	.79
Iron carbonate	.053	.034
Insoluble	.63	.63
Organic matter	.004	.08
Manganese oxide	.....	.005
Total	100.047	99.909

NEW DISCOVERIES.

Within the past few years there has been considerable activity among trade journals in calling attention to new discoveries of marble. Unfortunately many of these newly found sources are handicapped by difficulties in transportation. There are many sources of fine marble in the United States which are not utilized simply because the product can not yet be carried to the consumers. This is the case with a number of localities in Virginia and also in Colorado, Utah, and other Western States. It is apparently much more difficult to find ways and means of carrying marble from known sources hitherto unworked than to find still more new sources subject to the same limitations in regard to transportation. Considerable expense is involved in opening up a marble quarry and in demonstrating the applicability of the product to one or another of the various uses to which marble is applied. A certain amount of such pioneer work must, however, be done before a railroad company will extend its lines to accommodate the new enterprise, which must be able to show not only a product of fine quality but in large quantity as well. Unqualified success has attended the marble operations of Vermont, Tennessee, New York, and Georgia quarries, but much money and time have been expended in making these regions what they are to-day. Numerous financial failures mark the progress

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which has been made in these States, and the progress made by the successful has been attained by dint of expert knowledge of marble quarrying, unlimited perseverance, and ability to command the investment of money. Marble quarrying seems to have for the uninitiated the same kind of attraction in less degree that gold mining presents. The discovery of a new source of marble is very apt to be looked upon as inevitably meaning a large fortune for someone. While in former times there may have been good reason for such an attitude toward the production of marble, it is certainly not so justifiable at present, when prices for finished stock have been declining, and where success depends more and more upon financial resources, knowledge of quarrying and manufacturing, and the ability to command good transportation facilities.

Arizona.—White and colored marbles have been found in the Santa Rita Mountains in Arizona. The Tucson Marble Works, of Tucson, expect to operate quarries in this deposit.

Idaho.—Mr. R. S. Spence, of Paris, Idaho, has furnished the following information in regard to newly discovered marble in the vicinity of Paris:

The deposit is of large extent, varying in quality in different localities, and also in color. The colors are jet black, black with streaks of white, black and red, black and gold, and dark blue with gold markings. In one place a vein of onyx, 20 feet wide, runs through the mass. Blocks of any desirable size may be obtained, and apparently without flaw. Abundant water power is at hand. Efforts are being made to develop the property.

Massachusetts.—A combination of serpentine and marble, known as serpentine marble, occurring at Westfield, Mass., has been investigated and described by Prof. W. O. Crosby, of the Massachusetts Institute of Technology. The material is in possession of the Westfield Marble and Sandstone Company, of Westfield. The following is an abstract of Professor Crosby's report. The marble outcrops on one of the higher terraces on the south side of Little River, in the vicinity of West Parish, and only a short distance west of the boundary between the Triassic sandstone formation and the crystalline schists and granite. The deposit is closely parallel with the inclosing schists trending north-south with a vertical dip, and it is, mainly at least, of the same geologic age.

The deposit divides naturally into two parts, which are very distinct in character and origin:

1. A dike, nearly 50 feet wide, of dark-green to black serpentine.

2. On the east side of the serpentine dike, and in close contact with it, is a bed, some 75 feet thick, of gray to white crystalline marble, which is serpentine throughout. This bed of marble was originally a bed of impure limestone. During the metamorphism of the rocks of this region the limestone was changed to marble, and its impurities crystallized in the forms, chiefly, of tremolite (white) in the western

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part of the bed, and actinolite (green) in the eastern part. The tremolite was very finely and the actinolite rather coarsely crystalline, in slender prismatic forms. The great dike of serpentine must have been originally a very coarsely crystalline basic rock, consisting largely of hypersthene or some related mineral. During the alteration of the dike to serpentine the tremolite and actinolite in the adjoining bed of marble have also been changed to serpentine, the former largely and the latter almost wholly. The first process of metamorphism changed the original limestone into an ordinary gray marble, similar to that of scores of other deposits throughout New England; but the second process of metamorphism, when the accessory tremolite and actinolite were serpentinized, has added great interest, beauty, and value to the deposit, and given it a highly unique character.

The quarry which has been opened in the marble gives the following section, from west to east:

Section of a marble deposit at Westfield, Massachusetts.

	Feet.
1. Massive black and green serpentine (dike)	45
2. Finely crystalline white tremolite	5
3. Serpentinic and laminated gray marble (verd antique), with several thin partings of shaly material, about	11
4. Serpentinic gray marble (verd antique), not so much laminated and without definite partings	39
5. Massive serpentinic marble (spangled)	23
Total	123

In the quarry, the western border of the deposit appears to lie directly against a solid vertical wall of schist and coarse granite (pegmatite), which would be a very favorable condition in deep working. But on the east side there are several alternations of soapstone and actinolite with schist and pegmatite for a breadth of about 25 feet before the solid formation of schist and pegmatite is reached.

With the exception of the bed of tremolite (No. 2) and the shaly partings in No. 3, the entire section, aggregating fully 115 feet, is valuable marble. The most remarkable feature of this deposit is the fact that it embraces three entirely distinct varieties of serpentinic marble, each of great beauty and interest, and each forming a solid bed of ample thickness for convenient and economic working. These varieties are:

1. Massive black and green serpentine, forming the great dike, 45 feet thick, on the west side of the quarry.

2. Variegated or veined and mottled gray and green verd antique, 50 feet thick.

3. Massive black and gray spangled marble, 23 feet thick.

1. Massive black and green serpentine marble. This variety would be a valuable marble, even if it were simply a plain black; but its beauty and interest are greatly enhanced by the bright green spots or ocelli of marmolite (a foliated form of serpentine). These vary in diameter from about one-fourth to three-fourths of an inch, being smallest

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and most irregular near the borders of the dike. This marble polishes well, and it is not only strikingly rich and handsome, but is practically unique, being matched by no marble now in use. Furthermore, this dike of serpentine is thoroughly massive and solid in structure, so that blocks of almost any form or size can readily be obtained, and it is so free from the flaws and blind seams which are the bane of most serpentine marbles that it can be safely worked and used in almost any form, from thick columns to thin slabs. It will probably be found best adapted, however, for columns, pilasters, pedestals, etc. Its appearance in the natural ledges and bowlders is so sound and satisfactory that the writer is led to believe that it will also give good results in exterior work, although that is a crucial test for a serpentinic marble.

2. Laminated gray and green verd antique marble. This bed has a total thickness of about 50 feet, and the structure throughout is distinctly laminated or stratified in vertical north-south planes. The laminæ are thinnest in the western part of the bed, and, as already noted, several thin layers in the western quarter of the bed are of a somewhat shaly character. But the eastern three-quarters seems to be quite solid, so that sound blocks of almost any desired size can probably be obtained. This variety consists of a crystalline light-gray to white dolomite marble, mottled, clouded, and veined with light and dark green serpentine. When viewed edgewise it can be seen that the serpentine is to a large extent interlaminated in thin layers or patches with the dolomite, giving rise to a more or less distinct striping or banding, which must prove an attractive feature of the marble. But on surfaces parallel with the lamination it presents instead, as noted, mottled, clouded, and veined effects in endless variety and marked beauty. The colors, though bright, are soft and blending. This marble, like the others, can be used successfully in any form, but the writer anticipates that it will be wanted chiefly in the form of slabs for interior work, and then a choice will be presented between the laminated or banded and the mottled or veined verd antique. This marble resembles very closely certain phases of the celebrated Connemara marble of Ireland, but it is in the writer's opinion superior to the foreign marble in both strength and beauty.

3. Massive black and gray spangled marble. This marble is the most unique of all. The matrix or body is the same crystalline light-gray to white dolomite as in the second variety, except that the structure is in the main very massive and not distinctly laminated. This gray base or ground was originally thickly set or completely spangled with slender crystals of actinolite from 2 to 5 inches long, which are now all changed to black serpentine. Although distinctly green tints are wanting, this marble belongs, in competition, with the verd antiques. It is not unlike in general effect some of the black and white breccia marble, but spangled marble best expresses its most characteristic feature. The serpentine crystals (pseudomorphs) are set at all angles, and so closely as to form in general a complete network. But sometimes a marked

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radial symmetry may be observed, and other interesting and beautiful figures. This marble, like both the others, takes an excellent polish, and its strength and massive character render it available for use in all forms, from columns a yard in diameter to the thinnest slabs. In fact, it is so free from joints and seams that blocks of any size up to the full width of the bed (23 feet) can be obtained.

The massive black and green serpentine marble is essentially pure serpentine (hydrous silicate of magnesia), and certainly contains no ingredient which would be likely on exposure to prove detrimental to its appearance or durability. The verd antique and spangled marbles are more variable in composition, since they are mixtures, in constantly varying proportions, of serpentine and gray marble. This gray base or matrix appears to be the same for both varieties, and the fairest way of getting at the composition of these varieties seemed to be to select for analysis a sample of the gray matrix as free as possible from serpentine. The appended analysis, made by Prof. Arthur A. Noyes at the Massachusetts Institute of Technology, shows that these marbles, apart from the serpentine, are nearly pure dolomites, and especially that they are practically free from deleterious ingredients. In other words, as regards composition, they are ideal serpentinic marbles.

Analysis of marble from Westfield, Massachusetts.

	Per cent.
Water	0.00
Silica and silicate	.20
Ferrous oxide	.41
Calcium oxide	32.77
Magnesium oxide	19.68
Carbon dioxide	46.91
Total	99.97

The following tests of the marble were made by Maj. J. W. Reilly, at the Watertown Arsenal. The compressed surfaces were faced with plaster of paris.

Compressive strength tests of Westfield marble.

No. of test.	Dimensions.			Sectional area.	First crack.	Ultimate strength.	
	Height.	Compressed surface.				Total.	Per square inch.
	Inches.	*Inches.*	*Inches.*	*Sq. ins.*	*Pounds.*	*Pounds.*	*Pounds.*
8779	4.05	3.73	5.60	20.89	412,000	455,800	21,820
8780	9.75	3.57	3.24	11.57	139,900	139,900	12,090

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Along the north side of the quarry a mass of pegmatite partly cuts off the marble, and 250 feet south of this line a narrower mass of pegmatite divides the marble into two belts for a short distance. Between these two masses of pegmatite there is a clear body of marble 100 to 125 feet wide and 250 feet long, and this is fully exposed in the quarry for its entire breadth and about one-third of its length. Assuming an average width of only 100 feet, it is found that this body of marble contains, for every hundred feet in depth, 250 by 100 by 100 = 2,500,000 cubic feet. This amount may be regarded as reasonably certain or "in sight;" and all the geological conditions indicate an indefinite extension downward, probably hundreds of feet. The dike of black serpentine, as already noted, has been traced for a long distance north and south, but how far it is characterized by the bright green ocelli of marmolite remains to be proved. This attractive feature has nowhere been observed outside of the quarry, and, of course, its persistence in depth is not known. It can only be stated positively now that a large body of it is in sight, and that its indefinite extension downward is a fair assumption.

Utah.—The Hobble Creek Marble Company has secured 840 acres of marble property, situated at Springville, Utah County, about 8 miles from the Rio Grande, Western, and Union Pacific railways. The stone is described by Mr. Don C. Robbins as a chocolate-brown colored material containing crystals of calcite scattered through it, making a highly ornamental stone. The wagon road to the railroad is said to be an easy down grade, thus facilitating transportation to the railroad. Quarrying may be done to some extent without stripping.

The following information was furnished by Mr. J. E. Talmage, who examined the marble in the interest of the company:

The stone is a variety of concretionary limestone, and consists of a great number of concretions or nodules, globular and ellipsoidal, held together by calcareous cement. The nodules vary greatly in size, some being smaller than peas and others from 4 to 5 inches in diameter. The nodules are of a well-defined concretionary structure and in many cases show the nuclei about which the concretions have gathered. In a few instances well-preserved fossil shells are seen to form the nuclei, while in other instances the nucleus is nothing more than a grain of sand or a particle of other foreign matter not recognizable by the unaided vision. The concretions are sometimes found separate from the mass of pebbles, which, when cut, show a concretionary structure to perfection. An analysis made of one of these isolated concretions showed that 89.34 per cent of the material is calcium carbonate. The separate concretions and the massive stones are susceptible of a very high polish, and in a polished condition present a very beautiful appearance. The stone is comparatively free from ingredients such as would interfere with use for ornamental and building purposes, and is considered to be well adapted to such uses. It is of medium hardness, and therefore the

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labor of cutting and polishing will not be great; on the other hand, it is sufficiently hard to resist ordinary causes of injury. The stone occurs in extensive, well-defined ledges, compact, and while varying greatly in appearance, owing to the unequal distribution of the concretions, the formation affords very large masses of comparatively homogeneous material. The supply is practically inexhaustible, while the ready accessibility of the deposit and its proximity to a railway promise great results from an intelligent working of the formation.

West Virginia.—Marble has been discovered in Pocahontas County, West Virginia. The stone is in part dove colored, white mottled, and with dark veins. Variegated stone is also abundant, running from red to maroon. The stone is fossiliferous in character so far as the examination has gone, but as yet no cores running to considerable depth have been reported upon. Five or 6 miles are exposed to view and covered by little débris; the bed is said to be 40 feet thick and nearly horizontal. The property has been examined by Mr. George C. Underhill, a marble expert of Rutland, Vermont. As seems to be generally the case with a newly discovered marble bed, railroad facilities are lacking.

SLATE.

The following table shows the output of roofing and milled slate in 1896:

Value of slate product in 1896, by States.

State.	Roofing slate.		Other purposes, value.	Total value.
	Squares.	Value.		
Georgia	4,597	$20,388	.....	$20,388
Maine	23,078	99,831	$24,255	124,086
Maryland	15,557	70,194	1,948	72,142
Massachusetts	.....	.....	1,200	1,200
New Jersey	200	700	.....	700
New York	16,002	78,612	3,880	82,492
Pennsylvania	431,324	1,391,539	334,779	1,726,318
Tennessee	160	640	780	1,420
Vermont	155,523	509,681	99,915	609,596
Virginia	26,863	92,163	15,700	107,863
Total	673,304	2,263,748	482,457	2,746,205

A comparison of these figures with the corresponding totals for 1895 shows a gain of $47,505 in value of total output, a gain of $135,266 in the value of milled stock, a loss of $87,761 in the value of roofing slate, and a loss of 56,623 squares of roofing slate.

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The following table shows the average value of roofing slate per square since 1890:

Average annual price per square of roofing slate for the entire country.

1890	$3.34	1894	$3.11
1891	3.49	1895	3.23
1892	3.56	1896	3.36
1893	3.55		

The price per square has evidently risen about as much above that for 1895 as the latter exceeds the figure for 1894.

The industry as a whole has done exceedingly well considering the persistence of hard times. This would not have been the case had it not been for the appearance of what to all practical purposes is a new feature in the slate industry, namely the export trade. Attention was attracted to the export movement in the early part of the year, but its activity increased until in July some notably large shipments were made to England, Germany, and other countries. Much of the slate sent to England was reshipped to Australia and South America.

This roundabout way of reaching the consumers in the last-named countries has been quite freely discussed in some of the trade journals, and the advisability of dealing direct with the foreign users of slate is so apparent that it is not unreasonable to look for a readjustment of trade relations by which so much unnecessary transportation of the slate may be avoided. Exportations have not been confined to roofing slate, but have included blackboards in notable quantity and to some extent other milled products.

The cause of this rather sudden advance in exportation is in part the labor troubles and strike among the slate quarrymen of Wales. As a result of partial suspension of work in the Welsh quarries and their consequent inability to fill orders, the United States consuls in foreign parts were in a few instances called upon early in 1896 to furnish lists of United States slate exporters. As a result negotiations with American producers were soon under way, agents being sent abroad to receive orders, while foreign purchasers from England, Wales, and Germany made their appearance in our own slate markets. Our slate seems to have given satisfaction abroad, and the troubles at the Welsh quarries have given producers in this country such an opportunity to display their products and secure trade as might have been much longer withheld under normal conditions. It is to be hoped that the trade thus secured by reason of temporary conditions may be held by virtue of the quality of our product and the business enterprise and sagacity of our producers.

Some difficulty with steamship companies on the question of privilege to ship slate in bulk rather than in crates was at first experienced, but this was finally overcome. The expense of crating was a very serious item and had been almost prohibitory to exportation, so that the advantage of shipment in bulk is one of considerable moment.

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The following table shows the value of the production of slate, by States, during the years 1890 to 1896, inclusive:

Value of slate, by States, from 1890 to 1896.

State.	1890.			
	Roofing slate.	Value.	Other purposes than roofing, value.	Total value.
	Squares.			
California	3,104	$18,089	.....	$18,089
Georgia	3,050	14,850	$480	15,330
Maine	41,000	201,500	18,000	219,500
Maryland	23,099	105,745	4,263	110,008
New Jersey	2,700	9,675	1,250	10,925
New York	16,767	81,726	44,877	126,603
Pennsylvania	476,038	1,641,003	370,723	2,011,726
Vermont	236,350	596,997	245,016	842,013
Virginia	30,457	113,079	.....	113,079
Other States[a]	3,060	15,240	.....	15,240
Total	835,625	2,797,904	684,609	3,482,513

State.	1891.			
	Roofing slate.	Value.	Other purposes than roofing, value.	Total value.
	Squares.			
Arkansas	120	$480	.....	$480
California	4,000	24,000	.....	24,000
Georgia	3,000	13,500	.....	13,500
Maine	50,000	250,000	.....	250,000
Maryland	25,166	123,425	$2,000	125,425
New Jersey	2,500	10,000	.....	10,000
New York	17,000	136,000	40,000	176,000
Pennsylvania	507,824	1,741,836	401,069	2,142,905
Vermont	247,643	698,350	257,267	955,617
Virginia	36,059	127,819	.....	127,819
Other States[a]	.....	.....	.....	.....
Total	893,312	3,125,410	700,336	3,825,746

[a] Includes Arkansas, Michigan, and Utah.

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Value of slate, by States, from 1890 to 1896—Continued.

State.	1892.			
	Roofing slate.	Value.	Other purposes than roofing, value.	Total value.
	Squares.			
California	3,500	$21,000	.....	$21,000
Georgia	2,500	10,625	.....	10,625
Maine	50,000	250,000	.....	250,000
Maryland	24,000	114,000	$2,500	116,500
New Jersey	3,000	12,000	.....	12,000
New York	20,000	160,000	50,000	210,000
Pennsylvania	550,000	1,925,000	408,000	2,333,000
Vermont	260,000	754,000	260,000	1,014,000
Virginia	40,000	150,000	.....	150,000
Total	953,000	3,396,625	720,500	4,117,125

State.	1893.			
	Roofing slate.	Value.	Other purposes than roofing, value.	Total value.
	Squares.			
Georgia	2,500	$11,250	.....	$11,250
Maine	18,184	124,200	$15,000	139,200
Maryland	7,422	37,884	.....	37,884
New Jersey	900	3,653	.....	3,653
New York	69,640	204,776	206	204,982
Pennsylvania	364,051	1,314,451	157,824	1,472,275
Utah	75	450	400	850
Vermont	132,061	407,538	128,194	535,732
Virginia	27,106	104,847	12,500	117,347
Total	621,939	2,209,049	314,124	2,523,173

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Value of slate, by States, from 1890 to 1896—Continued.

State.	1894.			
	Roofing slate.	Value.	Other purposes than roofing, value.	Total value.
	Squares.			
California	900	$5,850	.....	$5,850
Georgia	5,000	22,500	.....	22,500
Maine	24,690	123,937	$22,901	146,838
Maryland	39,460	150,568	2,500	153,068
New Jersey	375	1,050	.....	1,050
New York	7,955	42,092	2,450	44,542
Pennsylvania	411,550	1,380,430	239,728	1,620,158
Vermont	214,337	455,860	202,307	658,167
Virginia	33,955	118,851	19,300	138,151
Total	738,222	2,301,138	489,186	2,790,324

State.	1895.			
	Roofing slate.	Value.	Other purposes than roofing, value.	Total value.
	Squares.			
California	1,500	$10,500	.....	$10,500
Georgia	2,500	10,675	.....	10,675
Maine	23,774	118,791	$21,363	140,154
Maryland	13,188	59,157	1,200	60,357
New Jersey	200	700	.....	700
New York	13,624	90,150	1,725	91,875
Pennsylvania	426,687	1,437,697	210,054	1,647,751
Vermont	221,359	531,482	93,849	625,331
Virginia	27,095	92,357	19,000	111,357
Total	729,927	2,351,509	347,191	2,698,700

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Value of slate, by States, from 1890 to 1896—Continued.

State.	1896.			
	Roofing slate.	Value.	Other purposes than roofing, value.	Total value.
	Squares.			
Georgia	4,597	$20,388	.....	$20,388
Maine	23,078	99,831	$24,255	124,086
Maryland	15,557	70,194	1,948	72,142
Massachusetts	.....	.....	1,200	1,200
New Jersey	200	700	.....	700
New York	16,002	78,612	3,880	82,492
Pennsylvania	431,324	1,391,539	334,779	1,726,318
Tennessee	160	640	780	1,420
Vermont	155,523	509,681	99,915	609,596
Virginia	26,863	92,163	15,700	107,863
Total	673,304	2,263,748	482,457	2,746,205

THE SLATE INDUSTRY IN THE VARIOUS STATES.

California.—The slate quarries of this State were shut down for the entire year on account of a lack of demand. Revival of general prosperity will doubtless result in a resumption of productive operations. The slate is of good quality, but has to compete with the excellent redwood shingles of the State, and naturally in hard times the cheaper material prevails. The producers state that they expect to operate during 1897.

Georgia.—The output in Georgia is an increase over that of 1895. A new firm, or rather an old one revived, will in 1897 add its efforts to those of the already existing concerns. The average price per square increased from $4.27 in 1895 to $4.43 in 1896.

The following is an analysis of Georgia slate, from the quarry of the Georgia Slate Company, at Rockmart, made by Messrs. J. W. Slocum and H. H. Van Deventer, of Knoxville, Tennessee.

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Analysis of Rockmart slate.

	Per cent.		Per cent.
Silica	58.20	Carbonic acid	.60
Alumina	18.83	Sulphur	.49
Protoxide of iron	5.78	Water	4.07
Lime	4.35	Titanic acid	.10
Magnesia	3.51	Lithia	.02
Potassium oxide	2.51	Oxide of manganese	Trace.
Sodium oxide	.69	Total	99.97
Carbon	.82		

If all that is now contemplated in the way of developing the Rockmart slate is actually carried out, the industry in this State should make itself felt over a much wider area of the country than it affects at present. Sixty thousand dollars have already been invested in one of the enterprises, resulting in thoroughly stripping the face of one of the older quarries, which is in condition now to yield slate without much more preliminary work. Preparations for the erection of a mill for making switch boards are under way. It is claimed, as the result of tests made at Columbia College, New York, that Georgia slate is excellent in its nonconducting power for electricity, and is therefore valuable for the manufacture of switch boards. A comparison of the results of chemical analyses of Georgia and Peach Bottom slates shows them to be quite similar in composition.

Maine.—Operations in Maine were less active than in the preceding year. The slate of this State is of fine quality and always commands a good price.

Maryland.—The output shows a slight increase in amount and in average value per square. This was $4.48 in 1895 and $4.51 in 1896. All the Maryland slate comes from the northern part of Harford County, and the quarries are all in what is known as the Peach Bottom region, which extends into York County, Pennsylvania.

The following analysis was made by Messrs. Booth, Garrett, and Blair, of Philadelphia:

Analysis of the Peach Bottom slate.

	Per cent.		Per cent.
Silica	58.370	Carbonic acid	.390
Protoxide of iron	10.661	Carbon	.930
Alumina	21.985	Water	4.030
Lime	.300	Titanic acid	Trace.
Magnesia	1.203	Oxide of manganese	Trace.
Alkali	1.933	Total	99.909
Sulphur	.107		

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The following test was made by Prof. L. E. Reber, of State College, Pennsylvania:

The first specimen, with pressure applied parallel to natural cleavage, fractured at 22,000 pounds and crushed at 48,200 pounds.

Second specimen, pressure applied perpendicular to the natural cleavage, fractured at 41,000 pounds and crushed at 94,800 pounds. The first specimen crushed at 385.6 tons per square foot. The second specimen crushed at 758.4 tons per square foot. The specimens used were 3-inch cubes.

At the end of the present chapter on slate will be found an abstract of a paper by Prof. Mansfield Merriman, of Lehigh, read before a meeting of the American Society of Civil Engineers on December 19, 1894. In this paper valuable data on slates of Cambrian and Silurian origin are presented. Peach Bottom slate is taken as typical of Cambrian slate, and the reader is therefore referred to this abstract for additional data respecting Maryland slate.

Massachusetts.—This State makes its first appearance in these reports as a slate-producing State, although the existence of slate within its borders has long been known, and small amounts of slate have been produced from time to time within recent years.

The following is a statement of the results of analysis of slate from Lancaster, Worcester County:

Analysis of Worcester County slate.

	Per cent.
Silica, SiO_2	60.80
Alumina, Al_2O_3	22.00
Magnesia, MgO	.70
Ferric oxide, Fe_2O_3	10.50
Water	1.80
Calcium oxide, CaO	.50
Potassium oxide, K_2O	1.50
Sodium oxide, Na_2O	.80
Carbon	.80
Total	99.40

Minnesota.—This State does not appear in the tables as producing slate and as yet it produces none, but good material has been found in Carlton County and is now being investigated, with favorable results so far as experiments have gone. About 200 squares have been disposed of locally. A sample examined by the writer shows excellent cleavage and permanent color. Cleavage is nearly vertical. Ribbons occur in the surface slate, but disappear with increasing depth. The slate is adapted to blackboard use as well as to roofing. Transportation

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facilities are at hand, and there is no reason thus far apparent why quarrying operations in times of average prosperity should not be profitable.

New Jersey.—The New Jersey slate is a continuation of the Pennsylvania slate belt, and the quarries are not far from the State line. As is evident from the tables, but little has been done during the past year.

New York.—The slate output of New York is of special interest, because it includes the only cherry-red slate produced in the United States. On account of its unique color and its scarcity, even in New York State, it commands the highest price of any of the slates in the United States. The total value of the output in 1896 was $82,492. Of this amount $78,612 represented the value of 16,002 squares of roofing slate; 7,502 squares were of red slate, valued at $57,412, and the remainder was purple or green slate of the same general character as much of the slate quarried in Vermont.

The following data relative to New York and Vermont slate are of interest and were the result of experiments by Mr. J. Francis Williams, C. E. One-inch cubes were used.

Compressive and flexural tests of New York and Vermont slates, in pounds per inch.

	Purple.	Red.	Green.
Compressive strength, wood cushions	19,380	14,170	13,140
Compressive strength, pasteboard cushions	27,760	18,110	17,560
Compressive strength, no cushions	13,860	10,190	8,040
Elastic limit, no cushions	10,260	4,850	5,150
Modulus of rupture	10,800	7,310	8,840

Pennsylvania.—Pennsylvania produced slate amounting to about 63 per cent of the total output of the whole country. An increase in product over 1895 is evident from the tables.

The following table shows the distribution of the output among the various productive counties:

Output of slate in Pennsylvania in 1896, by counties.

County.	Roofing slate.	Value.	Other purposes, value.	Total value.
	Squares.			
Carbon	4,000	$12,000	.....	$12,000
Lehigh	103,955	350,020	$153,948	503,968
Northampton	317,842	1,005,281	180,831	1,186,112
York	5,527	24,238	.....	24,238
Total	431,321	1,391,539	334,779	1,726,318

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A quite decided advance in the production of milled stock is apparent, as are also the effects of the increased export trade; in fact, but for this there would have been a decline in output as compared with 1895. Pennsylvania received most of the benefit of the increased exportation. Replies from many if not a majority of the Pennsylvania producers stated that domestic business was poor. Some, however, claimed that this deficiency was offset by the advance in the export trade. The increase in the production of milled stock is probably due to greater activity in the manufacture of blackboards, which contribute quite materially to the stock exported.

The following is an analysis of Bangor slate by Mr. Henry Leffman, of Philadelphia:

Analysis of Bangor (Northampton County) roofing slate.

	Per cent.
Silica	68.620
Iron oxide	4.200
Alumina	12.680
Calcium carbonate	2.337
Magnesia	3.759
Alkalies	3.730
Moisture and combustible matter	4.470
Total	99.796

Tennessee.—Slate has been known to exist in Tennessee for a long time, but systematic efforts to quarry it are of recent date.

The operated quarries are at Chilhowee, Blount County. The producing firm is the Tennessee Slate Company, with headquarters at Chattanooga. The quarries are at the junction of the Tennessee River and Abrams and Panther creeks. Water power is abundant. Two quarries are in operation, and a mill containing two planers, two saws, and one rubbing bed; facilities will be increased as business expands.

Director Charles D. Walcott, of the United States Geological Survey, has personally studied this locality and says that "when the layers of bedding coincide with those of cleavage the slates are of fine quality, even where the rock is of sufficiently varied composition to produce ribbons. The durability of the material is well shown by the cliffs along the river, which have stood the wear for centuries."

Vermont.—Vermont stands second in output of slate, producing a little more than two-thirds as much as Pennsylvania. The export trade benefited Vermont quite materially during the past year, although the total valuation falls below that of 1895. This benefit showed more for milled slate than for roofing. The slate of Vermont differs funda-

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mentally from Pennsylvania slate in color, that of Pennsylvania being black, or nearly so, while the Vermont material is of various shades of purple and green. Recently, however, black slate has been found and is being quarried by the American Black Slate Company, whose quarries and mills are at Benson, Vermont, on Lake Champlain. Future developments of the black slate will be awaited with interest.

Virginia.—The productive quarries are at Arvonia, in Buckingham County. The output in 1896 very nearly equaled that of 1895. Business was best in the early part of the year.

TESTS OF SLATE.

The following is an abstract of a paper by Prof. Mansfield Merriman, of Lehigh. It was read before the meeting of the American Society of Civil Engineers on December 19, 1894. One of the objects of the investigation was to compare slates of Cambrian and Silurian origin by tests upon typical representatives of the two classes. The results are therefore of general as well as of special interest. The material taken as typical Cambrian slate is the Peach Bottom slate of York County, Pennsylvania, and Harford County, Maryland, while the Silurian slate is represented by that from Northampton County, Pennsylvania.

Results of experiments on the Peach Bottom slate are first presented. The specimens were 12 by 24 inches, and varied from 0.21 to 0.29 inch in thickness. For test of strength they were laid on supports 22 inches apart and broken by a load slowly applied in the middle. The modulus of rupture was determined from the formula

$$\text{Mod} = \frac{3 \times \text{breaking load} \times \text{length}}{2 \times \text{width} \times \text{square of thickness.}}$$

Toughness was measured by taking deflection in inches at moment of rupture. The degree of softness was determined by taking the weight abraded by 50 turns of a small grindstone under a constant pressure of 10 pounds. The porosity was determined by taking the percentage of water absorbed in twenty-four hours after drying for the same length of time at 135° F. The test for corrodibility was the percentage of loss of weight after immersion for sixty-three hours in a solution of 98 parts water, 1 part hydrochloric acid, and 1 part sulphuric acid. The color was dark bluish-gray or bluish-black. The texture of the surface was scaly and soapy—less smooth than Northampton varieties. When upturned by flexure the specimens broke square across the grain, without splitting or lamination.

The author states that an examination of these results tends to confirm the conclusions announced in a previous paper—that in general the strongest specimens are the heaviest and softest as well as the least corrodible, although exceptions occur in the case of specimens marked Q_7 and P_2, and the specimens marked with Q's seem more corrodible

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than those marked with P's, though greater in strength. The tests for strength and corrodibility are probably those of greatest value in determining the durability of the slate under actual conditions of service. The test for softness, although a good one for a single lot of specimens, may not serve to fairly compare lots tested at different times, on account of the varying conditions of the grindstone.

The following table shows the results of tests of Peach Bottom roofing slate:

Results of tests of Peach Bottom roofing slate.

Mark of specimens.	Strength—modulus of rupture.	Toughness—ultimate deflection in inches on supports 22 inches apart.	Density—specific gravity.	Softness—grains abraded by 50 turns of a small grindstone.	Porosity—per cent of water absorbed in 24 hours.	Corrodibility—per cent of weight lost in 63 hours in acid solution.
Q_1	11,490	0.32	2.886	69	0.265	0.247
Q_2	12,585	.30	2.907	115	.197	.197
Q_3	8,400	.30	2.900	110	.304	.291
Q_4	13,430	.32	2.893	177	.228	.194
Q_5	8,320	.28	2.900	75	.264	.237
Q_6	12,010	.32	2.918	67	.209	.200
Q_7	14,210	.....	2.890	111	.278	.341
Q_8	13,060	.34	2.902	67	.261	.240
P_1	10,520	.24	2.912	69	.171	.150
P_2	9,360	.20	2.885	53	.143	.226
P_3	10,470	.34	2.858	87	.216	.161
P_4	11,255	.26	2.873	80	.155	.....
Means..	11,260	.293	2.894	90	.224	.226

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The following analyses show the composition of the Peach Bottom slates:

Analysis of Peach Bottom slate by the Pennsylvania Geological Survey in 1877.

	Per cent.
Silicic acid (SiO_2)	55.880
Alumina (Al_2O_3)	21.849
Ferrous oxide (FeO)	9.034
Water (H_2O)	3.385
Potash (K_2O) and Soda (Na_2O)	4.100
Carbon (C)	1.974
Magnesia (MgO)	1.495
Lime (CaO)	.155
Sulphuric oxide (SO_3)	.022
Titanic acid (TiO_2)	1.270
Manganous oxide (MnO)	.586
Iron bisulphide (FeS_2)	.051
Cobaltous oxide (CoO)	Trace.
Total	99.801

Analysis of Peach Bottom slate by Booth, Garrett, and Blair, in 1885.

	Per cent.
Silica	58.370
Alumina	21.985
Protoxide of iron	10.661
Water	4.030
Alkali	1.933
Carbon	.930
Magnesia	1.203
Lime	.300
Sulphur	.107
Titanic acid	Trace.
Oxide of manganese	Trace.
Carbonic acid	.390
Total	99.909

The valuable constituents in slate are the silicates of iron and aluminum, while the injurious constituents are sulphur and the carbonates of lime and magnesia.

The slates of the Cambrian formation are usually better in regard to strength and weathering qualities than those of the Silurian age, the market price of some varieties of the former being, indeed, more than double that of the common kinds of the latter.

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The Northampton slates take a high rank among the Silurian kinds, while the Peach Bottom specimens may be regarded as a good representation of the dark blue Cambrian varieties. The following tabulation, giving the mean results of the series of tests of both, may hence be taken as the best comparison possible at present of the average physical properties and chemical composition of the Silurian and Cambrian dark-colored slates of Pennsylvania:

Table showing relative properties of Silurian and Cambrian slates.

Property.	Measured by—	Silurian.	Cambrian.
Strength	Modulus of rupture in pounds per square inch.	8.480	11.260
Toughness	Ultimate deflection in inches on supports 22 inches apart.	.291	.293
Density	Specific gravity	2.777	2.894
Softness	Grains abraded on grindstone under stated conditions.	.1	.90
Porosity	Per cent of water absorbed in 24 hours.	.104	.224
Corrodibility	Per cent of water lost in acid solution in 63 hours.	.496	.226
Valuable constituents.	Silicates of iron and aluminum, per cent.	81.88	88.89
Injurious constituents.	Sulphur, per cent	.58	.07
	Carbonates of lime and magnesia, per cent.	12.59	3.19

With respect to the relative value of physical tests and chemical analyses, it may be said that while the latter are valuable, the former alone can be regarded as giving authoritative information as to the wear of slate under actual conditions. The strength and weathering qualities of slate or stone depends not merely upon its chemical constituents, but on the manner in which the grains are cemented together. For the determination of this a microscopic inspection is necessary, and in the absence of such the physical tests seem to carry far greater weight than the chemical analyses.

While the preceding methods of testing are readily carried on in the laboratory, they are not easily made under conditions of actual practice, on account of the absence of precise weighing apparatus and the lack of time and skill. It seems desirable that a test for slate should be devised which can be quickly applied by an architect or builder and used with confidence. An impact test made by simply dropping a ball appeared one likely to yield good results, and accordingly a series of experiments has been carried on to determine what can be done in this direction. In connection with these a series of severe acid tests has been made on the same specimens.

Seven varieties of slate were used in these experiments. Four, designated hereafter by the letters C, D, E, and F, were Silurian slates of

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Pennsylvania. Three were Cambrian slates, P and Q being Peach Bottom specimens, and V being a red slate from the New York and Vermont region.

The pieces of slate used in the impact test were 6 by 7¾ inches. Each piece was placed with the ends loosely clamped in grooved supports, so that it was approximately in the condition of a beam with fixed ends, the length between edges of supports being about 7¼ inches and the width 6 inches. A wooden ball weighing 15.7 ounces was dropped upon the middle of the slate from a height of 9 inches and the number of blows required to produce rupture was noted. The number of foot-pounds of work per pound of slate expended in causing rupture is a measure of the ultimate resistance of the material or of its capacity to resist shock, and thus is an index both of its strength and toughness. Five specimens of each kind of slate were thus tested, and the following table gives the individual results and means:

Table showing comparative tests of Silurian and Cambrian slates as to resiliency.

SILURIAN SLATES.

Specimens.	Thickness (inches).	Weight (ounces).	Number of blows.	Foot-pounds of work per pound of slate.
C_1	0.21	13.8	6	5.12
C_2	.19	12.9	4	3.65
C_3	.22	13.8	5	4.27
C_4	.20	12.8	7	6.62
C_5	.23	15.6	10	7.56
Means	.21	13.8	6.4	5.44
D_1	.19	13.0	5	4.53
D_2	.22	14.5	7	5.69
D_4	.19	12.4	3	2.85
D_9	.22	14.8	7	5.58
D_{11}	.24	16.2	6	4.37
Means	.21	14.2	5.6	4.60
E_1	.19	12.4	4	3.63
E_{14}	.20	13.5	2	1.74
E_{18}	.21	13.5	4	3.50
E_{30}	.19	13.0	6	5.44
E_{13}	.22	14.3	5	4.12
Means	.20	13.3	4.2	3.68
F_3	.22	14.4	4	3.27
F_4	.20	13.3	3	2.66
F_6	.22	14.7	5	4.01
F_7	.25	16.5	7	5.00
F_8	.20	13.7	3	2.58
Means	.22	14.5	4.4	3.50

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Table showing comparative tests of Silurian and Cambrian slates as to resiliency—Continued.

CAMBRIAN SLATES.

Specimens.	Thickness (inches).	Weight (ounces).	Number of blows.	Foot-pounds of work per pound of slate.
P_1	0.26	17.3	9	6.13
P_2	.26	17.2	15	10.29
P_3	.31	20.4	55	31.74
P_4	.28	18.4	52	33.35
PP_4	.29	20.4	68	39.33
Means	.28	18.7	39.8	24 17
Q_1	.26	17.2	11	7.54
Q_2	.27	17.8	20	13.25
Q_3	.29	19.3	17	10.39
Q_7	.28	18.2	6	3.89
QQ_7	.28	17.6	11	7.37
Means	.27	18.0	13.0	8.49
V_1	.21	13.0	32	29.04
V_2	.26	17.3	215	146.65
V_3	.21	12.9	339	310.09
V_4	.20	12.9	55	50.31
V_8	.25	14.2	117	97.22
Means	.23	14.1	151.6	126.66

Size of specimen, 6 by $7\frac{3}{4}$ inches.
Weight of ball, 15.7 ounces.
Height of fall, 9 inches.

The acid tests were purposely made severe in order to obtain, if possible, a better idea of the resistance to corrosion than is given by the previous test of sixty-three hours.

Seven jars containing a solution of 1 part of hydrochloric acid, 1 part of sulphuric acid, and 98 parts of water, by weight, were prepared, and two specimens of each variety of slate were immersed in each for one hundred and twenty hours, or five days, the solution being well stirred once a day. The specimens were then taken out, dried for forty hours, weighed, and the loss of original weight determined. The solution was next strengthened by adding the same amount of the two acids, and the specimens were then replaced for another one hundred and twenty hours, after which they were dried and weighed again. The solution was again strengthened by the addition of the same amount of acid, and the specimens were immersed for one hundred and twenty hours, after

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which they were dried and weighed as before. The specimens used for this purpose weighed about 1½ ounces each, and the scales were sufficiently delicate to detect one-half grain. With two exceptions they were parts of the pieces previously broken in the impact tests.

In the following table the percentages of loss of original weight at the end of the three periods are given, the specimens being arranged in order of corrodibility, and also in the last columns the mean foot-pounds of work per pound of slate required to cause rupture by impact and the mean specific gravities. These figures show that the specific gravity is not a good index of corrodibility, but they plainly indicate that the least corrodible slate offers the greatest resistance to impact, although there are slight exceptions in the case of D and E.

Corrodibility tests of slates by immersion in acid solutions.

Specimens.	Percentages of loss of weight.			Foot-pounds of work per pound of slate.	Specific gravity.
	After 120 hours.	After 240 hours.	After 360 hours.		
D_2	1.06	1.94	2.74		
D_9	1.22	1.94	2.79		
Mean	1.14	1.94	2.76	4.6	2.77
F_9	1.08	1.60	2.18		
F_2	1.43	2.47	2.98		
Mean	1.25	2.03	2.58	3.5	2.77
E_{18}	.82	1.36	1.82		
E_{20}	.88	1.48	2.09		
Mean	.85	1.42	1.95	3.7	2.78
C_2	.64	1.28	1.70		
C_5	.54	1.10	1.66		
Mean	.59	1.19	1.68	5.4	2.78
Q_3	.45	.90	1.27		
Q_5	.40	.99	1.32		
Mean	.42	.94	1.29	8.5	2.90
P_3	.32	.81	1.12		
P_4	.28	.93	1.10		
Mean	.30	.87	1.11	24.2	2.89
V_4	.00	.17	.34		
V_5	.00	.09	.17		
Mean	.00	.13	.25	126.7	2.81

With regard to the progress of the corrosion with time, it appears that the two are approximately proportional. A marked change in color of the Silurian specimens was noted, the dark blue becoming a

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grayish white after the last immersion, while but a slight change appeared in Q, and P and V remained almost unaffected. Change in color is thus a direct index of corrodibility, both being due to the same cause.

As the result of the investigations thus far made, it may be concluded that the tests for density and softness, although of importance for slates of the same locality, are not good indications of the strength and weathering qualities of those of different regions; that the tests for porosity, corrodibility, and flexual strength give good indications of these properties; that the results found for strength and corrodibility when mentally combined give, on the whole, an excellent idea of the value of the slate; and that an impact test with a wooden ball shows both strength and toughness, while it at the same time indicates the capacity for resistance to corrosion. The impact test may be therefore recommended, if only a single test is to be used, as one that can be quickly and cheaply made, and one likely to give reliable information of the comparative value of different kinds of slate.

The following matter of interest in connection with the Welsh slate quarries is taken from the American Slate Trade Journal, Bangor, Pennsylvania, issue of March, 1897.

WELSH SLATE QUARRIES.

English slates, instead of being sold by the square, are sold by the "mille," contracted into "M," which is in reality 1,200 slates. To this number is added 5 per cent for breakage, giving a standard unit of slate of 1,260 pieces. This standard is practically the one adopted in all foreign countries, and it becomes necessary for American quarrymen and dealers to familiarize themselves with this unit in order to do foreign trade.

A few of the principal sizes of slates, and the equivalent in squares of 1,260 pieces of each size, are as follows:

Principal sizes of slate in Wales.

20 × 10, M = 7 squares 43 feet.
24 × 12, M = 11 squares 3 feet.
24 × 14, M = 12 squares 86 feet.
22 × 12, M = 9 squares 97 feet.
22 × 11, M = 9 squares 15 feet.
18 × 10, M = 6 squares 56 feet.
18 × 9, M = 5 squares 91 feet.

Two of the largest slate quarries in the world are near Bangor, North Wales, and are the properties of Lord Penrhyn and George William Duff-Asheton Smith. The product of these two quarries is of excellent quality and of several colors. The quarries of North Wales yield in the aggregate something like 500,000 tons annually. There is but one slate-yielding district in Great Britain that may fairly claim distinction, i. e., the Westmoreland and Cumberland districts.

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The total output of slate from the quarries in the United Kingdom for the last five years, up to and including 1895, is as follows:

Total output of slate in Great Britain, 1891 to 1895.

Year.	Tons.	Value.
1891	415,029	£987,000
1892	418,241	1,025,922
1893	438,993	1,107,626
1894	461,673	1,171,366
1895	581,760	1,274,146

North Wales furnishes the bulk of this, two-thirds of it from open quarries and the remaining one-third from mines or true underground excavations. Of the 581,760 tons produced during 1895, 429,419 tons came from quarries and 152,341 tons from mines. The production from quarries during 1895 of 429,419 tons was made up as follows:

Distribution of the quarry product of slate in 1895.

	Tons.
Wales	288,000
England	76,322
Scotland	43,886
Ireland	10,848
Isle of Man	10,363
Total	429,419

The bulk came from Wales, and out of the total of 288,000 tons 258,587 tons are produced in Carnarvonshire alone. Most of this comes from the Penrhyn quarry, the output from which in 1895 was about 100,000 tons, and the Dinorwic quarry, which produced the same year some 80,000 tons.

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The imports of foreign slates during 1895 were as follows:

Imports of slate into Great Britain in 1895.

Country.	Quantity, in number of slates.	Value.
France	8,332,065	£33,074
Belgium	4,586,114	21,907
United States of America	1,587,810	11,206
Portugal	1,177,320	5,496
Holland	2,880	6
Total	15,686,189	71,689

The exports during 1895 were of the value of £176,023, and were distributed as follows:

Exports of slate from Great Britain in 1895.

Country.	Number of slates.
Germany	22,727,000
Denmark	2,323,300
Austria	1,195,200
Australasia	832,800
British South Africa	774,500
Belgium	559,500
Channel Islands	561,900
France	448,900
Argentine Republic	227,300
British Uruguay	209,500
British North America	64,500
British West Indies	51,400
Miscellaneous	67,500
Total	30,043,300

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The Penrhyn quarry is the largest in the United Kingdom, producing about 120,000 tons of slate annually, besides stripping top rock and rubbish to the extent of 1,500,000 tons per annum. It is situated at Bethesda, near Bangor, and the slates are shipped to Port Penrhyn, which is only a few miles from the quarry, with which it is connected by a private line of railway. This quarry is the property of Lord Penrhyn, and is under the management of Mr. E. A. Young. At the time of writing, however, the quarry is closed in consequence of a general strike of the 3,000 workmen engaged in the quarry, owing to the suspension by the management of 71 men.

SANDSTONE.

The following table shows the output of sandstone in the United States for the year 1896:

Value of the sandstone product in 1896, by States.

State.	Value.	State.	Value.
Alabama	$48,000	Montana	$3,250
Arizona	10,000	New Jersey	126,534
Arkansas	1,400	New York	223,175
California	7,267	North Carolina	13,250
Colorado	58,989	Ohio	1,679,265
Connecticut	426,029	Pennsylvania	446,926
Georgia	1,250	South Dakota	37,077
Idaho	16,060	Tennessee	4,100
Illinois	15,061	Texas	36,000
Indiana	32,847	Utah	7,860
Iowa	12,351	Washington	11,090
Kansas	18,804	West Virginia	24,693
Maryland	10,713	Wisconsin	65,017
Massachusetts	304,361	Wyoming	16,465
Michigan	111,321	Total	4,023,199
Minnesota	202,900		
Missouri	51,144		

The value of the output in 1895 was $4,211,314. It is evident that there has been some falling off during the past year.

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The following table shows the output of sandstone, by years, from 1890 to 1896:

Value of sandstone, by States, from 1890 to 1896.

State.	1890.	1891.	1892.
Alabama	$43,965	$30,000	$32,000
Arizona	9,146	1,000	35,000
Arkansas	25,074	20,000	18,000
California	175,598	100,000	50,000
Colorado	1,224,098	750,000	550,000
Connecticut	920,061	750,000	650,000
Florida	(a)	.....	.....
Georgia	(a)	.....	2,000
Idaho	2,490	.....	3,000
Illinois	17,896	10,000	7,500
Indiana	43,983	90,000	80,000
Iowa	80,251	50,000	25,000
Kansas	149,289	80,000	70,000
Kentucky	117,940	80,000	65,000
Maryland	10,605	10,000	5,000
Massachusetts	649,097	400,000	400,000
Michigan	246,570	275,000	500,000
Minnesota	131,979	290,000	175,000
Missouri	155,557	100,000	125,000
Montana	31,648	35,000	35,000
Nevada	(a)	.....	.....
New Hampshire	3,750	.....	.....
New Jersey	597,309	400,000	350,000
New Mexico	186,804	50,000	20,000
New York	702,419	500,000	450,000
North Carolina	12,000	15,000	.....
Ohio	3,046,656	3,200,000	3,300,000
Oregon	8,424	.....	35,000
Pennsylvania	1,609,159	750,000	650,000
Rhode Island	(a)	.....	.....
South Dakota	93,570	25,000	20,000
Tennessee	2,722	.....	.....
Texas	14,651	6,000	48,000
Utah	48,306	36,000	40,000
Vermont	(a)	.....	.....
Virginia	11,500	40,000	.....
Washington	75,936	75,000	75,000
West Virginia	140,687	90,000	85,000
Wisconsin	183,958	417,000	400,000
Wyoming	16,760	25,000	15,000
Total	10,816,057	8,700,000	8,315,500

a Sandstone valued at $26,199 was produced by Rhode Island, Nevada, Vermont, Florida, and Georgia together, and this sum is included in the total.

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Value of sandstone, by States, from 1890 to 1896—Continued.

State.	1893.	1894.	1895.	1896.
Alabama	$5,400	$18,100	$31,930	$48,000
Arizona	46,400	.....	20,000	10,000
Arkansas	3,292	2,365	13,228	1,400
California	26,314	10,087	11,933	7,267
Colorado	126,077	69,105	63,237	58,989
Connecticut	570,346	322,934	397,853	426,029
Florida	.....	.....	.....	.....
Georgia	.....	11,300	.....	1,250
Idaho	2,005	10,529	6,900	16,060
Illinois	16,859	10,732	6,558	15,061
Indiana	20,000	22,120	60,000	32,847
Iowa	18,347	11,639	5,575	12,351
Kansas	24,761	30,265	93,394	18,804
Kentucky	18,000	27,868	25,000	.....
Maryland	360	3,450	16,836	10,713
Massachusetts	223,348	160,231	339,487	304,361
Michigan	75,547	34,066	159,075	111,321
Minnesota	80,296	8,415	74,700	202,900
Missouri	75,701	131,687	100,000	51,144
Montana	42,300	16,500	31,069	3,250
Nevada	.....	.....	.....	.....
New Hampshire	.....	.....	.....	.....
New Jersey	267,514	217,941	111,823	126,534
New Mexico	4,922	300	2,700	.....
New York	415,318	450,992	415,644	223,175
North Carolina	.....	.....	3,500	13,250
Ohio	2,201,932	1,777,034	1,449,659	1,679,265
Oregon	.....	.....	.....	.....
Pennsylvania	622,552	349,787	500,000	446,926
Rhode Island	.....	.....	.....	.....
South Dakota	36,165	9,000	26,100	37,077
Tennessee	.....	.....	.....	4,100
Texas	77,675	62,350	97,336	36,000
Utah	136,462	15,428	5,000	7,860
Vermont	.....	.....	.....	.....
Virginia	3,830	2,258	.....	.....
Washington	15,000	6,611	14,777	11,090
West Virginia	46,135	63,865	40,000	24,693
Wisconsin	92,193	94,888	78,000	65,017
Wyoming	100	4,000	10,000	16,465
Total	5,295,151	3,955,847	4,211,314	4,023,199

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THE SANDSTONE INDUSTRY IN THE VARIOUS STATES.

Arizona.—Arizona seems to have gotten steadily under way as a sandstone-producing State, and in spite of hard times yielded $10,000 worth of product in 1896. That a comparatively new enterprise should have done anything at all last year speaks well for its standing.

The following information was submitted by the Arizona Company, operating quarries at Flagstaff. The crushing-strength tests were made at the navy-yard, Washington, D. C., in June, 1889:

Crushing tests of sandstone from Flagstaff, Arizona.

No.	Dimensions.	Cracked at—	Crushed at—
	Inches.	*Pounds.*	*Pounds.*
1	2.01 x 2.03 x 1.98.....	23,000	23,490
2	2.00 x 2.02 x 2.00.....	24,000	25,110
3	2.00 x 2.01 x 2.01.....	25,000	25,490
4	2.00 x 2.00 x 2.00.....	22,100	22,440

The following analytical results were obtained by Prof. F. W. Clarke, of the United States Geological Survey.

Analysis of sandstone from Flagstaff, Arizona.

	Per cent.
Silica insoluble in acid	79.15
Soluble silica	.04
Alumina (Al_2O_3)	1.30
Ferric oxide (Fe_2O_3)	2.45
Ferrous oxide (FeO)	None.
Lime (CaO)	7.76
Magnesia (MgO)	.23
Carbon dioxide (CO_2)	5.77
Water (H_2O) at 110° C	.32
Water at red heat	2.94
Total	99.96

Specific gravity		2.346
Weight per cubic foot (dry)	pounds..	142
Percentage of water absorbed (saturated)		3.76

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The following information is the result of investigations by Prof. E. W. Hilgard, of the Agricultural Experiment Station, University of California.

Composition of sandstone from Flagstaff, Arizona.

	Per cent
Sand and siliceous cement	71.33
Carbonate of lime	14.63
Crystallized insoluble silicates embedded in cement	8.23
Soluble silicates (zeolites) forming part of cement	2.67
Ferric oxide	2.07
Moisture	.06
Chemically combined water and loss	.07
Total	99.06

The stone in its natural condition, on prolonged immersion, absorbs about 4 per cent of its weight in water. Its base is formed by about 71 per cent of sand consisting of angular grains of quartz and feldspar, cemented by a cement chiefly siliceous, with a small proportion of zeolitic material, which has been subsequently to its formation impregnated with a solution of lime carbonate, the latter now forming nearly 15 per cent of the mass. Its red color is due to a small amount of red oxide of iron (red ocher), unchangeable in color, which has apparently no part in the cement of the stone. On treatment with dilute muriatic acid, the carbonate of lime is dissolved without materially affecting the firmness of the stone, even after remaining in the acid for four days.

On treatment with strong hot muriatic acid for six hours (at steam heat) the stone, though whitened by the solution of the iron oxide and by the partial decomposition of the zeolitic portion of the cement, still retains its form and coherence, although sensibly softened. This stone is a very durable one. From its slight absorption of water it is not liable to be injured even by freezing, and it is certain to endure well in the climate of California, even where, as in cities, the rain water and air may be somewhat acid. The fact that the stone is not dependent upon the carbonate of lime for its coherence, as shown by the above experiments, removes it from the class of calcareous sandstones, properly so called, which almost necessarily disintegrate when subjected to city smoke. Its color is practicably unalterable and is very attractive, as shown in numerous large buildings in Denver and elsewhere.

California.—As is the case with the other varieties of stone in California, but little was done in 1896. Better conditions of trade must exist before any material improvement in the industry can be expected. The output was small and less than in 1895. Sandstone from quarries at Niles, Alameda County, showed as the average result of tests on ten

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samples a crushing strength of 10,000 pounds to the square inch. The tests were made at the University of California.

Colorado.—Production fell off from $63,237 to $58,989 in 1896. In prosperous times Colorado is capable of producing and selling much larger quantities than have been quarried during the past few years. Lack of demand is all that prevents the opening of a number of easily worked quarries.

Connecticut.—The sandstone industry of Connecticut is a very important one. Production increased from a valuation of $397,853 in 1895 to $426,029 in 1896. The most productive quarries are those near Cromwell and Middletown, which are well known and have been productive for many years.

The following results of crushing tests made by Maj. J. W. Reilly, of the Watertown Arsenal, were submitted by the Brainerd, Shaler, and Hall Quarry Company of Portland. They show the resistance to gradually applied pressure, surface faced with plaster of Paris to secure even bearings in the testing machine, pyramidal fractures.

Physical tests of Connecticut sandstone.

Test No.	Marks.	Dimensions.			Sectional area.	First crack.	Ultimate strength.		Classification.
		Height.	Compressed surface.				Total.	Pounds per square inch.	
		Inches.	*Inches.*	*Inches.*	*Sq. in.*	*Pounds.*	*Pounds.*		
7330	No. 1 A	2.50	2.50	2.45	6.13	84,800	85,700	13,980	1st quality.
7331	No. 1 B	2.50	2.48	2.47	6.13	81,700	81,700	13,330	Do.
7332	No. 1 C	2.98	3.00	2.95	8.85	123,200	123,200	13,920	2d quality.
7333	No. 1 D	2.95	2.98	2.97	8.85	122,000	132,950	15,020	3d quality.
7334	No. 2 A	2.51	2.55	2.53	6.45	63,850	63,850	9,900	Bridge.
7335	No. 2 B	2.48	2.48	2.52	6.25	58,340	58,340	9,330	Do.

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The following tests by Mr. Ira H. Woolson, M. E., of the Engineering Department, Columbia College, School of Mines, were made in the latter part of December, 1896. These results were submitted by the Middlesex Quarry Company, of Portland.

Physical tests of Portland sandstone.

	Mark.			
	1.	2.	3.	4.
Test number	1653	1654	1655	1656
How tested	Bed.	Bed.	Bed.	Bed.
Grain	Fine.	Fine.	Fine.	Fine.
Shape of test piece	Cube.	Cube.	Cube.	Cube.
Length or height in inches	3.017	2.982	3.000	3.006
Diameter or breadth in inches	3.017	3.005	3.010	2.983
Thickness in inches	3.019	2.989	3.019	3.015
Area in square inches	9.108	8.981	9.087	8.993
Stress in pounds compression:				
First crack	100,000	94,000	75,200	111,000
Maximum	105,700	94,000	87,500	112,400
Per square inch maximum	11,605	10,466	9,629	12,498

Average resistance, 11,049 pounds per square inch.

Transverse tests.

No. of test.	Distance between end supports.	Dimensions.		Ultimate strength.	
		Breadth.	Depth.	Total.	Modulus of rupture R.
	Inches.	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*
1669	19	3.99	6.00	11,500	2,282
1670	19	4.00	6.00	9,400	1,860
1671	19	4.00	5.99	10,200	2,025
1672	19	3.98	6.00	10,900	2,168

Average modulus of rupture R. 2,084 pounds.

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The following compression and transverse tests were made by Prof. Ira H. Woolson, of New York City:

Additional tests of sandstone from Portland, Connecticut.

	Mark.			
	1.	2.	3.	4.
Test number	1657	1658	1659	1660
How tested	Bed.	Bed.	Bed.	Bed.
Grain	Moderately coarse.	Fine.	Fine.	Very coarse.
Shape of test piece	Cube.	Cube.	Cube.	Cube.
Original dimensions:				
Length or height in inches	3.017	2.977	3.007	3.011
Diameter or breadth in inches	3.004	3.000	3.022	3.014
Thickness in inches	3.007	3.011	3.003	3.005
Area in square inches	9.033	9.033	9.075	9.057
First crack	107,600	98,200	112,400	102,300
Stress in pounds compression:				
Maximum on specimen	110,400	98,200	112,400	102,400
Maximum per square inch	12,221	10,871	12,385	11,306

Transverse tests.

[All tested on edge of grain, or right angled to bed.]

Number of tests.	Distance between end supports.	Dimensions.		Ultimate strength.	
		Breadth.	Depth.	Total.	Modulus of rupture R.
	Inches.	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*
1665	19	4.02	6.01	9,500	1,864
1666	19	3.99	5.98	9,300	1,857
1667	19	4.01	6.00	10,500	2,073
1668	19	4.00	6.01	9,800	1,933

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The following compression and transverse tests of brownstone for the New England Brown Stone Quarries were made by Prof. I. H. Woolson, of New York City:

Physical tests of New England brownstone, Portland, Connecticut.

	Mark.			
	1.	2.	3.	4.
Test number	1649	1650	1651	1652
How tested	Bed.	Bed.	Bed.	Bed.
Grain	Fine.	Fine.	Fine.	Fine.
Shape of test piece	Cube.	Cube.	Cube.	Cube.
Original dimensions:				
Length or height in inches	3.019	3.037	3.021	3.026
Diameter or breadth in inches	3.020	3.010	3.043	3.035
Thickness in inches	2.995	3.035	3.034	3.048
Area in square inches	9.044	9.135	9.232	9.250
First crack	111,800	110,000	117,100	92,400
Stress in pounds—compression:				
Maximum on specimen	117,100	110,000	117,100	98,000
Maximum per square inch	12,947	12,041	12,947	10,594

Transverse tests.

[All tested on edge, at right angles to bed.]

No. of test.	Distance between end supports.	Dimensions.		Ultimate strength.	
		Breadth.	Depth.	Total.	Modulus of rupture R.
	Inches.	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*
1673	19	4.01	5.99	9,900	1,961
1674	19	4.11	6.04	10,400	1,977

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Tabulation and summary of tests made upon Connecticut brownstone.[1]

TESTS FOR RESISTANCE; 3-INCH CUBES.

Stone from—	Number.	Crushed at—	Resistance per square inch.
		Pounds.	*Pounds.*
Brainerd, Shaler & Hall Quarry Co.....	1	110,400	12,221
	2	98,200	10,871
	3	112,400	12,385
	4	102,400	11,306
Middlesex Quarry Co.....	1	105,700	11,605
	2	94,000	10,466
	3	87,500	9,629
	4	112,400	12,498
New England Brown Stone Co.....	1	117,100	12,947
	2	110,000	12,041
	3	117,100	12,947
	4	98,000	10,594

[1] By Prof. Ira H. Woolson, E. M., School of Mines, Columbia University, New York.

Total number of specimens, 12.
Average resistance of the 12 specimens, 11,625.

TRANSVERSE TESTS; SECTIONS 4 BY 6 BY 20 INCHES.

From—	Number.	Ultimate strength.	Modulus of rupture, R.
		Pounds.	*Pounds.*
Brainerd, Shaler & Hall Quarry Co.....	1	9,500	1,864
	2	9,300	1,857
	3	10,500	2,073
	4	9,800	1,933
Middlesex Quarry Co.....	1	11,500	2,282
	2	9,400	1,860
	3	10,200	2,025
	4	10,900	2,168
New England Brown Stone Co.....	1	9,900	1,961
	2	10,400	1,977

Total specimens, 10.
Distance between supports, 19 inches.
Average modulus of rupture R., 2,000 pounds.

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Idaho.—Sandstone is produced near Boise to a limited extent. Production reached a valuation of $16,060 in 1896, an increase over 1895.

Illinois.—The value of the output in 1896 was $15,061, about double the output of 1895. The industry in Illinois has never been large.

Indiana.—The value of the product in 1896 was $32,847; in 1895 it was $60,000. In 1891 the corresponding figure was $90,000. See report for 1895 for detailed information on Indiana sandstone. In addition the following results of investigation by Prof. W. S. Blatchley, State geologist of Indiana, are submitted. The report was made in November, 1895.

Crushing tests of sandstone from Riverside, Indiana.

	Per square inch.
	Pounds.
1. Gray sample	6,000
2. Blue sample	6,090

Chemical analysis of sandstone from Riverside, Indiana.

	Per cent.
Insoluble residue (silica SiO_3)	93.16
Alumina (Al_2O_3)	1.60
Iron oxide (Fe_2O_3)	2.69
Lime (CaO)	.13
Total	97.58

The analysis shows but little material injurious to the durability of the stone. The following are the results of the absorption and fire tests made at the Rose Polytechnic Institute, of Terre Haute, Indiana, on specimens of stone from same quarry:

Each specimen was soaked in water 25 hours, having previously been carefully weighed. It was then removed, wiped dry, and weighed again. The results were as follows:

Bluestone, specimen C: Water absorbed in per cent of dry weight, 6.8 per cent. Specimen C_2: Water absorbed in per cent of dry weight, 4.8 per cent. Graystone, specimen D: Water absorbed in per cent of dry weight, 6.1 per cent. Specimen D_2: Water absorbed in per cent of dry weight, 5.8 per cent.

In fire tests of blue Riverside sandstone the cold specimen and cold lead were placed in crucible and heated until lead would melt on surface of stone; the specimen was then cooled in air. It cracked through center, though pieces did not separate. Specimen No. 2, gray Riverside sandstone, gave the same results as above in every respect.

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Iowa.—A small output was obtained in 1896. The industry is not yet important in this State.

Kansas.—A small quantity of sandstone is annually produced.

Maryland.—A small amount of sandstone is annually produced in Montgomery County.

Massachusetts.—The sandstone output of 1895 amounted to a valuation of $339,487; the figure for 1896 was $304,361. Most of the product comes from quarries at Worcester and East Long Meadow.

Michigan.—The value of the output declined from $159,075 in 1895 to $111,321 in 1896. In prosperous times the output would undoubtedly be much greater, as the sandstone is well known and popular; some of it is quarried for abrasive purposes.

Minnesota.—The production of sandstone in Minnesota has shown a large increase during the past year, namely, from a valuation of $74,700 in 1895 to $202,900 in 1896. This is due to largely increased operations of a few firms in Pine County.

The following is an analysis of the Kettle River sandstone by Prof. N. H. Winchell:

Analysis of Kettle River sandstone.

	Per cent.
Water (H_2O)	0.00
Silica (SiO_2)	98.69
Alumina (Al_2O_3)	1.06
Ferric oxide (Fe_2O_3)	Slight tr.
Lime (CaO)	.42
Magnesia (MgO)	.01
Soda (Na_2O)	.17
Total	100.35

The following crushing tests of the same stone were made at the Watertown Arsenal:

Crushing strength of Kettle River sandstone.

	Total pounds.	Per square inch.
		Pounds.
4-inch cube	204,100	12,295
4-inch cube	109,900	12,799

Missouri.—About half as much quarrying was done in 1896 as in 1895. The value of the output in 1896 was $51,144.

Montana.—Very little was done in 1896.

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New Jersey.—An increase of output characterized the industry in 1896. The value in 1895 was $111,823; in 1896, $126,534. Sandstone from Montclair, New Jersey, is reported to have shown a crushing strength of 23,000 pounds to the square inch.

New York.—The sandstone output was valued at $415,644 in 1895, but the depressed conditions of trade permitted of only $223,175 in 1896. The sandstones of New York enjoy a long-established reputation for their general desirability as building stones.

North Carolina.—Production increased from $3,500 in 1895 to $13,250 in 1896. The following is a statement of the results of an analysis of brownstone from the Aldrich stone quarries at Sanford, North Carolina. The analysis was made by Dr. F. A. Genth, jr.:

Analysis of brown sandstone from Sanford, North Carolina.

	Per cent.
Moisture	0.79
Silica (SiO_2)	81.59
Ferric oxide (Fe_2O_3)	4.38
Alumina (Al_2O_3)	10.81
Magnesia (MgO)	.33
Lime (CaO)	1.02
Potash and soda (K_2O and Na_2O)	1.08
Total	100.00

The greater portion of this rock consists of a hard-grained quartz sand, mixed with silicates not easily acted upon by atmospheric influences.

Sandstone from Moore County has also been analyzed. The following table gives results:

Analysis of sandstone from Moore County, North Carolina.

	Per cent.
Silica (SiO_2)	84.97
Alumina (Al_2O_3)	10.31
Ferric oxide (Fe_2O_3)	1.41
Manganese (MnO_2)	.07
Lime (CaO)	1.05
Magnesia (MgO)	.79
Potash (K_2O)	.24
Combined water	1.15
Total	99.99

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Ohio.—Ohio stands far in the lead of all other States in the production of sandstone. Most of the product comes from quarries in the northern part of the State. The value of the output in 1895 was $1,449,659; in 1896 the value was $1,679,265. It is evident that a very substantial advance was made. Strikes characterized the industry at certain localities during the year. The product is used for building, curbing, flagging, grindstones, and whetstones.

Pennsylvania.—The output of sandstone in 1895 was valued at $500,000; in 1896 the figure was $446,926; a decrease. The following paper by Prof. T. C. Hopkins, of State College, is a valuable contribution to the literature on the subject of sandstones, representing as it does careful and laborious research in connection with this important item of the mineral resources of Pennsylvania.

BROWNSTONES OF PENNSYLVANIA.

By T. C. Hopkins.

Brownstones are among the oldest, best known, and handsomest building stones used in this country. The brownstone fronts of New York and other Eastern cities are found in the most fashionable parts of the cities and in great numbers. It is true that some years ago the use of brownstone was simply fashion, so much so that all the quarries, running to their full capacity, could not supply the demand. As a result there are long blocks of gloomy brownstone houses, with no mingling of colors and little variety of form to relieve the monotony. A reaction has now set in and the fashion is for light stone. As a result we shall in a few years have similar monotonous blocks of light-colored limestone, marble, and sandstone. By the time this second climax is passed a more rational mode of procedure will prevail; architects and builders will begin to use stone that will harmonize with the plan and style of the building and with its location and surroundings. Good building stone of different kinds and different colors will be in demand. The use of brownstone will again increase, as it is a useful and valuable building stone if properly used and not abused.

Much has been written on the paleontology, structural features, and relations of Eastern brownstones and published in the various journals and proceedings of scientific societies. These papers are all classified and enumerated in Bulletin 85 of the United States Geological Survey—The Newark System, by Prof. I. C. Russell—and only those that have any bearing on the economics of the Pennsylvania brownstones are mentioned below. All of these are very brief, very general, and, with one exception, local. There may possibly be a few references to the occurrence of the brownstone in other reports of the Pennsylvania Geological Survey, but none that have any bearing on the economic side of the question. Prof. George P. Merrill's work on building stones and the Tenth Census Report referred to below describe briefly the building stones of all the States.

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1. D'INVILLIERS, E. V. Annual Report Geological Survey of Pennsylvania, 1886, Part IV, pp. 1563–1567, Paint, Iron Ore, Limestone, and Serpentine.—Brief description of the brownstone quarries in the vicinity of Hummelstown.

2. FRAZER, PERSIFOR. Report of a geological survey of Chester County, 1880, C 4, Second Pennsylvania Geological Survey, pp. 178–214.—The stratigraphic and paleontologic relations of the Mesozoic red sandstone in Chester County.

3. FRAZER, PERSIFOR, JR. The geology of Lancaster County, Second Geological Survey of Pennsylvania, 1877, CCC.—Mentions the occurrence of the New Red Sandstone in Lancaster County.

4. LYMAN, BENJ. SMITH. Report on the New Red of Bucks and Montgomery counties, by Benj. Smith Lyman, in Summary Final Report Geology of Pennsylvania, Vol. III, part 2, pp. 2589–2638, 1895.—Gives geologic and topographic map and cross sections of the New Red of Bucks and Montgomery counties, with a detailed account of the stratigraphy, paleontology, and general scientific features; brief mention of the economic features.

5. MERRILL, G. P. Stones for building and decoration, Wiley & Son, New York, 1891, pp. 279–281.—Also in Smithsonian Report, part 2, 1886.

6. SHALER, N. S. Description of quarries and quarry regions, Tenth Census, Vol. X, pp. 156–157.—One of the best short descriptions of the brownstones of Pennsylvania.

GENERAL PROPERTIES OF BROWNSTONES.

Definition.—It might at first glance seem superfluous to offer a definition of such a simple term as brownstone, but the very fact that it is used with different meanings in the market is a reason why it is advisable to state the significance of the word as used in this report.

If all the brownstone occurred in one locality and were all of one shade or color the term would be self-explanatory, but stone with a more or less brown tint occurs in a dozen or more States and at several different geologic horizons, some of which may be called brown by one person and red, gray, brown, or something else by another. In some localities the term brownstone signifies the Portland, Connecticut, stone, because that is used in such large quantities and no other is there known. With some persons it signifies any rock from the Mesozoic or New Red formation, whether it be really brown or not. In this report the term is used for any stone that has a brown or red color, irrespective of locality or the geological formation in which it occurs. A light stone which is brown only in places, and which occurs in the New Red formation, is also included, because it is closely associated with brownstone, often in the same quarry, and because it frequently passes in the market as brownstone. Some of the so-called Trenton brownstone is not brown at all. There is also included red or brown stone from the Paleozoic rocks which may not be generally known in the market under the name brownstone, but which is as truly brown in color as many of the original brownstones. Hence the term is here used to designate a sandstone with a brown or red color, rather than a brownstone from any particular locality or formation. The red or brown marbles are not included.

Colors.—Brown is defined as a dark color shading toward red, yellow, or black, and may be produced by a mixture of these colors.[1]

[1] Standard Dictionary.

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We can thus see that there may be an almost infinite number of shades of brown, grading insensibly into red, yellow, or black, and that there may be a wide divergence of opinion as to where the division should be made. In the sandstones the change is most frequently toward the red, less commonly toward the yellow. So close is the relation that the same stone is called by some dealers red and by others brown.

From the standpoint of color it is one of the best of building stones, not only from the wide range of shades to select from but from the inherent beauty and richness of many of the shades, and, what is of great importance in architecture, the permanency of the color. There is probably not another color common among building stones that is as permanent and as little liable to tarnish as brown. Where brownstone is used to excess, particularly dark shades, and along narrow streets, it is gloomy and somber. It is at its best advantage when used along with other colored building stones, or at least with the liberal use of lighter brownstones. The darker colored stones, while more somber than the lighter shades, show the dirt and stains of the city atmosphere less and are in this respect better adapted to base courses and trimmings. The inherent beauty and permanency in the color, together with its durability in combination with stones of other colors for architectural effect, will always cause a demand for brownstone by the best architects.

The brownstones of Pennsylvania have as wide a range in color as those of any other State. There is the rich blue-brown and red-brown stone of Hummelstown, the dark-brown at Mohnsville, the light red-brown at Cornwall, the light purplish-brown at Newtown and Yardley, the very light brown to gray at Lumberville, Grenoble, and Fort Washington, the light pink south of Birdsboro, and the light red and dark red at White Haven and Laurel Run.

THE CHEMICAL COMPOSITION OF BROWNSTONES.

The accompanying tables of analyses give the chemical composition of all the well-known brownstones in this country so far as they could be obtained. The first table gives those of Pennsylvania; the second, those from other States. It may be noticed in comparing these that the figures for the Hummelstown stone, the best-known brownstone of Pennsylvania, correspond more nearly with those of the East Long Meadow, Massachusetts, sandstone than any other. The stones of the eastern part of Pennsylvania more nearly resemble the Portland, Connecticut, stones in composition than any others in the State.

The signification of the varying proportions of the different substances is not always perfectly clear, but a number of very useful deductions can be made, as follows: Of all the substances mentioned silica is the most durable, especially if it occurs in the form of quartz. If it is desirable to have the percentage of silica as high as is consistent with the desired hardness and workability of the stone—that is, from the standpoint of durability alone, quartz is the most desirable

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substance, but if the silica is all in quartz grains and the percentage too high the stone will be friable, not having sufficient cement to hold the grains together. On the other hand, if part of the silica is in the form of cement, binding the grains together, the stone is liable to be too hard to work. Hence, no definite limit can be placed on the amount of silica allowable in a good stone, as that depends on whether a hard stone or an easy-working stone is desired, and also on how much of the silica is in feldspar, mica, or clay. The proportions of alkali, lime, and alumina throw much light on this point. It also depends on the size and shape of the grains. Thus, round grains require more and stronger cement than sharply angular grains to produce a stone of equal strength; irregular angular grains, when closely compact, will make a very strong stone with very little cement. A high percentage of alumina is not desirable; if in the form of feldspar or mica, it is a source of decay; if in the form of clay, it will absorb water and injure the stone by freezing. The last injury is intensified if the clay is segregated in patches or layers. On the other hand, a certain percentage of clay is desirable to make an easy-working stone. If the cement is entirely or largely quartz or calcite, the stone will be too hard to work freely. No arbitrary standard can be given for the maximum percentage of alumina allowable, as that depends on the form in which it occurs, the manner of its distribution, and the character of the grains containing it.

The iron is desirable within reasonable limits, providing it occurs in the peroxide form, as it gives the color to the stone and forms a strong and durable cement. If it occurs in the form of pyrite or carbonate it is liable to be a source of disintegration. It is customary in making the analyses to determine the iron as peroxide without proving it to be such. Hence the small percentage of protoxide given with the Hummelstown stone does not signify that it does not occur in any of the others, but simply that it was not determined in any of the others, and is given to show that it does not occur in sufficient quantities in the Hummelstown stone to be any serious injury to the stone, as might be suggested by its blue color.

The lime is not a desirable element, but it is probably less injurious in the form of feldspar (the form in which much of it occurs in the tables) than in the form of calcite, as in the latter case it hardens the stone, and where it does not form all the cement, hardens it unequally, and in the presence of acids is liable to be a source of weakness. In the first instance the only injury is in the presence of feldspar, which is liable to decay. The alkalies are not desirable, on account of their solubility and the tendency of the substances in which they occur to disintegrate.

The following table shows the chemical composition of the Pennsylvania brownstones:

Analyses of Pennsylvania brownstones.

No.	Location of quarry.	Specific gravity.	Silica (SiO_2).	Alumina (Al_2O_3).	Ferric oxide (Fe_2O_3).	Lime (CaO).	Magnesia (MgO).	Potash (K_2O).	Soda (Na_2O).	Ferrous oxide (FeO).	Manganese dioxide (MnO_2).	Water (H_2O).	Total.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	Hummelstown Brown Stone Co.—blue	2.657	90.34	4.35	1.09	0.95	0.17	1.30	0.19	0.74	.....	0.61	99.74
2	Hummelstown Brown Stone Co.—brown	2.669	88.96	4.74	2.19	.86	.44	1.31	.24	.....	.....	.87	99.61
3	Swatara Brown Stone Co	.....	91.52	3.80	2.02	.50	.22	*a* 1.20	.....	.....	.....	.74	100.00
4	Mount Gretna	2.695	91.07	2.68	3.29	.23	.33	1.12	.24	.....	.....	.73	99.69
5	Westley's Quarry, Mohnsville	2.73	84.96	7.78	3.71	.10	.38	1.11	.43	.....	0.18	1.40	100.05
6	Grenoble Station	2.66	79.08	12.42	2.50	.....	.....	2.02	3.00	.....	.09	.55	99.66
7	Mitchell's Quarry, Newtown	2.66	82.34	11.46	1.07	.27	.19	.17	3.76	.....	.07	.80	100.13
8	Yardley Quarry, Yardley	2.675	82.72	10.29	1.92	.17	.36	.10	2.92	.....	.16	1.20	99.84
9	Hummelstown	.....	88.13	5.81	1.77	.20	.53	2.63	.06	.31	.....	.49	99.93
10	Laurel Run Red Stone, Laurel Run	2.666	*b* 94.00	Trace.	1.98	1.10	1.00	.....	.....	.....	Trace.	*c* 1.92	100.00
11	Daneker's Quarry, White Haven	.....	90.36	2.17	*d* 1.15	2.00	Trace.	.....	.....	.....	.....	.....	95.68

a Includes alkalies and loss. *b* Silica and insoluble residue. *c* Volatile matter—water and carbonic acid. *d* Given as protoxide, evidently a mistake.

NOTE.—Analyses 1–8, inclusive, made in the chemical laboratory at State College, Pa. No. 9, by E. A. Schneider, Bulletin 90, U. S. Geol. Survey, page 65; No. 10, by A. A. Breneman, New York; No. 11, by Crane Iron Company laboratory.

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The following table shows the chemical composition of various brownstones:

Analyses of brownstones.

No.	Locality.	Silica (SiO_2).	Alumina (Al_2O_3).	Iron oxide (Fe_2O_3).	Lime (CaO).	Magnesia (MgO).	Alkalies.	Water.	Total.	Authority.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
12	Portland, Conn.....	69.94	13.15	2.48	3.09	Trace.	8.73	*a* 1.01	.....	Merrill, Building and Ornamental Stones, page 420.
		70.11	13.49	4.85	2.39	1.44	7.37	.....	99.65	
13	Cromwell, Conn.....	70.84	13.15	2.48	3.09	Trace.	8.73	1.01	99.30	New England Brown Stone Co.
14	East Longmeadow, Mass., Worcester Quarry.	88.89	5.95	1.79	.27	.....	.86	*a* 1.83	100.00	Worcester Polytechnic Institute.
15	East Longmeadow, Mass., Maynard Quarry.	79.38	8.75	2.43	2.57	.....	4.08	*a* 2.79	100.00	Do.
16	Wilburtha, N. J.....	93.55	4.00	.....	.40	.18	.30	.12	98.55	Geology of N. J., 1868, page 515.
17	.....do	93.60	1.59	3.30	.....	.....	.35	1.20	100.04	Geology of N. J., 1868, page 516.
18	Milford, N. J	79.25	7.49	3.78	1.86	.....	1.12	3.16	*b* 99.51	Do.
19	Center Bridge, N. J	96.20	1.58	*c* 1.37	.15	.36	.....	1.15	100.81	Geology of N. J., 1868, page 515.
20	Washington Valley, N. J .	88.45	3.92	3.03	.36	.12	.88	*d* 1.94	98.70	Do.
21	Hancock, Md.....	76.43	17.78		.84	.92	.....	.....	98.76	Bulletin 55, U. S. G. S., page 80.
22	.....do	*e* 88.68	.....	7.13	1.32	.66	.....	2.20	99.99	Do.
23	Sanford, N. C., brown ...	81.59	10.81	4.38	1.02	.33	1.08	.79	100.00	Garrett and Dix, Philadelphia.
24	Sanford, N. C., red	82.58	8.95	3.95	1.18	.81	.83	1.68	99.98	Do.
25	Mansfield, Ind.....	*e* 92.16	.....	6.29	.05	.....	.09	.....	98.59	Rose Polytechnic Institute.

a Includes water, CO_2, and loss. No. 14 contains 0.41 per cent manganese dioxide.
b Includes also sulphuric acid 1.39 per cent and carbonic acid 1.46 per cent.
c Iron given as protoxide.
d Includes 0.14 per cent SO_3.
e Insolub e residue includes silica and insoluble silicates. No. 21 includes also 2.79 per cent loss by ignition, and is an analysis of the same as 22, in which all the silica is determined by fusion with soda carbonate; both from the Jaitelle Quarry.

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Analyses of brownstones—Continued.

No.	Locality.	Silica (SiO_2).	Alumina (Al_2O_3).	Iron oxide (Fe_2O_3).	Lime (CaO).	Magnesia (MgO).	Alkalies.	Water.	Total.	Authority.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
26	St. Anthony, Ind	*a* 88.41	.63	8.40	.13	.....	.....	.....	97.57	Rose Polytechnic Institute.
27	Bloomfield, Ind	*a* 85.29	.19	11.83	.06	.....	.....	.....	97.37	Do.
28	Greenhill, Ind	*a* 98.73	.28	.36	.03	.....	.....	.....	99.40	Do.
29	Hillsboro, Ind	*a* 91.65	.56	6.60	.12	.....	.....	.....	98.93	Do.
30	L'Anse, Mich	*a* 78.55	14.21	5.54	.42	Trace.	.....	.....	98.72	
31	Portage Entry, Mich	90.17	4.23	3.16	.....	.29	.....	1.01	98.86	Maurier and Hoskins, Chicago.
32	.....do	82.60	8.32	.28	.55	.18	6.49	.99	99.41	Report Geol. Survey Mich., 1891-93.
33	Marquette, Mich	77.18	9.69	3.20	0.26	1.48	4.85	2.90	*b* 100.00	F. F. Sharpless.
34	Keweenaw Bay, Mich	78.55	14.21	5.54	.42	Trace.	.....	1.28	100.00	Stone, Vol. IX, No. 1.
35	Houghton, Wis	91.40	3.53	2.00	.25	.....	2.50	.05	99.73	Columbia College School of Mines.
36	Bass Island, Wis	87.02	7.17	3.91	.11	.06	1.65	Trace.	99.92	Geol. of Wis., Vol. III, page 208.
37	Fond du Lac, Wis	78.24	10.88	3.83	.95	1.60	1.73	.....	97.23	Geol. of Minn., Vol. I, page 202.
38	Flagstaff, Ariz	79.19	1.30	2.45	7.76	.23	.....	3.26	*c* 99.96	Bulletin 78, U. S. G. S., page 124.
39	Kettle River, Minn	98.69	1.06	Trace.	.42	.01	.17	.....	100.35	N. H. Winchell.
40	Pipestone, Minn	84.02	12.33	2.12	.31	Trace.	.45	*d* 2.31	101.54	

a Insoluble residue includes silica and insoluble silicates.
b Includes P_2O_5 0.21 per cent and SO_3 0.23 per cent.
c Includes 5.77 per cent CO_2; analyzed by Dr. T. M. Chatard.
d Includes water, CO_2, and loss.

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MINERALOGICAL COMPOSITION OF BROWNSTONE.

The mineralogical composition is frequently as valuable an indication of the quality of the stone as the chemical composition, and sometimes more so, especially when combined with a microscopic examination, which shows not only the minerals present, but the relative quantity and the condition in which they occur. The bulk of all sandstones is made up of quartz grains, which generally form from 70 to 95 per cent of the rock. In the quartzites the grains are cemented by quartz deposited in the interstices, thus giving a high percentage of silica. However, a high percentage of silica does not always signify a quartzite, as may be seen on comparing a few analyses in the foregoing tables. Thus, the Mount Gretna and the Hockersville stone each shows more than 91 per cent silica, while the White Haven stone has less than 91 per cent; yet the first two, especially the Mount Gretna stone, are friable sandstones, and the last is a hard quartzite. Likewise, the Wilburtha stone, which has 93 per cent silica, is a soft stone; and the Mansfield (Indiana) stone, with more than 92 per cent silica, is a friable sandstone; and the Lumberville stone, which is a hard quartzite, has less than 80 per cent silica. The advantage of the microscopic examination over the chemical, or rather in combination with the chemical, is that it shows the form in which these elements occur. Thus, the Lumberville stone has the grains of quartz and feldspar firmly bound in a quartz cement which would not be shown by the analysis.

The next most abundant substance after quartz found in the grains of sandstone is feldspar. In some localities orthoclase and microcline, the alkali feldspars, are abundant, while in other places the plagioclase or basic feldspars predominate. As most of the feldspars occur in the sandstone in a more or less decayed condition, where plagioclase abounds calcite is liable to be found in the sandstone, and in many places there is formed on the stone in protected places an efflorescence of sodium or potassium sulphate from the alkali of the feldspar. While this was observed in many places, it was determined by analysis from only one locality, and it proved to be mirabalite, or glauber's salt (sodium sulphate). The resulting products of decaying feldspar are numerous, depending on the conditions under which it decomposes. The most common products are clay, quartz, and muscovite (mica). In none of the brownstones examined was muscovite observed in large flakes where it appeared to be secondary product, but aggregates of clay with much finely granular quartz and minute flakes of what is apparently muscovite are plentiful, sometimes in a rim of feldspar, sometimes with included fragments of partially decayed feldspar—in fact, nearly all stages from fresh feldspar to clay in which the outlines of the feldspar have been lost.

Mica is very scarce in the Pennsylvania brownstones, occurring only in a few widely scattered fragments. It readily decomposes, yet it is an element of weakness, not so much from its disintegration as from the

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tendency of the flakes all to lie the same way and make planes of easy cleavage, along which the stone flakes and scales on exposure. It is one of the most injurious minerals occurring in the sandstones.

Iron oxide occurs diffused through the clay cement and surrounding many of the grains of sand. It occurs in such a finely divided state that it is impossible to determine in many cases what mineral form it takes. Most of it is presumably red hematite, judging from the color of the rock, and in some places small hematite grains occur, visible in the microscope. There is possibly some limonite, but none was distinguished as such.

Calcite occurs in small quantities in the interstices between the grains in some localities, but in general the percentage is very small. It is most abundant in the hard stone from White Haven and Laurel Run.

Other minerals occur in small quantities, but are not sufficiently abundant to affect the durability or the character of the stone to any extent. Small crystals of apatite, zircon, and rutile needles occur in the quartz grains, and small fragments of magnetite, augite, and hornblende were observed. There are liable to be present small fragments of any minerals that occur in the rocks from which the débris was obtained.

STRUCTURAL FEATURES OF BROWNSTONES.

Brownstones vary in structure from fissile shales on one side to massive seamless beds on the other. The thin-bedded stone that occurs in regular layers less than 5 or 6 inches thick is sufficiently hard for use as flagstone; if it is in irregular layers, it has no value, except for broken stone or for cellar walls. In many instances quarries that furnish flagstone at the outcrop furnish heavy-dimension stone in the interior, the numerous bedding planes being opened by the weathering influences. This is particularly true in the White Haven and the Laurel Run red-stone quarries.

As in other sandstones, false bedding or cross grain is common in the brownstones. Sometimes the flagstone layers are formed by the false bedding planes. The false bedding is in nearly all cases an injury to the rock, causing a great deal of waste and making the stone difficult to quarry and dress properly. False bedding stone is nearly always banded and varied in texture, having alternating streaks and patches of fine and coarse-grained stone.

TEXTURAL FEATURES OF BROWNSTONES.

Like all other sandstones, the brownstones vary in texture, grading from the shales and slates on one side to the coarse conglomerate or pudding stone on the other, thus forming an intermediate class between these two. The coarse-grained varieties look well in heavy masonry in rock-face work, and are better adapted to that line of work, the finer grained being better adapted to fine carving or tool-dressed, but adapted to rock-face work as well. The most desirable texture from a commercial standpoint is one that is homogeneous throughout and not very

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coarse, but a uniform coarse grained stone is better than one having a mixture of coarse and fine grain. As a rule, the coarse-grained rocks are more porous and absorb water more freely, and hence are more liable to injury from the frost. On the other hand, they are less liable to be laminated or "reedy," less liable to have clay seams, will generally work more freely in all directions, and are less liable to be cut up by numerous seams, both vertical and horizontal, than the fine grained ones. The fine-grained stones are generally stronger but less elastic, not so apt to disintegrate, but more apt to crack and shell. They are equally well adapted to rock-faced, tool-dressed, or fine carved work.

The microscope reveals several features in regard to the texture and composition of the rocks that are not brought out in any other way. It reveals both the mineral constituents and their condition of preservation, as well as the proportions, kind, and character of the cement—facts which are given under the different varieties.

PHYSICAL TESTS.

The accompanying table shows specific gravity, absorption, and crushing tests made on brownstones from a number of productive quarries in the United States. In comparing the results made at different places considerable allowance must be made for the fact that different methods produce different results. Thus there are several different methods of obtaining the specific gravity, each of which has its merits, though obtaining different results. The Hummelstown stone appeared from the results to be much heavier than the other brownstones of similar appearance. When, in order to verify the comparison, tests were made in the same manner on other stones, it was discovered that the difference was in the method of taking the specific gravity. A carefully trimmed 6-inch cube of the purple brownstone was found to weigh 18¼ pounds, equal to 146 pounds per cubic foot, the weight from the specific gravity showing 166 pounds, a difference of 20 pounds to the cubic foot. A cube of brownstone gave 150 pounds to the foot, which is the weight used by the company.

Crushing tests made on stone of the same kind, from the same block, all prepared by the same stone-cutter, tested on machines of the same make, but by different operators in different places, show a variation in one set of four samples each of more than 2,000 pounds per square inch, and on another set of more than 4,000 pounds per square inch, or more than one-third of the total strength.

Crushing strength, specific gravity, and ratio of absorption of brownstones.

No.	Quarry.	Locality.	Crushing strength per square inch.	Number of specimens tested.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.	Authority.
			Pounds.			*Pounds.*		
1	Hummelstown Brown Stone Co.	Hummelstown, Pa.....	13,097	3	.....	.....	.....	Riehlé Bros., Philadelphia, Pa.
2	.....do	.....do	12,810	.....	.....	.....	.....	Merrill, Stones for Building and Decorating.
3	Hummelstown Brown Stone Co., No. 3.	.....do	14,630	4	.....	.....	.....	Riehlé Bros., Philadelphia, Pa.
4	Hummelstown Brown Stone Co., No. 4.	.....do	10,933	4	.....	.....	.....	Do.
5	Hummelstown Brown Stone Co., No. 3.	.....do	14,000	3	2.66	146.0	1–27	Rose Polytechnic Institute.
6	.....do	.....do	14,753	3	.....	.....	1–37	Watertown Arsenal, Mass.
7	George Brook's quarry..	Birdsboro, Pa	11,448	3	.....	.....	.....	Do.
8	Lumberville Granite Co.	Lumberville, Pa.....	19,895	4	.....	.....	1–93	Fairbanks's Laboratory, N. Y.
9	.....do	.....do	24,625	2	2.60	162.5	1–88	Booth, Garrett & Blair, Philadelphia, Pa.
10	.....do	.....do	22,025	8	.....	.....	.....	Garrison & Olsen, Philadelphia, Pa.
11	Oliver's quarries.....	Laurel Run, Pa.....	22,250	.....	2.66	166.1	.....	School of Mines, Columbia College.
12	.....do	.....do	17,600	12	2.66	166.1	1–900	Cornell University.
13	John Daneker's quarry..	White Haven, Pa.....	29,252	3	.....	.....	.....	Watertown Arsenal.
14	.....do	.....do	32,397	7	.....	.....	.....	Do.
15	Portland quarries	Portland, Conn.....	12,580	6	2.35	146.9	1–40	Do.
16	.....do	Middletown, Conn.....	6,250	2	{2.63 2.36}	148.5	1–40	General Gillmore, Chief of Eng., Rep. 1875.
17	New England Brown Stone Co.	Cromwell, Conn	16,894	2	{2.68 2.50}	156.0	1–40	Watertown Arsenal.

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Crushing strength, specific gravity, and ratio of absorption of brownstones—Continued.

No.	Quarry.	Locality.	Crushing strength per square inch.	Number of specimens tested.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.	Authority.
			Pounds.			*Pounds.*		
18	James & Marra (red)	E. Longmeadow, Mass.	12,210	.....	2.49	154.5	1–23	Watertown Arsenal, July, 1893.
19	James & Marra (brown)	.....do	12,330	.....	2.48	154.5	.....	Do.
20	Worcester quarry (brown).	.....do	10,936	2	2.49	155.3	1–19	Watertown Arsenal, Dec., 1883, 6-inch cube.
21	Maynard quarry (red)	.....do	10,274	1	2.49	155.3	1–20	Watertown Arsenal, Mar., 1889, 6-inch cube.
22	.....	Medina, N. Y.	16,031	2	2.40	150.0	1–53	General Gillmore, 1875.
23	.....	Little Falls, N. J.	9,500	2	2.25	140.6	1–34	Do.
24	.....	Potsdam, N. Y.	42,800	1	2.60	162.3	1–48	School of Mines, Columbia College.
25	J. B. Lynne & Sons	St. Anthony, Ind.	3,000	.....	.....	.....	1–13	Rose Polytechnic Inst., Terre Haute, Ind.
26	.....	Marquette, Mich.	10,780	.....	.....	.....	1–50	Stone, June, 1894.
27	.....	.....do	5,992	3	2.29	142.8	1–32	General Gillmore.
28	.....	.....do	6,150	6	2.16	135.3	1–20	Do.
29	.....	.....do	3,800	.....	.....	.....	.....	Geol. Surv. Michigan, 1891 and 1892.
30	.....	Portage Entry, Mich	7,300	.....	2.54	158.2	1–11	Stone, June, 1894.
31	.....	.....do	6,350	.....	.....	.....	.....	Geol. Surv. Michigan, 1891 and 1892.
32	.....	L'Anse, Mich	10,645	.....	.....	.....	.....	
33	.....	Keweenaw Bay, Mich.	10,645	.....	.....	.....	.....	Stone, June, 1894.
34	.....	Bass Island, Wi	4,662	3	2.04	127.5	1–15	General Gillmore.
35	.....	Fond du Lac, Wis.	6,237	2	2.22	138.8	1–22	Do.
36	.....	Houghton, Wis	7,316	2	.....	.....	.....	School of Mines, Columbia College.
37	.....	Wilson Island	7,548	1	.....	150.0	.....	
38	.....	Fond du Lac, Minn.	8,750	.....	2.25	141.3	.....	The Geol. of Minn., Vol. I, page 200.
39	Minnesota Sandstone Co	Kettle River, Minn.	12,547	2	.....	.....	.....	Watertown Arsenal.

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OCCURRENCE OF PENNSYLVANIA BROWNSTONES.

The brownstones, so far as commercially developed, are confined largely to the eastern and southeastern part of the State. The New Red area in which most of the quarries are located extends from the Delaware River north of Trenton in an irregular, rather broad belt west-southwest through Bucks, Montgomery, Berks, Chester, Lebanon, Lancaster, Dauphin, York, and Adams counties. The most productive quarries are those near Hummelstown. Other less productive quarries are at Mount Gretna, Schaefferstown, Mohnsville, Birdsboro, Phœnixville, Valley Forge, Port Kennedy, Fort Washington, Norristown, Grenoble Station, Neshaminy, Newtown, Yardley, and Lumberville. Quarries of a considerable size near Middletown and Goldsboro were once productive, but are now abandoned.

The Mauch Chunk formation, of Lower Carboniferous age, from which the red-brown quartzose sandstone is obtained, surrounds the anthracite coal basin in the eastern part of the State, and, according to the State geological map, underlies the Coal Measures of the west and west-central portion of the State. So far as is known to the writer the only places where the Mauch Chunk red stone has been quarried are the southern part of the north anthracite field and the east end of the middle field at Mocanaqua, Laurel Run, and White Haven. A quarry reported near Rockwood, Somerset County, may be in this formation. There is brownstone in the Catskill, Clinton, and Medina groups in Pennsylvania, but so far as known no quarries have been opened in any of them. Time did not permit a personal examination of these areas to see whether good stone occurred in commercial quantities or not. The fact that there are many productive quarries in the Medina formation in western New York, and the promising appearance of the few outcrops observed in this State, would suggest the possibilities of good brownstone from this formation.

METHODS OF QUARRYING AND HANDLING THE PENNSYLVANIA BROWNSTONES.

In all of the small brownstone quarries the work is mostly done by hand, with the liberal (entirely too liberal for the good of the stone) use of powder. Holes are drilled by hand, either by the churn-drill or the jumper, and heavily charged with powder and fired, loosening sometimes a large quantity of stone. If the blocks thus loosened are too large to be broken by repeated blows with a heavy hammer another charge is put in and the demolition completed. As may be well imagined, but little good dimension stone is quarried in this manner; yet much stone that would be good dimension stone if properly quarried is taken out in this way. Where good dimension stone is required, it is taken out either by splitting from the ledge with wedges (plugs and feathers), or by the Knox blasting system or some similar system. Channeling machines are not used in any of the brownstone quarries

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of this State, nor is the stone in any of them in such a shape as to require or justify their use. There are numerous seams in all of the quarries, either bedding or joint seams, and by utilizing these seams the stone can be extracted more cheaply by wedging and blasting than by channeling. In the Hummelstown region the strata are too highly inclined to be channeled to advantage. In the larger quarries, like those at Hummelstown, the Knox system of blasting is used, and this, if properly managed, reduces the injury to the stone almost to a minimum. Where the rock occurs in regular layers, after once getting a straight face successive blocks are broken off by putting a row of holes parallel with the face and firing with a battery. The channeling machine may here be used to advantage in cutting out the ends of the quarry, or if on a long face by making cross cuts, if the position of the stone is such that it can be used.

In all small quarries the stone is loaded on the car, boat, or wagon either by hand or with the use of a man-power or horsepower derrick. The larger quarries have steam hoists. Nearly all the quarries in operation are near the railway or canal. The shipping facilities of each is mentioned in the description of the quarry.

USES AND ADAPTABILITY.

Brownstones are used for almost all classes of work for which any other rock is used. It is preeminently a building stone, probably one of the most valuable in the market, and is adapted to as many different classes of structural uses as any other. In Pennsylvania, besides its use as a building stone, it has been used as sand for plastering, masonry, for furnace hearths, lining blast furnaces, monuments and paving blocks, curbing, flagging, stepping stones, macadam, and concrete. But by far the larger part quarried goes into structures of some kind; the better qualities into superstructure, as walls or trimmings, and the inferior grade into foundations, bridge piers and abutments, culverts, retaining walls, etc. The different varieties are all adapted to these different uses if selected with care. Thus, where the stone is to be carved or smooth dressed, a fine-grained stone of homogeneous color and not too hard should be selected; for rock-faced work and heavy masonry the coarse grained can be used; but all kinds are suitable that are sufficiently strong and durable. In bridge piers and foundations mixed stone—that is, stone variegated in color or texture—may be used. In nearly all quarries there is considerable stone that may be as strong and durable as any but is lacking in beauty or homogeneity, and can not be used as first-class stone in superstructures, but which can be used to advantage in bridge work, where strength and not beauty is required.

Soft stones, like those from Newtown and Yardley, are admirably adapted for building in face work or for heavy trimmings, but will not stand the wear in pavements and streets, or heavy cross strain in lintels and sills, unless protected in some way. Stones like those from White

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Haven, Wilkesbarre, and Lumberville are sufficiently hard not only for foot wear in pavements, but for street wear, as Belgian blocks or crushed stone. On the other hand, they are not adapted to buildings where much cutting or carving is to be done, on account of their hardness.

To obtain the best architectural effects care must be taken in selecting the colors. This is largely in the hands of the architects and the contractors, but when they persist in putting up entire blocks of dark brownstones along narrow streets it is time that owners and residents should protest. Some shades of brownstone are pretty in themselves; others have their natural beauty intensified and brought out by judicious mingling with other colors and shades. The lighter colored brownstones could be used in larger quantities, either in the same building or the same town, with more pleasing results than the dark colored, but the two together will produce a better effect than either alone. The darker stones are better adapted to business blocks on the principal thoroughfares, as they do not soil or show stain so readily. The lighter colored ones are adapted to residences in the suburbs or country towns. The very hard quartzite varieties should not be used in excess in face work, as the hard, stony glare produced by them is repellent. On a large face this could be relieved in part by an intermingling of sawed or tool-dressed faces among the rock-faced ones.

BROWNSTONE QUARRIES IN THE NEW RED AREA OF PENNSYLVANIA.

Goldsboro.—Brownstone occurs over an extended area in Adams and York counties, but only one quarry of any extent has been opened. That is 2½ miles west of Goldsboro, York County, the nearest railway station. It was opened in 1851 and was operated most of the time until 1869, from which date to 1880 it was in continuous operation. It has been idle since 1880. The stone is a mediumly fine-grained, rather dark colored brown, occurring in a bed 12 to 15 feet thick, overlain by red-brown shale. The product was used for building purposes in many of the towns of south central Pennsylvania, some being shipped as far south as Baltimore and Washington.

Hummelstown and vicinity.—Nine different companies have operated quarries in the vicinity of Hummelstown, but there is only one in active operation at the present time—the Hummelstown Brownstone Company. Some of the companies have been absorbed by this company, some of the quarries abandoned, and some possibly only temporarily idle. The quarries of the Hummelstown Brownstone Company, situated about 3 miles south of Hummelstown, were opened about 1800, and have been in more or less active condition since that date. Their greatest period of activity has been since 1866. Since that date it has ranked among the largest, most productive, and best-known brownstone quarries in this country. Dozens of fine buildings all over eastern and central United States attest its beauty and right to rank among the best brown-

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stones in the country. The company is now operating three quarries, employing 100 or more men; in busy seasons, from 500 to 700 men; has a large, well-equipped mill, 30 steam-power derricks, 2 wire cable ways, 2 steam travelers, abundance of steam drills, a large steam shovel, and their own railway and locomotives, connecting with the Philadelphia and Reading road at Brownstone Station, 2 miles distant.

The strata in this locality all dip about 40° to 45° to the north, thus giving the strike or the line of outcrop an east-west direction. The separate layers vary from 20 inches to 20 feet in thickness. While the bedding planes are not abundant, and, where they do occur, are not conspicuous open seams, yet there is throughout the bed an easy cleavage parallel with the bedding, on which the layers can be readily split into any thickness desired. These seams are more abundant near the outcrop, and least so in the bottom of the quarry. The joint seams in in these quarries are not numerous. The total thickness of the stone is not known. Including the conglomerate and the shales there is certainly not less than several hundred, probably several thousand, feet. The greatest thickness of good quality of brownstone at one place is about 50 feet, as shown in the quarries of this company. But while this is immediately underlain and overlain by red shale and conglomerate, good stone is known to occur both above and below the bed quarried. In fact, some good stone has been quarried from strata both above and below that in the productive quarries. Thus the supply of good stone is practically unlimited. The only question is the economic production of it, which question the company has answered successfully so far. The stone varies somewhat in texture. There are fissile red shale, fine-grained sandstone, and both shale and quartz conglomerate; but there is not an intimate intermingling or gradation of these one into the other, which is noticeable in other localities. The series alternate, but rarely mix, though in places there is a mingling of the shale fragments with the sandstone. There are heavy layers of coarse quartz pebble scattered through the sandstone. The first-class stone is an even-grained, fine-grained stone, remarkably uniform, perhaps unsurpassed in this property by any brownstone in the United States. The texture of the Hummelstown stone is very close and it will take a very smooth finish. The absorption of the stone is about the average for brownstone, but it appears to be harder than the average brownstone.

There are two decided shades of stone from the different quarries. The most abundant shade—the one that comes from all but one of the quarries—is a reddish brown, resembling the East Longmeadow (Massachusetts) stone in color. It is among the darkest-colored ones in this State, those farther east being almost all lighter colored, except that at Mohnsville and Frog Hollow. The other shade is a purplish brown, which comes from their No. 3 quarry. It harmonizes well with the redder tint, and buildings with the lower part of the blue stone and the upper part of the red stone present a good appearance.

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The chemical composition, crushing strength, absorption, and specific gravity of this stone are given in the tables on the preceding pages, and show it to have all the essential properties of a strong and durable stone and at the same time to be not too difficult to work. Its durability is shown not only by its composition and tests but by exposure. The Berst house at the quarry was constructed in 1800 and shows not the least sign of decay, the stone not even being discolored. The same is true of other old buildings in the vicinity. It is practically free from mica, and nowhere has it been observed to scale and flake off.

Quarries of more or less local value occur along the mountains eastward from Hummelstown as far as Reading, but no large quarries that do any shipping. In the vicinity of Cornwall and Schaefferstown the stone, which has had considerable local usage, has a light attractive color, but is coarse, most of it containing pebbles.

There are three quarries at Mohnsville, south of Reading, of dark-colored brownstone associated with much conglomerate, that has been used in Reading and the surrounding country. South of Birdsboro is a handsome pink sandstone that has been used for building purposes in considerable quantities.

Other quarries occur along the Schuykill Valley at Phœnixville, Valley Forge, Port Kennedy, Norristown, Bridgeport, and Fort Washington, some of considerable size, but the markets are mostly local. There are productive quarries near Doylestown and Greenoble in Bucks County.

The most productive localities for fine brownstone in the New Red area in eastern Pennsylvania are at Newtown, Yardley, and Lumberville, Bucks County. The quarry at Newtown is comparatively small, yet produces a good grade of stone that is used in fine building work. The stone is comparatively soft, has a purplish-red color, works quite freely, and looks well either in rock-face or tool-dressed surface. The quarry has been operated since 1862, and has furnished stone for use in Philadelphia and its suburbs, Trenton and Newtown.

There are two quarries within half a mile of Yardley, each of which has produced considerable stone for the local markets, Trenton, Philadelphia, and Camden. Only one of these quarries is in operation at present. Both produce a light-reddish brownstone resembling somewhat that on the New Jersey side of the Delaware at Wilburtha, all known in the market as the Trenton brownstone, which term is frequently used also to include the Stockton and Lumberville stone, farther up the Delaware. There are other smaller quarries of purely local importance in the vicinity of Yardley which are not in operation at present. The Lumberville stone, called by one of the companies "Lumberville granite," by another "Lumberville graystone," is a different character of rock from any of the other brownstones of the State. It is not properly a brownstone, much of it having a gray mixed color. Yet some of it is light brown, and it occurs in the New Red formation intercalated with red shale at what is thought to be a little lower horizon

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than the Newtown and Yardley quarries. The stone is much harder than the common sandstone, owing to the prevalence of siliceous cement. It closely approaches a quartzite in hardness, and might be classed as a quartzite, or at least as a very quartzitic sandstone. It differs from ordinary quartzite in having a great many grains of feldspar among the quartz grains, in some places the feldspar being in excess of the quartz. It has been used in quantity in Philadelphia for paving blocks, and has been used at various points for building stone. Its chief defects as a building stone are its hardness and lack of homogeneity in color. The first is in part compensated for by the remarkably straight grain of the rock, by means of which it can be split with great facility; the second, by quarrying in large quantities and selecting the shades. The quarries are on the Delaware division of the Lehigh Canal, on which most of the stone is shipped, but one of the companies has a wire cableway across the Delaware River to the Pennsylvania Railroad in New Jersey.

BROWNSTONE QUARRIES IN THE MAUCH CHUNK RED SHALE FORMATION.

In the Mauch Chunk Red Shale formation, in east-central Pennsylvania, in a number of places there are layers of a hard red quartzite, which is used for building and paving stone to considerable extent. It has been quarried in the vicinity of White Haven, at Laurel Run south of Wilkesbarre, and at Mocanaqua southwest of Wilkesbarre. There are two quarries about 2 miles north of White Haven, and three in active operation along the Lehigh River south of White Haven, and one or two idle ones. The product is used for flagstone, Belgian blocks, foundations, retaining walls, and superstructures. The stone is well adapted to street work, both on account of its hardness and its color. It is even harder than the Lumberville stone, and is more truly a real quartzite, as there is less feldspar among the grains and even more quartz in the cement. In a few localities there is an appreciable percentage of lime carbonate in the cement. As may be seen in the table seven pages back, the crushing strength of the stone is very high and the absorption very low. It makes a durable stone in exposed situations, like foundations and base courses, because of its slight absorption. The flagstone occurs on the outcrop almost entirely, and appears to be due to the opening of the incipient bedding seams, sometimes false bedded, by the weathering influence, the interior of the bed being massive.

The stone at Laurel Run and Mocanaqua is very similar to that at White Haven, and the uses are about the same, probably a larger proportion of it being used for building stone and less for paving than the White Haven stone. The product of all these quarries is used for the most part in Wilkesbarre, Scranton, Mauch Chunk, and smaller towns along the Lehigh Valley Railroad and the Central Railroad of New Jersey. Some has even been shipped into New York, but Wilkesbarre is the principal market. Brownstone quarries are operated at Rockwood, Somerset County, and Elwood City, Lawrence County. Gray and buff sandstones are quarried at many localities throughout central

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and western Pennsylvania, but have not been examined in detail by the writer.

South Dakota.—An advance from $26,100 in 1895 to $37,077 in 1896 has been made. The sandstone industry is comparatively new in the State.

Tennessee.—Sandstone valued at $4,100 was produced in 1896. The output comes from Bledsoe County. It was used for building, curbing, and flagging.

Texas.—Sandstone to the value of $97,336 was quarried in 1895; in 1896 the total value amounted to $36,000. Complaints of the depressed conditions were made by nearly all of the producers.

Utah.—A small quantity was produced in 1896. The demand was very dull.

Washington.—Sandstone to the value of $11,090 was quarried in 1896. This is somewhat below the valuation for 1895.

The following results of tests were obtained by Maj. J. W. Reilly, at the Watertown Arsenal, on Chuckanut sandstone from Whatcom County:

Tests of sandstone from the Chuckanut quarries, Washington.

Dimensions.			Sectional area.	First crack.	Ultimate strength.	
Height.	Compressed surface.				Total.	Per square inch.
Inches.	*Inches.*	*Inches.*	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
3.99	4.22	4.20	17.72	179,000	182,000	10,276
4.09	4.13	4.20	17.35	183,000	221,900	12,790
4.20	4.21	4.23	17.81	192,000	197,700	11,100

West Virginia.—The output in 1895 was valued at $40,000. This decreased to $24,693 in 1896. There is much good sandstone in the State, and some of it has made a good reputation for building purposes. Stone from Elkins, Randolph County, has been found by the Watertown Arsenal to have a crushing strength of 18,791 pounds to the square inch.

Wisconsin.—The value of the output in 1895 was $78,000, while in 1896 it was $65,017. Ordinarily prosperous conditions would have made a much larger output probable, as a number of firms failed to operate owing to lack of demand.

Wyoming.—An advance from $10,000 in 1895 to $16,465 in 1896 was made. Prospects for 1897 are said to be good.

LIMESTONE.

The total value of all limestone and lime produced by quarrymen in 1896 was $13,022,637. The figure for 1895 was $15,308,755. A falling off of somewhat over $2,000,000 is evident.

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The following table shows the value of the output by States and uses for the year:

Value of limestone production in 1896, with the uses to which the stone was applied.

State.	Lime.	Building and road making.	Flux.	Total.
Alabama	$124,756	$36,300	$19,865	$180,921
Arizona	17,730	740	.....	18,470
Arkansas	22,962	7,746	.....	30,708
California	134,280	7,893	1,692	143,865
Colorado	14,360	5,027	45,676	65,063
Connecticut	138,158	80	707	138,945
Florida	16,107	875	.....	16,982
Georgia	29,081	.....	.....	29,081
Idaho	5,610	52	.....	5,662
Illinois	145,294	1,102,482	13,583	1,261,359
Indiana	194,916	1,337,530	126,053	1,658,499
Iowa	80,914	329,123	.....	410,037
Kansas	6,576	151,385	151	158,112
Kentucky	6,672	112,877	16,418	135,967
Maine	606,998	1,000	79	608,077
Maryland	250,477	13,801	.....	264,278
Massachusetts	110,537	6,616	1,469	118,622
Michigan	61,217	43,678	4,532	109,427
Minnesota	31,372	195,620	2,000	228,992
Missouri	291,268	510,247	1,453	802,968
Montana	25,100	1,200	57,627	83,927
Nebraska	640	7,285	2,730	10,655
New Jersey	109,630	591	23,992	134,213
New York	1,152,787	413,659	25,520	1,591,966
Ohio	835,594	434,208	129,610	1,399,412
Oregon	1,600	.....	.....	1,600
Pennsylvania	1,082,682	435,431	586,661	2,104,774
Rhode Island	11,456	.....	133	11,589
South Carolina	25,000	1,000	.....	26,000
South Dakota	1,126	2,000	.....	3,126
Tennessee	86,913	68,403	1,860	157,176
Texas	44,005	12,710	20,537	77,252
Utah	3,835	200	5,323	9,358
Vermont	145,800	288	1,050	147,138
Virginia	84,632	8,193	89,815	182,640
Washington	80,150	.....	3,592	83,742
West Virginia	32,961	5,152	21,000	59,113
Wisconsin	314,704	237,835	382	552,921
Total	6,327,900	5,491,227	1,203,510	13,022,637

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The figures for "blast-furnace flux" given in this table do not correctly represent the value of all the flux quarried during the year, but only of such as was quarried and sold to the operators of blast furnaces. Some of the blast-furnace operators quarry their own limestone from quarries owned or leased by them, and as such stone does not come into the market in any way it does not appear in this table, which is intended to represent the value of the limestone output of the country in so far as the various products were sold by the producers.

Mr. James M. Swank, general manager of the American Iron and Steel Association, has kindly supplied figures showing the amount of limestone quarried by blast-furnace operators in 1896 for use as flux in their own furnaces. The amount thus quarried reaches a valuation of $685,756; these figures, added to the total given in the above table, $1,203,510, makes the total value of limestone quarried in the United States in 1896 for blast-furnace flux $1,889,266.

THE LIMESTONE PRODUCT, BY STATES, FROM 1890 TO 1896.

The following table shows the value of limestone, by States, since 1890:

Value of limestone, by States, from 1890 to 1896.

State.	1890.	1891.	1892.
Alabama	$324,814	$300,000	$325,000
Arizona	(a)	.....	.....
Arkansas	18,360	20,000	18,000
California	516,780	400,000	400,000
Colorado	138,091	90,000	100,000
Connecticut	131,697	100,000	95,000
Florida	(a)	.....	.....
Georgia	(a)	.....	.....
Idaho	28,545	.....	5,000
Illinois	2,190,607	2,030,000	3,185,000
Indiana	1,889,336	2,100,000	1,800,000
Iowa	530,863	400,000	705,000
Kansas	478,822	300,000	310,000
Kentucky	303,314	250,000	275,000
Maine	1,523,499	1,200,000	1,600,000
Maryland	164,860	150,000	200,000
Massachusetts	119,978	100,000	200,000
Michigan	85,952	75,000	95,000
Minnesota	613,247	600,000	600,000
Missouri	1,859,960	1,400,000	1,400,000
Montana	24,964	.....	6,000

a Limestone valued at $77,935 was produced in Oregon, Georgia, Florida, Arizona, South Dakota, and Wyoming. The value is included in the total.

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Value of limestone, by States, from 1890 to 1896—Continued.

State.	1890.	1891.	1892.
Nebraska	$207,019	$175,000	$180,000
New Jersey	129,662	100,000	180,000
New Mexico	3,862	2,000	5,000
New York	1,708,830	1,200,000	1,200,000
Ohio	1,514,934	1,250,000	2,025,000
Oregon	(a)	.....	.....
Pennsylvania	2,655,477	2,100,000	1,900,000
Rhode Island	27,625	25,000	30,000
South Carolina	14,520	50,000	50,000
South Dakota	(a)	.....	.....
Tennessee	73,028	70,000	20,000
Texas	217,835	175,000	180,000
Utah	27,568	.....	8,000
Vermont	195,066	175,000	200,000
Virginia	159,023	170,000	185,000
Washington	231,287	25,000	100,000
West Virginia	93,856	85,000	85,000
Wisconsin	813,963	675,000	675,000
Wyoming	(a)	.....	.....
Total	19,095,179	15,792,000	18,342,000

a Limestone valued at $77,935 was produced in Oregon, Georgia, Florida, Arizona, South Dakota, and Wyoming. The value is included in the total.

State.	1893.	1894.	1895.	1896.
Alabama	$205,000	$210,269	$222,424	$180,921
Arizona	15,000	19,810	24,159	18,470
Arkansas	7,611	38,228	47,376	30,708
California	288,626	288,900	322,211	143,865
Colorado	60,000	132,170	116,355	65,063
Connecticut	155,000	204,414	154,333	138,945
Florida	35,000	30,639	10,550	16,982
Georgia	34,500	32,000	12,000	29,081
Idaho	1,000	5,315	7,829	5,662
Illinois	2,305,000	2,555,952	1,687,662	1,261,359
Indiana	1,474,695	1,203,108	1,658,976	1,658,499
Iowa	547,000	616,630	449,501	410,037
Kansas	175,173	241,039	316,688	158,112
Kentucky	203,000	113,934	154,130	135,967
Maine	1,175,000	810,089	700,000	608,077
Maryland	.....	350,000	200,000	264,278
Massachusetts	156,528	195,982	75,000	118,622

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Value of limestone, by States, from 1890 to 1896—Continued.

State.	1893.	1894.	1895.	1896.
Michigan	$53,282	$336,287	$424,589	$109,427
Minnesota	208,088	291,263	218,733	228,992
Missouri	861,563	578,802	897,318	802,968
Montana	4,100	92,970	95,121	83,927
Nebraska	158,927	8,228	7,376	10,655
New Jersey	149,416	193,523	150,000	134,213
New Mexico	.....	4,910	3,375	.....
New York	1,103,529	1,378,851	1,043,182	1,591,966
Ohio	1,848,063	1,733,477	1,568,713	1,399,412
Oregon	15,100	.....	970	1,600
Pennsylvania	1,552,336	2,625,562	3,055,913	2,104,774
Rhode Island	24,800	20,433	.....	11,589
South Carolina	22,070	25,100	.....	26,000
South Dakota	100	3,663	4,000	3,126
Tennessee	126,089	188,664	156,898	157,176
Texas	28,100	41,526	62,526	77,252
Utah	17,446	23,696	22,503	9,358
Vermont	151,067	408,810	300,000	147,138
Virginia	82,685	284,547	268,892	182,640
Washington	139,862	59,148	75,910	83,742
West Virginia	19,184	43,773	42,892	59,113
Wisconsin	543,283	798,406	750,000	552,921
Wyoming	.....	.....	650	.....
Total	13,947,223	16,190,118	15,308,755	13,022,637

The following is a consideration of the general condition of the industry in the various productive States:

Alabama.—As in many other States, there was a decline in Alabama in the value of the output in 1896, i. e., from $222,424 in 1895 to $180,921 in 1896. Most of this value is that of lime made by the quarrymen from the limestone quarried. Considerable was used for blast-furnace flux. The producing counties are, in order of importance, Shelby, Franklin, Lee, Calhoun, Blount, and Jackson.

Analysis of limestone from Sheffield, Franklin County, Alabama.

	Per cent.
Silica (SiO_2)	0.50
Ferric oxide (Fe_2O_3)	1.45
Lime (CaO)	54.20
Magnesia (MgO)	1.23
Carbon dioxide (CO_2)	42.61
Total	99.99

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The following analysis was made at the Watertown Arsenal for Messrs. T. L. Fossick & Co.

Analysis of limestone from Siluria, Shelby County, Alabama.

	Per cent.
Calcium carbonate ($CaCO_3$)	99.13
Water (H_2O)	.08
Organic matter	.05
Silica (SiO_2)	.23
Alumina (Al_2O_3)	.21
Ferric oxide (Fe_2O_3)	Trace.
Magnesium carbonate ($MgCO_3$)	.12
Phosphoric acid (P_2O_5)	Trace.
Loss	.18
Total	100.00

Specific gravity, 2.84.

The following were taken from the report of the State geologist, Mr. E. A. Smith, for 1895:

Analysis of limestone, Longview, Shelby County, Alabama.

	1.	2.	3. (a)
	Per cent.	*Per cent.*	*Per cent.*
Carbonate of calcium	99.11	99.16	99.11
Carbonate magnesium	.75	.75	.14
Oxide of iron and aluminum	.13	Trace.	.21
Silica and insoluble	.39	.15	.23
Total	100.38	100.06	99.69

a By Prof. William Geuner, analytical chemist.

Specific gravity, 2.84.

Arizona.—A somewhat smaller quantity of output was realized in 1896 than in 1895, most of the value being that of lime made by the producers.

Arkansas.—The output of 1895 was valued at $47,376; of 1896 at $30,708. Most of the output is lime from stone quarried in Benton County.

California.—A marked decline characterized the year 1896 in this State. The value for 1895 was $322,211; for 1896, $143,865. The productive counties are, in order of importance, Kern, San Benito, Santa Cruz, Riverside, Santa Clara, Shasta, and Los Angeles. Most of the product is lime.

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Colorado.—The output of 1895 amounted to a valuation of $116,355; for 1896 the figure was $65,063. The stone was used chiefly for blast furnace flux; it was quarried in Jefferson, Pitkin, and Chaffee counties.

Connecticut.—Most of the output of limestone comes from Litchfield County; the rest from Fairfield County. It is practically all burned into lime, the value of which was $154,333 in 1895 and $138,945 in 1896.

Florida.—A small quantity of limestone was quarried in Marion County and practically all was burned into lime, the value of which was $16,982.

Georgia.—Limestone is quarried in Catoosa, Bartow, and Polk counties. It is practically all burned into lime, the value of which in 1896 was $29,081, about double the value of the product in 1895.

Idaho.—The value of lime made in 1896 was $5,610. Practically all the limestone quarried was burned into lime. Most of it was quarried in Kootenai County.

Illinois.—This State in the past has stood first in the production of limestone for building, but in 1896 it is second to Indiana, for whose output the value was $1,658,499, against $1,261,359 for Illinois in 1896. In 1895 the value of the product in Illinois was $1,687,662. The most important producing county is Cook County; Will County comes next in importance. Small quantities are produced in quite a large number of other counties in the State. The stone is largely used for building, flagging, and curbing. The extensive quarries in the vicinity of Lemont and Joliet have been fully described in former reports.

The following are physical tests of dolomite from Niota, Illinois:

Physical tests of limestone from Niota, Illinois.

Crushing strength per square inch	pounds..	14,120
Weight per cubic foot	do....	161
Specific gravity		2.58
Ratio of absorption	per cent..	0.0325

Weight per cubic foot of limestone taken from quarry at Grafton, Illinois, 156 pounds.

Physical tests of limestone from Joliet, Illinois.

Position		Bed.
Specific gravity		2.644
Ratio of absorption	per cent..	2.73
Crushing strength per square inch	pounds..	16,900
Weight per cubic foot	do....	170

Indiana.—For its output of ornamental and building limestone Indiana is the most important and interesting State in the Union. The stone is well known as Bedford oölitic limestone, and has been quite fully described in former reports. At present it is used over practically all parts of the country, and it is popular. Prices for the stone, owing to hard times and competition, have been declining. The value of the tota output of limestone, most of which is Bedford stone, was

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almost the same in 1896 as in 1895; the figures were $1,658,976 in 1895 and $1,658,499 in 1896.

The following paper is the result of careful investigation and is a valuable contribution to the literature of Indiana oölitic stone. In connection with the statistical portion it should be remembered that the figures apply to oölitic limestone only, and not to the entire limestone of the State, as is the case with the total for the State already given in the tables.

THE BEDFORD OÖLITIC LIMESTONE.

By T. C. Hopkins and C. E. Siebenthal.[1]

The term "Bedford oölitic limestone," so long and so well known in commercial circles, has now been adopted as a geologic term, and designates that bed of oölitic limestone of Lower Carboniferous or Mississippian age that forms an irregular area through southwest-central Indiana, and has been quarried in at least five counties. It is now one of the best and most widely known of our building stones, having been used in at least 24 States and Territories and in 1 foreign country. Its wide reputation is due to its general usefulness in masonry, ornamentation, and monuments; its abundance; the ease with which it can be quarried and dressed, and its pleasing color and durability. The stone is properly a calcareous sandstone or freestone, differing from the ordinary sandstones in having the grains composed of lime carbonate instead of quartz and in the grains being small fossils instead of sediment transported by water from the débris of some former rock mass. It differs from other limestone in its granular texture and freestone grain.

The stone has been variously designated in geological reports as St. Louis limestone, Warsaw limestone, Spergen Hill limestone, Bedford limestone, and by more local terms—Ellettsville limestone, Salem limestone, and names of other places where it has been quarried. The term Bedford oölitic limestone is believed to be the most appropriate term, as it is the one best known commercially.

The Bedford oölitic limestone extends in a general southerly direction from Greencastle, in Putnam County, to and beyond the Ohio River into the State of Kentucky, in a belt from 2 to 14 miles wide, averaging about 5 miles, covering parts of Putnam, Owen, Monroe, Lawrence, Washington, Perry, and Crawford counties, and is quarried in large quantities in Lawrence, Monroe, Owen, and Washington counties. The towns and villages of Bedford, Bloomington, Sanders, Ellettsville, Stinesville, Romona, Salem, and Heltonville are the points around which the quarries are clustered and from which the stone is shipped. The stone

[1] While this paper is to a certain extent the work of the two writers jointly, Mr. Siebenthal, who has recently prepared a detailed map of the productive part of the oölitic limestone area, assumes responsibility for the subject-matter under the headings "Location," "Stratigraphy," and "Statistics." Mr. Hopkins is responsible for the remainder of the topics and the arrangement of the paper.

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extends north of Gosport as far as Quincy, in Owen County, there being a single exposure as far north as Greencastle, Indiana, but it does not occur in commercial quantities north of Romona.

The valley of the north fork of White River at Gosport, in the north part of the oölitic area, is 570 feet above sea level, and the valley of the east fork of White River south of Bedford, south of the middle of the area, is 500 above sea level. Crests along the divide between these two forks in the vicinity of Bloomington are 900 to 950 feet high. The oölitic limestone has no topographic features distinguishing it from the other limestone. Where it forms the top rock of the ridge, the surface is gently undulating, and along the stream sources it frequently forms bold bluffs, but in both respects it is not different from other limestones of the area.

The Bedford oölitic limestone occurs in the sub-Carboniferous or Mississippian division of the Paleozoic. The associated sub-Carboniferous rocks are the Rockford goniatite limestone, the Knobstone group, the Harrodsburg limestone, the Bedford oölitic limestone, the Mitchell limestone, and the Chester or Kaskaskia group, named in order of superposition, with the oldest first.

The Harrodsburg limestone, which lies immediately below the Bedford oölitic limestone, is named from Harrodsburg, in Monroe County, where it is typically developed. It varies locally in character, being composed of massive fossiliferous crystalline limestone, blue and yellow shale, chert, compact and flaggy limestone, and in many places geodes. It varies from 60 to 90 feet in thickness.

The Mitchell limestone, immediately overlying the oölitic limestone, is named from the town of Mitchell, in Lawrence County, and consists of a series of impure limestones, calcareous shales, and fossiliferous limestones aggregating 150 to 250 feet in thickness. Specimens of lithographic limestone have been obtained from the group, but not in commercial quantities.

The Bedford oölitic limestone occurs in a massive bed varying in thickness from 25 to nearly 100 feet. The greater part of the stone is free from lamination or bedding seams. On weathered surfaces the lines of sedimentation, both true and false bedding, are brought out more or less conspicuously in several places. Sometimes even a shaly structure is developed by weathering. These are local features, as in many places the outcrop shows a comparatively regular surface, free from lamination. In almost every quarry or natural exposure there is at least one system of vertical or nearly vertical joint seams, and in many places two systems, one having a general eastward direction, the other a general north-south direction. The joint seams are rarely so numerous as to prevent the occurrence of stone in large dimensions.

Where there is a firm rock covering, the joints are seldom more than regular cracks or cleavage planes in the rock mass, but in many places where the overlying rock has disintegrated and the oölitic stone has no

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rock covering the weathering agencies have penetrated along the joint planes, forming irregular cave-like openings from a few inches to several feet across, which openings are now filled with the residual clay and soil, thus causing much waste and expense in quarrying. The stylolite seam, known to the quarrymen as "crow-foot" or "toe-nail," causes much waste. As seen on the face of the rock, it resembles roughly a suture joint, horizontal or nearly so, corresponding in a general way to a bedding seam, but differing from the ordinary bedding seam in the vertical jagged tooth-like projections on each side of the seam. The seam is frequently black from the collection of carbonaceous matter. These seams do not occur in all the quarries alike, some having one or two on every channel cut, some having only one or two on the whole quarry face, and a few being entirely free from them.

The Bedford stone is a granular limestone, a calcareous sand rock, in which both the grains and the cement are carbonate of lime. In the common sandstone the grains are hard and nearly angular; in the Bedford stone the grains are always soft and either round or rounded. In the siliceous sandstones the grains are harder than the cement; in the Bedford stone the cement is harder than the grains. The grains are almost entirely small fossil forms, mainly Foraminifera. These are commonly about the size of average sand grains, but in several places there are a great many larger fossils, brachiopods, gastropods, etc. The part containing these large fossils is not used for building stone, but is thrown out with the waste. The smaller forms that make up the mass of the rock vary in size in different localities, causing finer-grained stone in some localities. The finest-grained stone is the one most sought after, provided it is uniform in both grain and color.

All the Bedford stone is classed as buff, blue, or mixed. The blue is apparently the original color of at least the greater part of the stone, and is thought to be caused by the organic matter and the iron in the protoxide state, which, in contact with the oxidizing agents, give the buff color, the organic matter disappearing in gases and the iron changing to the protoxide state. There is so little of either present that the difference in color is but slight. The oxidation generally does not follow along regular lines, so that the parting is frequently marked by a very zigzag line, and in quarrying considerable stone containing the two colors intermingled, known as mixed stone, is produced, and while it is as strong and durable as any other it is nearly all thrown in the waste, as there is no demand for any but first-class stone.

The Bedford oölitic stone has been tested by most of the methods used for determining the qualities of building stone. The following table shows the specific gravity, weight per cubic foot, absorption and crushing tests made on the oölitic limestone. All of those not otherwise designated were made at the Rose Polytechnic Institute, Terre Haute, Ind. The compression tests were made upon approximately 2-inch cubes, each specimen being measured to the nearest one hundredth of an inch.

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As will be seen, the tests mostly range between 4,000 and 10,000 pounds to the square inch. Counting individual tests instead of the average, there were 5 out of 50 that were more than 11,000 pounds to the square inch, the highest being as high as 13,500 pounds.

The following table give the physical characteristics of the Bedford oölitic limestone:

Physical characteristics of Bedford oölitic limestone.

No.	Operators.	Locality.	Crushing strength per square inch.	Number of specimens tested.	Specific gravity.	Weight per cubic foot.	Ratio of absorption.	Authority.
			Pounds.			*Pounds.*		
1	G. K. Perry.....	Ellettsville .	10,000	4	.....	.....	1–31	Rose Polytechnic Institute.
2	Matthews Bros ...	.....do	13,500	.....	.....	142.2	1–28	General Gillmore.
3	Indiana Steam Stone Works.	Stinesville..	5,600	3	.....	.....	1–17	Rose Polytechnic Institute.
4	Hunter Valley Stone Co.	Bloomington	4,100	3	.....	.....	1–14	Do.
5	Hunter Brothers Stone Co.	.....do	5,700	3	2.46	153.7	1–19	Do.
6	Crescent Stone Co.	.....do	5,700	3	.....	.....	1–15	Do.
7	Romona Oölitic Stone Co.	Romona	9,100	4	2.48	155	1–39	Do.
8	Bedford, Ind., Stone Co.	Bedford	5,600	3	2.47	154.4	1–23	Do.
9	The Chicago and Bedford Stone Co.	.....do	8,600	3	.....	.....	1–31	Do.
10	Bedford Quarries Co.	.....do	4,450	4	.....	.....	1–15	Do.
11	Twin Creek Stone Co.	Salem	9,900	3	2.51	156.9	1–31	Do.
12	Dark Hollow Stone Co.	Bedford	6,625	.....	.....	142.9	1–19	General Gillmore.

Samples from each of the different districts in the State were tested thoroughly at high temperatures to find their fire-resisting properties. This was done by first heating them to a temperature of 619° F. and cooling, some in air and some in cold water, all the specimens remaining uninjured. The same experiment was tried at 779° F. and 928° F. with the same result—specimens uninjured except a slight discoloration. They were then heated to the temperature of melting aluminum, about 1,157° F., when the specimens cooled in water crumbled on the lower edges, the upper edges and faces being uninjured. Some were heated to "cherry red"—about 1,500° F.—and cooled in air. Calcination was pronounced, but the specimens retained their cubical form and sharp edges.

Samples from different districts were analyzed with the results shown on the accompanying table. They show a remarkable similarity in composition over the entire area, the carbonate of lime which constitutes almost the entire rock varying between 95 and 98.27 per cent, a varia-

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tion of less than 3 per cent in 16 different samples from widely separated localities.

The following table shows the chemical analyses of the Bedford oölitic limestone:

Chemical analyses of Bedford oölitic limestone.

No.	Quarry.	Calcium carbonate ($CaCO_3$).	Magnesium carbonate ($MgCO_3$).	Insoluble residue.	Iron oxide (Fe_2O_3).	Alumina (Al_2O_3).	Alkalies (K_2O, Na_2O).	Water (H_2O).	Total.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	Bedford Indiana stone quarry	98.27	0.84	0.64	0.15				99.90
2	Hunter Valley quarry	98.11	.92	.86	.16				100.05
3	Romona quarry	97.90	.65	1.26	.18				99.99
4	Twin Creek quarry	98.16	.97	.76	.15				100.04
5	Hoosier quarry, buff	98.20	.39	.63	0.39				99.61
6	Hoosier quarry, blue	97.26	.37	1.69	.49				99.81
7	Salem quarry	96.04	.72	1.13	1.06		0.15	0.10	
8	Mauckport quarry	98.09		.31	.18	0.14	.40	.12	
9	Big Creek quarry	93.80	4.01	.15	.64			1.09	99.69

The Bedford stone ranks among the most durable limestones in the market, proofs of which fact are (1) the chemical and physical tests showing its freedom from elements of weakness, its great uniformity of composition and texture, and its great elasticity in withstanding extremes of heat and cold; (2) the appearance of the stone in its outcrop, where it presents in many places hard compact, fairly regular faces, in some places forming perpendicular or overhanging cliffs; (3) old buildings and monuments. There are not many extremely old buildings constructed of this stone, as the first quarries were opened as late as about 1840, and it was not quarried on a large scale until after the war. The buildings that were erected at that early date, as well as those of more recent date, are all, as far as known, in a good state of preservation. In the old quarries from which the first stone was taken, there is no evidence of disintegration either on the quarry face or in the waste stone in the quarry, except that in a few places where water stands in the quarry, the stone has been observed to scale, especially where it is coarsely fossiliferous, for a few feet above the water.

There is probably not another stone in this country that works more freely and easily than the Bedford oölitic limestone. It almost rivals the French Caen limestone in this respect. The French stone is a little softer and a little more easily cut and carved, but it is also a much less durable stone. The Bedford stone is easily drilled and channeled and is thus not expensive to quarry. It is easily sawed, cut, and carved when

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it is first quarried. While it hardens on exposure, it never becomes so hard as granite, marble, or many of the sandstones. It is eminently adapted to carved and ornamental work, because of the ease with which it can be cut, while it is at the same time hard and durable enough to retain the marks and not to crumble under the carver's tool or on exposure.

Few building stones are more accessible than the Bedford oölitic limestone. Occurring as it does in an almost horizontal position, it outcrops over a comparatively large area, with either no covering at all or one so light that it can profitably be removed. A recently prepared geologic map of the area shows the total length of the outcrop in Owen, Monroe, and Lawrence counties to be not less than 1,600 miles. The topographic features are such that almost any point in the whole area is readily accessible by railway grade. This is practically demonstrated by the location of the different railways. The Monon Railway traverses the area from north to south over all the productive part, and that it was built before the value of the oölitic stone was known speaks well for the relative ease of building the road and for the agricultural prosperity of the region. There are also three east-west railroads and a short line known as the Belt, which serves to connect many quarries around Bedford with the other roads. There are short branch roads making switch connections with one or more of these roads running into each of the quarries.

The stone is practically all cut free on the four sides by a channeling machine. If the quarry is opened on the top of the bed, the center or the key block is removed by breaking it loose with wedges or bars at the side and lifting it out with the derrick. After the removal of the first block the subsequent blocks are removed by drilling holes along the bottom and wedging them loose, when they are lifted out with the derrick. Where the quarry is opened on the face of a cliff or a steep hillside, there is no key block, and the stone is worked back from the outcrop. In many of the larger quarries blocks from 20 to 50 feet long, 6 to 10 feet deep, and about 4 feet across are loosened. The channel cuts are commonly made either 6 feet 6 inches or 10 feet deep, but sometimes vary from these figures in order to utilize to best advantage the entire thickness of the bed and the varying thickness between the stylolyte or crowfoot seams. The stone is lifted from the quarry to the railway car by large derricks with steam-power hoists, and may be squared into mill blocks by the scabblers on the car, or it may be sent in the rough to the mill and there sawed into the desired forms for the order in hand. The saws are almost entirely the common gang saw with long iron blades made to swing to and fro across the stone, sand and water being fed under each saw automatically. One of the mills is supplied with a large diamond saw, and one company uses the wire-cable saw, first for sawing dimension stone in the yard, later for sawing stone from the quarry. In the stone mill, besides the saws, there are stone planers

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and headers or jointers and lathes for smoothing, trimming, and shaping the stone. The large mills are also supplied with overhead travelers, operated by steam or electricity.

The major part of the stone is used for fine dimension stone for buildings, both for face work and trimmings. It forms one of the best known and most widely used building stones in the American market, having been used in a great many public and private buildings. It has been used in at least four State houses—Indiana, Illinois, Georgia, and New Jersey—and one of the State buildings (the library) of Pennsylvania. It is known to have been used in not less than 20 court-houses in Indiana and in many Government buildings—custom-houses and post-offices—throughout the country. It finds equal favor for both face stone and trimmings, its light color harmonizing so well with many of the different colored stones throughout the country, and the ease with which it can be worked making it of double value in trimmings. A large quantity of it is used for monumental purposes, as bases for monuments or for monuments themselves. Much is used for pavements, being first sawed into flags. It makes a strong and durable pavement and does not wear slippery, as many limestones do. It is used for curbing and sewer piers and abutments, but bridge stone is mostly a cheaper grade of stone, which it does not pay to ship long distances. In a number of places it has been burned for quicklime, of which it makes a pure quality. In only two points, Salem and Romona, has this proven successful and of long duration. Limekilns at Ellettsville, Bloomington, and south and southwest of Bedford have long been abandoned and fallen into decay. In recent years it has been acquiring a local use for ballast for both railways and wagon roads.

The following table shows the commercial importance of this industry in the State. This table has been carefully prepared, and is as reliable as such tables can be made. The figures showing the capital, number of men, production, and value were necessarily obtained from the operators, but the other data were obtained by direct observation, each of the writers having visited every oölitic limestone quarry in the State. The figures do not show the total value of the stone, as much of it is shipped in the rough and sawed and cut to dimensions in the cities, at mills in Chicago, Philadelphia, New York, and elsewhere, which gives the stone an added value, but the data for which are not available.

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Statistics of the Bedford oölitic limestone production in Indiana.

	North district: Romona, Big Creek, Stinesville, Ellettsville.	Middle district: Bloomington, Hunter Valley, Sanders.	Southern district: Bedford, Dark Hollow, Reeds Station, Oölitic, Peerless, Paradise, Heltonville, Salem.	Mills in Indianapolis.	Total.
Cubic feet of stone produced in—					
1895	1,295,000	1,812,716	3,030,591	.....	6,138,307
1896	673,000	1,343,926	3,438,656	.....	5,455,582
Value of stone produced in—					
1895	$311,875	$420,487	$771,468	$19,430	$1,523,260
1896	$165,697	$294,635	$725,883	$23,417	$1,209,632
Capital invested, 1896	$497,700	$458,400	$1,337,000	$26,500	$2,319,600
Number of men employed in—					
1895	473	424	825	62	1,784
1896	315	374	787	60	1,536
Number of quarries in operation recently	12	15	21	.....	48
Number of channeling machines in operation	19	39	78	.....	136
Number of channeling machines idle	11	7	11	.....	29
Number of steam drills in operation	15	15	44	.....	74
Number of steam drills idle	4	3	5	.....	12
Number of derricks in operation	24	29	49	1	103
Number of derricks idle	6	3	8	.....	17
Number of derrick turners in use	3	10	24	.....	37
Number of planers and jointers	6	3	16	4	29
Number of saw gangs in operation	*a* 32	32	68	11	143
Number of saw gangs idle	9	.....	9	.....	18
Number of steam and electric travelers	4	3	12	1	20
Number of lathes in operation	4	0	6	.....	10
Number of limekilns in recent operation	1	.....	5	.....	6

a One wire saw or cable way, and 1 diamond saw.

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Iowa.—The output of limestone in Iowa in 1895 was valued at $449,501; in 1896 at $410,037. There has thus been something of a decline, although not so great as might have been expected. The production of limestone is spread over many counties in the State, and the industry is on the whole an important one. Most of the output is used for building and roadmaking. The producers are quite numerous, and there are but few who are doing business on what might be called a large scale.

The following are tests of limestone from Stone City, Iowa:

Physical tests of limestone from Stone City, Iowa.

Crushing strength per square inch	pounds..	5,150
Weight per cubic foot	do....	136
Specific gravity		2.3

Kansas.—Production declined from $316,688 in 1895 to $158,112 in 1896. Stone quarries are quite numerous and widespread, but none of them are operated by very large concerns.

Kentucky.—The value of the limestone output declined from $154,130 in 1895 to $135,967 in 1896. The Bowling Green oölitic stone is one of interest to builders and is quite unique in character. Some of the stone gives excellent lime on burning.

Maine.—The limestone industry of Maine is almost entirely limited to Knox County, where, at Rockland and Rockport and vicinity, large quantities of lime are made for shipment to numerous points of consumption on the Atlantic coast. The value of the lime made in Maine in 1896 was $608,077. The figure for 1895 was $700,000 and for 1894 $810,089; it is thus evident that production has been decreasing for some time.

Maryland.—The total value of the limestone output in 1896 was $264,278. This represents a gain of more than $64,000 over 1895. Of this amount more than $250,000 is the value of lime made from the limestone quarried. Oyster shells are quite freely used for lime burning in this State, and some years ago, when blast furnaces were more active than at present in the vicinity of Baltimore, they were also consumed as flux.

The productive counties for limestone in the order of their importance are Frederick, Baltimore, Washington, Allegany, and Howard. The first two are about equally productive and are far in advance of the others.

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The following is the result of an analysis of limestone from the vicinity of Highlands, Howard County, by Prof. H. J. Patterson:

Analysis of limestone from Howard County, Maryland.

	Per cent.
Calcium carbonate ($CaCO_3$)	77.82
Magnesium carbonate ($MgCO_3$)	3.19
Insoluble matter	13.60
Oxide of iron and alumina	5.15
Undetermined	.24
Total	100.00

Massachusetts.—Production increased from a valuation of $75,000 in 1895 to $118,622 in 1896. The output comes almost entirely from Berkshire County. Most of the product was made into lime.

Michigan.—The total value of the product in 1896 was $109,427. This is quite a heavy falling off as compared with 1895, when the output was valued at more than $300,000.

Analysis of limestone from Michigan quarries at Bay Port, Huron County.

	Per cent.
Silica (SiO_2)	3.330
Oxide of iron and alumina	1.334
Magnesium carbonate ($MgCO_3$)	.944
Calcium carbonate ($CaCO_3$)	91.538
Phosphorus and sulphur	Traces.
Organic matter and loss	2.854
Total	100.000

Analysis of limestone from quarries at Dundee, Monroe County, Michigan.

	Per cent.
Silica (SiO_2)	1.10
Calcium carbonate ($CaCO_3$)	86.80
Magnesium carbonate ($MgCO_3$)	11.60
Oxide of iron and alumina	.12
Total	99.62

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Analyses of limestone from quarries at Trenton, Wayne County, Michigan (different depths.) (a)

	No. 1.	No. 2.	No. 3.
	Per cent.	*Per cent.*	*Per cent.*
Calcium carbonate ($CaCO_3$)	85.00	88.50	96.00
Magnesium carbonate ($MgCO_3$)	12.36	6.93	2.10
Silica (SiO_2)	2.00	2.24	.70
Oxides of iron and alumina	Traces.	Traces.	.00
Loss	.64	2.33	1.20
Total	100.00	100.00	100.00

a By K. J. Sundstrom, chemist.

Minnesota.—Production increased from a valuation of $218,733 in 1895 to $228,992 in 1896. Reports from individual producers are more encouraging in tone than they were in 1895. The output is largely used for building and road making. The most productive county is Lesueur.

Missouri.—The limestone industry of this State is an important one, being scattered over 26 different counties, of which Jackson, St. Louis, Greene, Jasper, Marion, and Pike are the most important.

The value of the product in 1896 was $802,968, which is somewhat below that for 1895. Over $500,000 worth of the stone is used for building and road making, while nearly all the remainder represents the value of lime made.

The following analysis, made by Chauvenet & Bro., of the limestone of Hannibal, Marion County, shows the stone to be a very pure carbonate of calcium:

Analysis of limestone from Hannibal, Missouri.

	Per cent.
Silica (SiO_2)	0.08
Oxides of iron and aluminum	.40
Magnesia (MgO)	.02
Calcium carbonate ($CaCO_3$)	98.80
Total	99.30

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The following were also made by Chauvenet & Bro.:

Analysis of limestone from Ralls County, Missouri.

	Per cent.
Calcium carbonate	99.64
Silica	.15
Magnesium carbonate	.21
Total	100.00

Analysis of limestone from Greene County, Missouri.

	Per cent.
Silica (SiO_2)	0.33
Oxide of iron	.21
Carbonate of calcium	99.46
Total	100.00

Montana.—The limestone output of this State was valued at $83,927, a figure slightly below that of the previous year. The product is used mainly for blast-furnace flux, and comes from Cascade and Jefferson counties, which are about equally productive.

Nebraska.—A small amount of limestone used mainly for building and road making was quarried in 1896. The most important counties are Cheyenne, Pawnee, and Gage.

New Jersey.—Most of the limestone quarried in New Jersey is burned into lime. The total value of the output in 1896 was $134,213. The most productive county is Sussex.

New York.—Thirty different counties in this State produce limestone. The total value of the output in 1896 was $1,591,966. Of this total $1,152,787 represents the value of lime made. Onondaga County produced nearly $900,000 worth of the output, while Warren County stood second with an output valued at $103,877. Quite an advance was made in 1896.

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Analysis of limestone made in Onondaga County, New York.

	Per cent.
Silica (SiO_2)	5.50
Oxides of iron and alumina	1.99
Calcium oxide (CaO)	84.40
Calcium carbonate ($CaCO_3$)	4.80
Magnesium oxide (MgO)	1.80
Calcium sulphate ($CaSO_4$)	.65
Total	99.14

Analysis of limestone from Ulster County, New York.

	Per cent.
Carbonate of calcium	97.00
Silicious material	2.60
Oxide of iron	.40
Total	100.00

The following is an analysis of dolomite used in the sulphite pulp mills at Watertown, New York:

Analysis of dolomite from Natural Bridge, New York.

	Per cent.
Silica (SiO_2)	0.24
Oxides of iron and aluminum	.24
Calcium oxide (CaO)	22.43
Magnesium oxide (MgO)	29.48
Carbon dioxide (CO_2)	47.73
Total	100.12

Analysis of lime made in Washington County, New York.

	Per cent.
Silica (SiO_2)	0.23
Alumina (Al_2O_3)	1.04
Ferric oxide (Fe_2O_3)	.25
Calcium oxide (CaO)	97.64
Magnesium oxide (MgO)	.80
Total	99.96

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Analysis of lime from West Coxsackie, Greene County, New York.

	Per cent.
Calcium oxide (CaO)	90.066
Magnesium oxide (MgO)	7.405
Oxides of iron and aluminum	.753
Insoluble matter	1.776
Total	100.000

Ohio.—Thirty-two counties of the State yield limestone. Of these the most important are Ottawa, Erie, Marion, and Wood, in the order named. The total value of the output in 1896 was $1,399,412, while in 1895 it was $1,568,713; there has been evidently a falling off, although, comparatively speaking, it is not serious. The value of the lime made was $835,594. Most of the remaining value is of stone devoted to building and roadmaking.

Analyses of limestone from Ohio.

Locality.	Calcium carbonate ($CaCO_3$).	Magnesium carbonate ($MgCO_3$)	Alumina (Al_2O_3).	Ferrous oxide (FeO).	Ferric oxide (Fe_2O_3).	Phosphoric anhydride (P_2O_5).	Silica (SiO_2).	Total.
	Per cent.	*Per cent.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Per cent.*	*Per cent.*	*Per cent.*
Snowflake limestone, Wood County	53.98	43.25	0.43	.....	.....	.....	1.53	99.19
Fostoria, Wood County	52.00	45.26	2.70			.....	Trace.	99.96
Sugar Ridge, Wood County	55.23	43.12	.65			.....	.84	99.84
Williston, Ottawa County	53.90	44.82	.21			0.0011	.21	99.1411
Rex, Miami County (*a*)	95.60	3.93	.40			.....	Trace.	99.93
Steece, Lawrence County	93.12	.98	.....	.....	1.92	.....	3.12	99.14
Youngstown, Lawrence County	95.30	.....	1.25	.....	.....	.017	*b* 3.45	100.017
Tiffin, Seneca County	57.48	40.36	.10	.....	.03	.....	1.62	*c*100.00

a Made by Professor Orton. *b* Silicates. *c* Includes 0.41 per cent H_2O.

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Pennsylvania.—The limestone industry of Pennsylvania during the year 1896 overtops that of any other single State. The total value of the output was $2,104,774. Of this amount $1,082,682 represents the value of lime made, $586,661 that of blast-furnace flux, and $435,431 that of stone devoted to building and road making. Thirty-seven counties of the State are productive of limestone. Of these the following are the most important, in the order given: Chester, Blair, Montgomery, Lawrence, Westmoreland, Berks, Northampton, Lehigh, Lancaster, and York. The value of the output from these counties is $1,505,312; the value of the output from no single one of the remaining counties is as much as $50,000. Over 1,400 separate quarries have sent in carefully prepared returns of output. Much of the lime made is used for fertilizing purposes, and consumption is decidedly on the increase. The price for such lime is 6 or 7 cents per bushel, although it is sometimes as low as 5½ cents.

The following are analyses of limestone from various localities in Pennsylvania:

Analyses of Pennsylvania limestone.

Locality.	Calcium carbonate ($CaCO_3$).	Calcium oxide (CaO).	Magnesium carbonate ($MgCo_3$).	Magnesium oxide (MgO).	Alumina (Al_2O_3).	Ferrous oxide (FeO).	Ferric oxide (Fe_2O_3).	Silica (SiO_2).	Phosphoric anhydride (P_2O_5).	Miscellaneous.	Total.	Authority.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	
Hanover, Adams County	83.12	.....	8.23	.....	0.03			0.53	0.10	*a* 4.23 *b* 3.20	99.44	
Lebanon, Lebanon County	.....	38.81	.....	12.85	3.75			2.80	.....	.....	.....	
Greshville, Berks County	87.267	.....	8.324	.....	.810			3.48	.006	.....	99.887	Prof. Andrew McCreath.
Avondale, Chester County	94.27	.....	1.56	.....	.26			.....	.....	*b* 3.91	100.00	
Bethlehem, Lehigh County *c*	.....	28.78	.....	20.86	1.60			3.53	.009	*d* 45.30	100.079	
Bridgeport, Montgomery County	53.491	.....	45.759	.....	.....	.....	0.45	.20	.....	.....	99.90	Booth, Garrett, and Blair.
Do	54.044	.....	45.506	.....	.....	.....	.20	.25	.....	.....	100.00	Do.
Esterly, Berks County	55.58	.....	39.21	.....	1.22			3.89	.....	.....	99.90	Mr. Chas. T. Davies.
Fairfield, Adams County	85.23	.....	2.78	.....	1.50			10.30	.....	*e* .19	100.00	Franklin Menges, Ph. D.
Do	83.92	.....	3.11	.....	.....	.....	.60	11.85	.10	*f* .38	99.96	
Northampton, Northampton County.	93.01	.....	.69	.....	0.67	.....	.20	4.18	.....	.....	98.75	Do.
Northampton County	57.88	.....	39.95	.....	.97			1.20	.....	.....	100.00	Do.
Turbotville, Northumberland County.	96.125	.....	1.767	.....	2.108			.....	.....	.....	100.00	
Williamson, Franklin County	97.357	.....	1.551	.....	.290			.85	.002	*g* .015	100.065	

a K_2Co_3. *b* Insoluble. *c* Largely used as flux. *d* CO_2. *e* H_2O and loss. *f* K_2O. *g* Sulphur.

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Limestone from Avondale varies in composition, particularly in the amount of magnesium carbonate, which is sometimes as high as 38 per cent, approaching dolomite in its constitution.

The following are analyses of lime from various localities in Pennsylvania:

Analyses of Pennsylvania lime.

Constituents.	Hanover, Adams County.	Emigsville, York County.	Dalmatia, Northumberland County. a
Calcium oxide (CaO)	92.00	90.68	81.38
Magnesium oxide (MgO)	3.55	1.90	1.32
Ferric oxide (Fe_2O_3)	.03	.14	6.80
Ferrous oxide (FeO)			
Alumina (Al_2O_3)			
Silica (SiO_2)	.53	.53	.....
Potassium carbonate (K_2Co_3)	4.23	.....	.....
Potassium oxide (K_2O)	.....	.....	.65
Phosphoric anhydride (P_2O_5)	.....	.....	.35
Carbon dioxide (CO_2)	.....	.....	7.05
Water (H_2O)	.....	6.75	
Undetermined	.....		.....
Insoluble	.....	.....	2.43
Total	100.34	100.00	99.98

a Analyzed by Dr. William Frear.

Rhode Island.—The production of limestone in this State has always been quite limited in amount. Quarries are operated to some extent at Lime Rock, Providence County.

South Carolina.—Limestone is produced in Cherokee County in comparatively small amount. Most of it is burned into lime, which has a good reputation for building.

South Dakota.—Very little was accomplished in this State in 1896. The stone is used for building and for burning into lime. The productive quarries are in Lawrence and Custer counties.

Tennessee.—The limestone produced in this State is about equally divided between lime burning and building. Blast furnaces quarry their own stone largely, and such production is not included in the figures given in the table for Tennessee. Eleven counties in the State produce limestone, but most of it comes from Davidson, Hamilton, Franklin, and Dickson counties.

Texas.—Production in 1896 amounted to $77,252. This is somewhat in excess of the output in 1895. Most of the product is burned into lime. El Paso and Coryell counties are the most productive. Smaller amounts are quarried in Williamson, Hood, and Travis counties.

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Utah.—Small amounts of limestone were quarried in Salt Lake and San Pete counties.

Vermont.—Production of limestone fell off somewhat in 1896. Quarries were operated in Franklin, Windham, Addison, and Windsor counties.

An analysis of limestone from the quarry of Palmer & Everett, New Haven, Addison County, showed 98.37 per cent of calcium carbonate ($CaCO_3$.)

Virginia.—The production of limestone in Virginia fell off from $268,892 in 1895 to $182,640 in 1896. In the consumption of limestone for blast furnace flux, Virginia stood in third place in 1896, according to the figures of Mr. James M. Swank. The value of this flux amounted to about $350,000, including what was sold to blast furnaces and also what was quarried by the blast-furnace operators themselves. Limestone is quarried in twelve counties, of which Botetourt, Alleghany, Warren, and Shenandoah are the most important.

Analysis of limestone from Botetourt County, Virginia. (*a*)

	Per cent.
Calcium carbonate ($CaCO_3$)	98.71
Magnesium carbonate ($MgCO_3$)	.65
Oxides of iron and aluminum	.31
Silica (SiO_2)	.25
Total	99.92

a Analyzed by Dr. Henry Froehling.

Analysis of limestone from Riverton, Warren County, Virginia.

	Per cent.
Calcium carbonate ($CaCO_3$)	98.290
Magnesium carbonate ($MgCO_3$)	.462
Iron carbonate ($FeCO_3$)	.167
Silica (SiO_2)	.533
Organic matter, etc	.578
Total	100.030

Washington.—Production of limestone in 1896 slightly exceeded that of 1895. The product was almost entirely converted into lime, and was quarried in San Juan County.

West Virginia.—Limestone is quarried in Berkeley, Jefferson, Greenbrier, and Tucker counties. Most of it was converted into lime.

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The following is an analysis of stone from Greenbrier County:

Analysis of limestone from Fort Spring, Greenbrier County, West Virginia.

	Per cent.
Calcium carbonate ($CaCO_3$)	96.46
Organic matter and loss	Trace.
Insoluble silicious matter	.97
Sulphur	None.
Oxide of aluminum (Al_2O_3)	1.46
Phosphoric acid	None.
Magnesium carbonate ($MgCO_3$)	1.21
Total	100.10

Wisconsin.—Twenty-eight counties of the State produce limestone. As will be seen from the table, the value of the limestone products in 1896 was something over more than half a million dollars, and less than in 1895. The output is divided in its uses between lime burning and building, somewhat more than half being converted into lime. Among the most important counties producing limestone are Calumet, Brown, Manitowoc, Fond du Lac, Waukesha, Milwaukee, and Racine.

Analysis of limestone from Calumet County, Wisconsin.

	Per cent.
Calcium carbonate ($CaCO_3$)	55.09
Magnesium carbonate ($MgCO_3$)	43.96
Silica (SiO_2)	.59
Oxide of aluminum	.36
Total	100.00

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SOAPSTONE.

By Edward W. Parker.

OCCURRENCE.

Soapstone, or talc, is found in nearly every State along the Atlantic slope, the principal deposits being in New York and North Carolina, though it is also quarried in New Hampshire, Vermont, Massachusetts, New Jersey, Pennsylvania, Maryland, Virginia, and Georgia. It has also been reported in some of the Western States, particularly in California, Arizona, South Dakota, Arkansas, and Texas. Prior to 1896 all of the commercial product in the United States was reported from States east of the Mississippi River. Last year, however, an output of 150 tons of soapstone was reported from Santa Catalina Island, in Los Angeles County, California. The California soapstone, so called, is of two qualities, one being soft and suitable for most of the purposes for which soapstone is used, the other much harder and resembling serpentine. The latter is said to make an excellent substitute for marble in columns and monuments and for wainscoting and other interior work, being fireproof and acid proof, like soapstone, and having the hardness and beauty of marble. The soapstone deposits of the Eastern States show widely varying qualities. In some places, notably at Gouverneur, Saint Lawrence County, New York, it occurs in a foliated or fibrous form, which makes it valuable as a filler or makeweight in the manufacture of medium grades of paper. This variety is known as fibrous talc, and is treated separately in these reports. The soapstone of Maryland, Pennsylvania, and New Jersey is also extensively used in paper manufacture. The entire product is ground. New Hampshire, Virginia, and North Carolina furnish soapstone suitable for sawing and manufacture into sinks, washtubs, griddles, slate pencils, etc. North Carolina also produces a very pure white soapstone which is used as the principal ingredient in complexion powders.

PRODUCTION.

The soapstone product of the United States in 1896 amounted to 22,183 short tons (exclusive of the product of fibrous talc), a slight gain over the output of 1895, which was 21,495 short tons. A small amount of soapstone ground for pigment is included among mineral paints, and is not considered here.

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Comparing the statistics of soapstone production in 1895 and 1896, as shown in the following table, it is seen that the product sold in the crude state during 1896 was about 50 per cent more, both in amount and value, than it was in 1895. The amount sawed into slabs increased from 863 tons to 923 tons, or about 7 per cent, while the value increased 25 per cent, from $12,320 to $15,481. The increase in the amount of ground soapstone sold was 775 tons, or about 9 per cent. The value of the ground material increased a little less than 25 per cent. The increase in the value of manufactured articles shows the greatest difference when compared to the product. The amount of soapstone manufactured in 1896 was less by 656 tons than it was in 1895; the value indicates an increase of $61,470. This can not be taken as indicating a sharp advance in price. It must be considered as showing merely a difference in the class of manufactured articles. In 1894, when the amount of soapstone manufactured was only 6,425 tons, the value of the product was $244,000, representing a value of about $38 per ton. In 1895 the value per ton was not quite $16, and in 1896 it was a little less than $22. As stated in the footnote following the table, the output of manufactured articles in 1896 includes 50 tons made into crayons. In 1895 only 1 ton was so reported.

Production of soapstone in 1893, 1894, 1895, and 1896.

Condition in which marketed.	1893.		1894.	
	Short tons.	Value.	Short tons.	Value.
Rough	5,760	$51,600	5,620	$50,780
Sawed into slabs	104	4,400	1,303	19,500
Manufactured articles (*a*)	7,070	123,600	6,425	244,000
Ground (*b*)	8,137	75,467	9,796	87,045
Total (*c*)	21,071	255,067	23,144	401,325

Condition in which marketed.	1895.		1896.	
	Short tons.	Value.	Short tons.	Value.
Rough	1,041	$8,886	1,550	$13,375
Sawed into slabs	863	12,320	923	15,481
Manufactured articles (*a*)	*d* 10,789	170,791	*e* 10,133	232,261
Ground (*b*)	8,802	74,498	9,577	92,948
Total (*c*)	21,495	266,495	22,183	354,065

a Includes bath and laundry tubs; fire brick for stoves, heaters, etc.; hearthstones, mantels, sinks, griddles, slate pencils, and numerous other articles of everyday use.

b For foundry facings, paper making, lubricators, dressing skins and leather, etc.

c Exclusive of the amount used for pigment, which is included among mineral paints.

d Includes 1 ton of soapstone, reported as 325 gross of slate pencils.

e Includes 50 tons manufactured into crayons and slate pencils.

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In the following table is shown the amount and value of soapstone produced in the United States since 1880, exclusive of fibrous talc and soapstone ground for paint:

Annual product of soapstone since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	8,441	$66,665	1889	12,715	$231,708
1881	7,000	75,000	1890	13,670	252,309
1882	6,000	90,000	1891	16,514	243,981
1883	8,000	150,000	1892	23,208	423,449
1884	10,000	200,000	1893	21,070	255,067
1885	10,000	200,000	1894	23,144	401,325
1886	12,000	225,000	1895	21,495	266,495
1887	12,000	225,000	1896	22,183	354,065
1888	15,000	250,000			

FIBROUS TALC.

The supply of this variety of soapstone is obtained only at Gouverneur, Saint Lawrence County, New York. The entire output is ground, and used principally as a filler in the manufacture of medium grades of paper. A small amount goes to paint manufacturers and into the manufacture of wall plasters. The product in 1896 was 46,089 short tons against 39,240 short tons in 1895, an increase of 6,849 short tons, or 17 per cent. The value of the product increased less in proportion, from $370,897 to $399,443, a gain of $28,546, or less than 8 per cent. The value per ton of ground talc declined from $9.05 in 1895 to $8.87 in 1896, the decline being due to overproduction.

The following table shows the amount and value of fibrous talc used for different purposes in 1895 and 1896.

Disposition of fibrous talc product in 1895 and 1896.

	1895.		1896.	
	Short tons.	Value.	Short tons.	Value.
Sold crude	.....	.....	1,363	$2,726
Paper filling	39,021	$369,007	44,726	396,717
Paint	48	552		
Wall plasters	171	1,338		
Total	39,240	370,897	46,089	399,443

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The annual production of fibrous talc since 1880 has been as follows:

Annual production of fibrous talc since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880.....	4,210	$54,730	1889.....	23,746	$244,170
1881.....	*a* 7,000	60,000	1890.....	41,354	389,196
1882.....	*a* 6,000	75,000	1891.....	53,054	493,068
1883.....	*a* 6,000	75,000	1892.....	41,925	472,485
1884.....	*a* 10,000	110,000	1893.....	35,861	403,436
1885.....	*a* 10,000	110,000	1894.....	39,906	435,060
1886.....	*a* 12,000	125,000	1895.....	39,240	370,897
1887.....	*a* 15,000	160,000	1896.....	46,089	399,443
1888.....	*a* 20,000	210,000			

a Estimated.

THE TALC DEPOSITS OF SAINT LAWRENCE COUNTY, NEW YORK.[1]

* * * While precise data are lacking, it is safe to say that about three-quarters of Saint Lawrence County lie within the area of crystalline rocks constituting the Adirondack region. In this portion of the county the most abundant rocks are gneisses; the term gneiss being used in a very broad sense, and implying nothing as to the origin of the rocks. Much less extensive, but of great interest, both scientifically and economically, are the crystalline limestones, which form large irregular belts, with a general northeast and southwest trend, separated by areas of gneiss. Sometimes the limestone is sufficiently pure and uniform in color and composition to be quarried for building and monumental marble; but more often it is unsuited for these purposes, commonly through the presence of various disseminated minerals. Of these, one of the most widespread is tremolite. Specimens of this mineral in handsome groups of crystals from localities in Gouverneur, Pierrepont, Russell, etc., are to be found in most mineral collections; but these represent exceptional occurrences, limited in number and extent. More commonly, the tremolite forms very imperfect, bladed crystals scattered through the limestone, sometimes in such abundance as to constitute a tremolite schist. The individuals are very thin, elongated in the direction of the vertical axis and decidedly columnar or fibrous in structure. They are prevailingly white, though pink, brown, and gray varieties appear at times. When the tremolite is in sufficient quantity to make up the bulk of the rock, it forms masses of interlocking fibers, in which it is difficult to distinguish any clearly defined individuals. Sometimes enstatite is present in large amount, mingled with or taking the place of the tremolite in the schist. It is usually light colored or white, and so strongly resembles tremolite that the two minerals can hardly be distinguished in the field, requiring optical examination for their discrimination. This phase of the limestone formation has its greatest development in the towns of Fowler and Edwards; and as it is here intimately associated with the talc deposits it is of importance in the present connection, affording, in fact, the best line of approach for the consideration of the talc.

[1] Extract from a paper by C. H. Smyth, jr., on the "Genesis of the talc deposits of Saint Lawrence County, New York:" School of Mines Quarterly, No. 4, Vol. XVII.

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The limestone of this belt is usually impure, containing many layers of varying thickness, composed largely of silicates. Conspicuous among these is a thick body of tremolite and enstatite schist which stretches across part of Fowler and Edwards, a distance of 7 or 8 miles, and contains the important talc deposits. The strike of this rock is northeasterly, with a northerly dip varying from about 40° to vertical. In these large structural features it is quite conformable with the limestone, into which it gradually passes, both above and below. The relations shown between this schist and the limestone, as well as similar phenomena repeated on a smaller scale at many points, seem to prove that they are different portions of one formation, which, as shown by the study of the geology of the region, must be regarded as of sedimentary origin. This is an important point in tracing out the history of the talc deposits, and will require further consideration after the description of the latter.

The intimate association of the talc with the other silicates has been recognized in all descriptions of the deposits, but their structural relations have not been clearly described. In most accounts it is stated that the talc forms a clearly defined vein with walls of granite or gneiss, the vein being penetrated by and including horses of tremolite.

According to the writer's observations, the talc occurs in the form of beds lying wholly within the schist of the limestone formation. These beds range in thickness from 30 down to a few feet, and sometimes pinch out. They dip and strike with the rest of the formation and have schist for both foot and hanging walls, sometimes with an intervening thin layer composed largely of quartz. There is little in the character of the beds to suggest a vein formation, while the walls of gneiss and granite are wholly lacking.

A brief examination suffices to show that, as might be expected, the association of talc with tremolite and enstatite schist is not fortuitous, but has a genetic basis. Between the two rocks there is a complete gradation, but not, as in the case of the schist and limestone, of such a character as to indicate that present differences are the result of primary variation. On the contrary, it is evidently a gradation resulting from secondary causes which have led to the conversion of tremolite and enstatite into talc. The talc nearly always shows more or less of the bladed, columnar, or fibrous structure which characterizes the tremolite and enstatite, although in some cases the structure becomes quite obscure. But the most compact and structureless talc shades off into the more abundant bladed variety, and this again into schist. A specimen of the talc usually shows bladed and fibrous portions, with smaller quantities of scaly and wax-like materials. The color is greenish white, with pearly, silky, or greasy luster. In the eastern part of the belt the fibrous structure is generally very marked. Toward the west this structure becomes less conspicuous, and the material is more compact, with a considerable amount of the scaly variety. This is the so-called "foliated talc," and is well shown in the American mine in Fowler.

Conclusions as to the relations between the two rocks, based upon field study, are entirely supported by microscopic examination. Sections of the talc show every stage from original tremolite or enstatite to a complete alteration of the mineral into talc. When crushed with a hammer, the softer specimens of fibrous talc yield a more or less coherent, felt-like mass of fibers, the length and toughness of the fibers varying considerably. Under the microscope the coarser fragments are semitransparent, and closely resemble fragments of the original minerals, but have numerous fine, straight rulings parallel to the original cleavage. Subjected to pressure under a glass slip these fragments separate into fibers parallel to the rulings, the number and fineness of the fibers being proportional to the pressure applied. Naturally the transmission of light is much impeded, and the specimen, though thinned by the pressure, becomes decidedly less transparent. It is evident that the talc is not made up of bundles of loosely aggregated fibers, but of homogeneous masses, with a tendency toward a fibrous fracture. This fracture is parallel to the

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cleavage of the original mineral, so far as the vertical element of the latter is concerned, and is, in a sense, an inheritance from the tremolite or enstatite, by whose original structure it has been conditioned in its development. In thin sections, however, there are parts of the talc that consist of distinct fibers, often irregularly arranged. In some cases these appear to be direct products of growth of the mineral; but in others, and perhaps in all, they are the result of the application of pressure to compact homogeneous masses like those described above. That the rocks have been subjected to much pressure is clearly shown by abundant slips and slicken sides. In some thin sections there is good reason for believing that the fibrous structure has been made more evident by the pressure of grinding.

IMPORTS.

The following table exhibits the imports of talc of all kinds since 1880. From 1880 to 1889 the imports were fairly regular. Since 1889 they have been very irregular. From 19,229 short tons, valued at $30,993 in 1889, they dropped to 1,044 tons, worth $1,560 in 1890, and 81 tons, worth $1,121 in 1891. They increased in 1892 to 531 tons, and again in 1893 to 1,360 tons, decreasing in 1894 to 622 tons. In 1895 they increased to 3,165 short tons, valued at $26,843, decreasing again in 1896 to 1,966 tons, worth $18,693.

Talc imported into the United States from 1880 to 1896, inclusive.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	.....	$22,807	1889	19,229	$30,993
1881	.....	7,331	1890	1,044	1,560
1882	.....	25,641	1891	81	1,121
1883	.....	14,607	1892	531	5,546
1884	.....	41,165	1893	1,360	12,825
1885	.....	24,356	1894	622	6,815
1886	.....	24,514	1895	3,165	26,843
1887	(a)	49,250	1896	1,966	18,693
1888	24,165	22,446			

a Quantity not reported previous to 1888.

CANADIAN PRODUCTION.

In the following table is shown the output of soapstone in Canada for a period of ten years. It will be observed that the values are usually much less than those given for the United States product, and the fluctuations in value are even more pronounced than in this country. In 1886 and 1887 the product was valued at $8 per ton. The output in both years was small. In 1888, with an increase of only 40 tons in product, the value fell to $2 per ton. In 1889 the output increased 55 tons and the price went up to $6 per ton. In 1890 the output increased to 917 tons, nearly five times the amount obtained in 1889, but the

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value increased only $69, the price per ton declining to $1.35. No output was reported in 1891. In 1892 the product was 50 per cent more than in 1890, the value increasing five times, or to $4.54 per ton. In 1893, with a decrease of nearly 50 per cent in the product, there was a decline to $2.68 per ton. The price declined again in 1894 to $1.78 per ton, and in 1895 advanced to $4.50 per ton, the output of 475 tons being valued at $2,138. These figures are obtained from the annual report of the geological survey of Canada:

Production of soapstone in Canada from 1886 to 1895.

Calendar year.	Tons.	Value.
1886	50	$400
1887	100	800
1888	140	280
1889	195	1,170
1890	917	1,239
1891	None.	None.
1892	1,374	6,240
1893	717	1,920
1894	916	1,640
1895	475	2,138

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STATISTICS OF THE CLAY-WORKING INDUSTRIES IN THE UNITED STATES IN 1896.

By JEFFERSON MIDDLETON.

BRICK AND TILE.

INTRODUCTION.

The conditions confronting the clay-working industries at the beginning of 1896 in the United States were not very encouraging. The prevailing financial depression, which always has an especially disastrous effect on the building trades, coupled with the fact that 1896 was a presidential campaign year, when business interests are generally more or less disturbed, gave no promise of an active year. This prospect was, unfortunately, fully realized, as the canvass of this industry by the Geological Survey shows. In spite of the fact that the value of pottery produced is included in the 1896 figures, and the fact that returns were received from over one thousand more producers in 1896 than in 1895, the total value of the product decreased nearly three million dollars.

That over one thousand more producers not only replied, but did so more promptly and more satisfactorily than heretofore, is very gratifying, and the producers are here thanked for this evidence of their increasing interest in the work.

PRODUCTION AND VALUE.

In the following table is given a résumé of the total value of the brick and tile and the pottery products of the United States in 1896, by States, with the grand total:

Value of the clay products of the United States in 1896.

State.	Total brick and tile.	Total pottery.	Grand total.
Alabama	$365,760	$6,425	$372,185
Arizona	55,663	.....	55,663
Arkansas	193,832	22,500	216,332
California	663,185	17,022	680,207
Colorado	328,680	.....	328,680
Connecticut	1,102,898	48,700	1,151,598
Delaware	61,003	.....	61,003

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Value of the clay products of the United States in 1896—Continued.

State.	Total brick and tile.	Total pottery.	Grand total.
District of Columbia	$350,565	$3,000	$353,565
Florida	119,844	2,300	122,144
Georgia	897,653	7,160	904,813
Idaho	16,000	.....	16,000
Illinois	5,441,765	421,482	5,863,247
Indiana	2,545,980	128,345	2,674,325
Iowa	1,901,623	43,035	1,944,658
Kansas	252,837	7,250	260,087
Kentucky	735,059	95,750	830,809
Louisiana	401,812	600	402,412
Maine	956,681	250	956,931
Maryland	1,422,359	27,696	1,450,055
Massachusetts	2,056,631	206,343	2,262,974
Michigan	985,255	20,150	1,005,405
Minnesota	555,265	41,436	596,701
Mississippi	223,809	1,000	224,809
Missouri	2,629,312	50,933	2,680,245
Montana	276,311	.....	276,311
Nebraska	144,373	.....	144,373
New Hampshire	581,169	17,000	598,169
New Jersey	3,658,861	1,069,142	4,728,003
New York	6,102,473	311,733	6,414,206
North Carolina	408,544	14,955	423,499
North Dakota	59,625	.....	59,625
Ohio	7,050,221	2,899,350	9,949,571
Oklahoma *a*	38,444	.....	38,444
Oregon	118,545	7,800	126,345
Pennsylvania	8,445,712	617,601	9,063,313
Rhode Island	297,000	.....	297,000
South Carolina	353,175	1,100	354,275
South Dakota	53,004	.....	53,004
Tennessee	499,664	37,661	537,325
Texas	857,672	58,081	915,753
Utah	137,573	.....	137,573
Vermont	83,274	.....	83,274
Virginia	869,086	10,440	879,526
Washington	160,348	1,180	161,528
West Virginia	492,237	410,707	902,944
Wisconsin	760,785	12,500	773,285
Wyoming	9,659	.....	9,659
United States	55,721,226	6,620,627	62,341,853
Per cent of total	89.38	10.62	100.00

a Including Indian Territory and New Mexico.

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As will be seen by the tables, the total value of the product in 1896 was $62,341,853 as compared with $65,319,806 in 1895, a decline of $2,977,953, or 4.56 per cent. The decrease in production is really greater than this would indicate, since in 1896 the value of the pottery is included. In 1895 some of this pottery product was included, notably the stoneware, but nothing like $6,620,627, the value of the pottery product in 1896.

The number of producers reporting increased from 6,284 in 1895 to 7,298 in 1896. Some of this increase is no doubt also due to the taking up of the pottery industry, but the producers of coarser clay goods answered much more promptly and satisfactorily than ever before.

The statistics of Maryland were collected by the geological survey of that State, under the supervision of Prof. W. B. Clark, State geologist, to whom thanks are here extended for the completeness of the figures furnished, the results being a complete census of the clay-working industry of the State.

The following table gives a statement of the brick and tile product of the United States in 1896, showing in detail the value of each product by States:

Brick and tile products of the United States in 1896.

State.	Number of firms reporting.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.		
		Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
		Thousands.			*Thousands.*		
Alabama	80	49,817	$263,708	$5.29	2,149	$22,300	$10.50
Arizona	19	9,060	51,593	5.69	140	3,250	23.21
Arkansas	71	26,472	161,872	6.11	2,455	25,260	10.29
California	91	74,240	391,567	5.27	1,039	34,424	33.13
Colorado	87	27,461	153,627	5.59	8,790	80,700	9.18
Connecticut	47	166,995	966,738	5.79	90	1,900	21.11
Delaware	26	8,091	57,433	7.09	.....	.....	.....
Dist. Columbia	16	40,368	220,762	5.46	376	4,366	11.61
Florida	35	17,376	89,219	5.13	.....	.....	.....
Georgia	88	132,469	615,771	4.64	2,390	21,678	9.07
Idaho	19	2,150	15,700	7.30	20	300	15.00
Illinois	836	586,506	2,831,752	4.83	21,995	196,658	8.94
Indiana	827	262,936	1,207,247	4.59	9,071	99,954	11.01
Iowa	519	172,195	1,003,624	5.83	6,088	47,386	7.78
Kansas	71	19,694	110,254	5.59	1,541	9,440	6.13
Kentucky	125	63,675	317,749	4.99	1,475	15,550	10.54

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Brick and tile products of the United States in 1896—Continued.

State.	Number of firms reporting.	Common brick.			Pressed brick, including buff, gray, and other fancy-colored brick.		
		Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
		Thousands.			*Thousands.*		
Louisiana	59	69,887	$370,487	$5.30	3,600	$29,000	$8.05
Maine	117	68,604	375,353	5.47	1,695	15,650	9.23
Maryland	137	144,519	987,706	6.83	4,572	97,426	21.35
Massachusetts	123	274,956	1,601,537	5.82	4,240	109,780	25.89
Michigan	238	110,523	590,095	5.34	2,157	13,827	6.41
Minnesota	146	87,844	398,872	4.54	2,839	21,368	7.52
Mississippi	46	38,867	208,109	5.36	1,475	12,400	8.40
Missouri	290	263,037	1,317,916	5.00	31,260	293,193	9.37
Montana	28	29,927	204,366	6.83	396	5,208	13.15
Nebraska	110	20,527	124,746	6.08	1,020	9,512	9.32
New Hampshire	64	109,885	550,789	5.01	870	11,680	13.42
New Jersey	140	237,781	950,113	3.99	15,655	340,919	21.77
New York	295	931,565	4,141,973	4.45	18,409	298,515	16.22
North Carolina	129	67,015	370,129	5.52	513	5,060	9.86
North Dakota	8	10,100	59,625	5.90	.....	.....	.....
Ohio	1,021	313,995	1,516,088	4.83	29,890	337,567	11.29
Oklahoma *a*	25	5,533	35,882	6.49	90	1,060	11.78
Oregon	66	8,775	55,719	6.34	275	2,062	7.50
Pennsylvania	536	675,444	4,118,206	6.10	47,213	662,188	14.03
Rhode Island	1	28,000	175,000	6.25	3,000	45,000	15.00
South Carolina	56	70,114	305,150	4.35	420	2,600	6.19
South Dakota	11	7,265	51,004	7.02	.....	.....	.....
Tennessee	101	65,548	364,463	5.56	7,881	66,865	8.48
Texas	149	113,027	665,091	5.88	12,891	142,500	11.05
Utah	54	15,808	96,161	6.08	3,165	35,862	11.33
Vermont	18	15,760	78,920	5.00	75	1,046	13.95
Virginia	114	101,311	604,161	5.96	13,087	195,046	14.90
Washington	52	10,164	55,758	5.48	422	8,390	19.88
West Virginia	45	29,462	164,831	5.59	972	11,370	11.70
Wisconsin	157	116,001	662,617	5.71	5,404	48,671	9.00
Wyoming	5	520	4,560	8.76	.....	.....	.....
United States.	7,298	5,701,269	29,664,043	5.20	271,105	3,386,931	12.49
Per cent of total	.....	.....	47.58	.....	.....	5.43	.....

a Including Indian Territory and New Mexico.

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Brick and tile products of the United States in 1896—Continued.

State.	Vitrified paving brick.			Fancy or ornamental and enameled brick (value).	Fire brick (value).	Draintile (value).
	Quantity.	Value.	Average price per thousand.			
	Thousands.					
Alabama	2,000	$22,252	$11.13	$1,200	$56,300	.....
Arizona	.....	.....	.....	20	.....	.....
Arkansas	400	4,000	10.00	.....	1,200	$1,500
California	120	1,400	11.66	6,691	11,875	4,528
Colorado	100	1,100	11.00	.....	46,323	100
Connecticut	20	400	20.00	.....	71,800	14,100
Delaware	.....	.....	.....	.....	.....	3,570
Dist. Columbia	26	260	10.00	500	.....	1,475
Florida	.....	.....	.....	.....	.....	30,000
Georgia	390	5,660	14.51	1,000	25,297	8,740
Idaho	.....	.....	.....	.....	.....	.....
Illinois	60,955	486,519	7.98	52,624	125,408	517,684
Indiana	41,292	175,670	4.25	36,050	28,350	475,919
Iowa	14,385	112,985	7.85	.....	5,198	648,906
Kansas	16,934	125,293	7.39	.....	2,300	4,400
Kentucky	7,000	70,000	10.00	.....	168,210	24,750
Louisiana	70	700	10.00	.....	25	1,600
Maine	20	340	17.00	2,450	4,200	4,738
Maryland	186	2,382	12.80	37,300	150,655	1,945
Massachusetts	.....	.....	.....	88,000	131,950	.....
Michigan	3,650	40,750	11.16	4,600	2,300	225,293
Minnesota	3	75	25.00	100	1,375	5,240
Mississippi	.....	.....	.....	800	2,000	500
Missouri	7,500	61,500	8.20	136,964	328,148	23,383
Montana	16	93	5.81	2,636	54,520	1,000
Nebraska	125	800	6.40	3,065	3,000	250
New Hampshire	1,000	8,000	8.00	700	10,000	.....
New Jersey	2,575	35,600	13.82	188,819	604,983	37,850
New York	23,723	259,550	10.94	17,854	345,485	292,954
North Carolina	160	1,900	11.87	.....	3,945	1,910
North Dakota	.....	.....	.....	.....	.....	.....
Ohio	72,254	619,463	8.57	62,982	575,748	569,871
Oklahoma *a*	.....	.....	.....	.....	5,099	.....
Oregon	200	3,000	15.00	175	200	14,239
Pennsylvania	47,229	404,182	8.57	30,545	2,083,414	49,039
Rhode Island	4,000	48,000	12.00	10,000	3,000	.....
South Carolina	10	125	12.50	.....	22,400	700
South Dakota	.....	.....	.....	.....	2,000	.....

a Including Indian Territory and New Mexico.

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Brick and tile products of the United States in 1896—Continued.

State.	Vitrified paving brick.			Fancy or ornamental and enameled brick (value).	Fire brick (value).	Draintile (value).
	Quantity.	Value.	Average price per thousand.			
	Thousands.					
Tennessee	7,503	$54,030	$7.20	$685	$4,372	$8,575
Texas	1,400	9,200	6.57	3,150	8,315	2,040
Utah	.....	.....	.....	500	5,050	.....
Vermont	.....	.....	.....	.....	.....	3,308
Virginia	7,240	30,000	4.14	24,283	2,678	2,918
Washington	3,196	31,500	9.85	1,500	8,300	3,700
West Virginia	21,485	177,856	8.28	32,237	1,500	22,972
Wisconsin	.....	.....	.....	.....	.....	27,797
Wyoming	.....	.....	.....	.....	.....	.....
United States.	347,167	2,794,585	8.05	747,430	4,906,923	3,037,494
Per cent of total	.....	4.48	.....	1.20	7.87	4.87

State.	Sewer pipe (value).	Ornamental terra cotta (value).	Fireproofing (value). *a*	Tile, not drain (value). *b*	Miscellaneous (value). *c*	Total brick and tile (value).
Alabama	.....	.....	.....	.....	.....	$365,760
Arizona	.....	.....	.....	$800	.....	55,663
Arkansas	.....	.....	.....	.....	.....	193,832
California	$208,000	$2,000	$2,700	.....	.....	663,185
Colorado	40,000	.....	.....	4,330	$2,500	328,680
Connecticut	2,460	30,000	500	15,000	.....	1,102,898
Delaware	.....	.....	.....	.....	.....	61,003
Dist. Columbia	39,558	.....	1,000	1,000	81,644	350,565
Florida	500	125	.....	.....	.....	119,844
Georgia	*d* 172,662	31,280	15,565	.....	.....	897,653
Idaho	.....	.....	.....	.....	.....	16,000
Illinois	187,350	720,100	213,315	110,355	.....	5,441,765
Indiana	125,839	65,150	136,461	175,390	19,950	2,545,980
Iowa	73,039	800	7,685	2,000	.....	1,901,623
Kansas	.....	.....	900	.....	250	252,837
Kentucky	55,000	.....	7,800	76,000	.....	735,059

a Including terra-cotta lumber and hollow building tile or blocks.

b Including roofing tile, floor tile, encaustic and art tile.

c Including conduits for underground wire, flue lining, fire kindlers, stone pumps, fence posts, Cornwall stone, clay pipes (smoking), terra-cotta chimneys, clay furnaces, burnt-clay ballast, chimney tops, statuary, paper clay, glass-house pots, fire-clay shapes, glass-house furnace blocks, clay pots, gas retorts, specialties for glass melters, china casts, acid brick, doorknobs, vitrified wall coping, pots and furnace supplies, toy marbles, lot markers, ovalware roasters, burnt clay, and clay posts.

d Included in Tennessee.

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Brick and tile products of the United States in 1896—Continued.

State.	Sewer pipe (value).	Ornamental terra cotta (value).	Fireproofing (value). *a*	Tile, not drain. (value). *b*	Miscellaneous (value). *c*	Total brick and tile (value).
Louisiana	.....	.....	.....	.....	.....	$401,812
Maine	$551,613	$1,337	$1,000	.....	.....	956,681
Maryland	.....	5,075	.....	$27,003	$112,867	1,422,359
Massachusetts	.....	52,164	73,000	200	.....	2,056,631
Michigan	105,140	750	2,450	50	.....	985,255
Minnesota	117,620	.....	10,290	325	.....	555,265
Mississippi	.....	.....	.....	.....	.....	223,809
Missouri	171,652	11,000	44,956	14,400	226,200	2,629,312
Montana	4,330	187	3,913	58	.....	276,311
Nebraska	.....	.....	500	2,500	.....	144,373
New Hampshire	.....	.....	.....	.....	.....	581,169
New Jersey	16,205	618,502	721,694	143,292	884	3,658,861
New York	85,289	484,113	72,410	99,060	5,270	6,102,473
North Carolina	23,000	.....	.....	.....	2,600	408,544
North Dakota	.....	.....	.....	.....	.....	59,625
Ohio	2,058,210	63,100	279,264	805,198	162,730	7,050,221
Oklahoma *d*	.....	.....	.....	.....	1,502	38,444
Oregon	40,000	.....	2,000	150	1,000	118,545
Pennsylvania	323,239	142,200	104,401	122,707	405,591	8,445,712
Rhode Island	.....	.....	.....	16,000	.....	297,000
South Carolina	22,000	.....	.....	.....	200	353,175
South Dakota	.....	.....	.....	.....	.....	53,004
Tennessee	(*e*)	.....	.....	674	.....	499,664
Texas	21,626	.....	.....	1,135	4,615	857,672
Utah	.....	.....	.....	.....	.....	137,573
Vermont	.....	.....	.....	.....	.....	83,274
Virginia	.....	.....	.....	.....	10,000	869,086
Washington	47,000	1,100	3,100	.....	.....	160,348
West Virginia	77,171	.....	.....	.....	4,300	492,237
Wisconsin	20,000	.....	.....	500	1,200	760,785
Wyoming	.....	.....	.....	.....	.....	9,659
United States.	4,588,503	2,228,983	1,704,904	1,618,127	1,043,303	55,721,226
Per cent of total	7.36	3.58	2.74	2.60	1.67	89.38

a Including terra-cotta lumber and hollow building tile or blocks.

b Including roofing tile, floor tile, encaustic and art tile.

c Including conduits for underground wire, flue lining, fire kindlers, stone pumps, fence posts, Cornwall stone, clay pipes (smoking), terra-cotta chimneys, clay furnaces, burnt-clay ballast, chimney tops, statuary, paper clay, glass-house pots, fire-clay shapes, glass-house furnace blocks, clay pots, gas retorts, specialties for glass melters, china casts, acid brick, doorknobs, vitrified wall coping, pots and furnace supplies, toy marbles, lot markers, ovalware roasters, burnt clay, and clay posts.

d Including New Mexico and Indian Territory.

e See Georgia.

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The following table shows the quantity and value of the clay products of the United States in 1895, and is here given for purposes of comparison:

Clay products of the United States in 1895.

State.	Number of firms reporting.	Common brick.			Pressed brick, including buff, gray, and other fancy colored and enameled brick.		
		Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
		Thousands.			*Thousands.*		
Alabama	60	35,822	$190,157	$5.38	318	$3,325	$10.45
Arizona	9	960	6,855	7.14	.....	.....	.....
Arkansas	54	27,381	185,009	6.76	566	5,840	10.32
California	94	144,403	922,712	6.40	3,885	71,286	18.34
Colorado	81	48,762	252,018	5.16	9,828	113,105	11.50
Connecticut	44	118,550	642,462	5.41	150	4,500	30.00
Delaware	17	7,184	48,915	6.80	400	7,200	18.00
Dist. Columbia	16	49,002	277,750	5.67	1,126	13,560	12.04
Florida	28	19,489	108,775	5.58	70	1,240	17.71
Georgia	76	135,480	655,275	4.83	4,783	46,265	9.69
Idaho	14	2,085	17,540	8.41	70	1,050	15.00
Illinois	678	717,079	3,786,747	5.28	29,093	330,318	11.35
Indiana	659	319,751	1,488,370	4.65	17,085	161,336	9.44
Iowa	412	180,664	1,095,074	6.06	11,159	87,130	7.81
Kansas	63	20,756	121,892	5.87	3,730	25,775	6.91
Kentucky	92	86,521	455,927	5.27	1,800	14,240	7.91
Louisiana	44	70,247	378,418	5.39	3,320	25,750	7.99
Maine	95	72,594	403,217	5.55	1,370	13,520	9.86
Maryland	65	117,016	743,023	6.35	2,555	35,229	13.78
Massachusetts	112	245,423	1,443,677	5.88	8,509	200,234	23.53
Michigan	200	168,574	767,203	4.55	6,530	47,719	7.31
Minnesota	126	127,242	578,329	4.55	5,061	30,635	6.05
Mississippi	38	31,135	174,800	5.61	1,290	12,650	9.80
Missouri	221	234,201	1,251,200	5.34	29,674	275,725	9.29
Montana	18	16,662	112,083	6.70	2,150	15,740	7.32
Nebraska	105	28,191	175,480	6.22	2,696	29,659	11.00
New Hampshire	54	91,415	469,567	5.13	2,300	23,800	10.34
New Jersey	130	248,831	1,097,063	4.40	18,417	387,737	21.05
New York	280	955,442	4,396,027	4.60	18,437	290,910	15.78
North Carolina	96	60,946	311,088	5.10	577	5,605	9.70
North Dakota	7	9,000	48,000	5.33	.....	.....	.....
Ohio	980	381,065	1,887,023	4.95	44,396	518,717	11.68
Oklahoma *a*	21	7,095	39,502	5.56	176	2,510	14.26

a Includes Indian Territory and New Mexico.

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Clay products of the United States in 1895—Continued.

State.	Number of firms reporting.	Common brick.			Pressed brick, including buff, gray, and other fancy colored and enameled brick.		
		Quantity.	Value.	Average price per thousand.	Quantity.	Value.	Average price per thousand.
		Thousands.			*Thousands.*		
Oregon	68	12,612	$70,812	$5.61	40	$800	$20.00
Pennsylvania	513	612,492	3,570,536	5.82	56,810	1,018,682	17.93
Rhode Island	1	28,000	175,000	6.25	3,000	45,000	15.00
South Carolina	51	56,010	240,785	4.29	310	3,075	9.92
South Dakota	10	1,195	8,865	7.41	75	1,875	25.00
Tennessee	90	69,034	355,420	5.14	2,633	25,352	9.62
Texas	136	138,465	805,772	5.81	16,143	103,255	6.39
Utah	46	13,533	69,511	5.13	2,496	31,715	12.70
Vermont	20	18,376	97,212	5.29	140	2,220	15.80
Virginia	111	96,407	560,316	5.81	11,176	204,078	18.25
Washington	52	14,865	84,305	5.67	585	19,100	32.64
West Virginia	46	35,815	208,337	5.82	1,845	18,400	9.97
Wisconsin	146	141,018	782,552	5.54	12,530	123,505	9.85
Wyoming	5	1,175	8,525	7.25	.....	.....	.....
United States	6,284	6,017,965	31,569,126	5.25	339,204	4,399,367	12.97
Per cent of total	.....	.....	48.33	.....	.....	6.74	.....

State.	Vitrified paving brick.			Fancy or ornamental brick (value).	Fire brick (value).	Drain tile (value).
	Quantity.	Value.	Average price per thousand.			
	Thousands.					
Alabama	2,300	$23,500	$10.21	$73,979	$900	.....
Arizona	.....	.....	.....	.....	.....	.....
Arkansas	926	9,260	10.00	.....	2,000	$2,450
California	.....	.....	.....	13,654	10,836	8,980
Colorado	977	10,572	10.82	1,960	42,264	320
Connecticut	.....	.....	.....	600	64,000	1,000
Delaware	.....	.....	.....	.....	.....	2,500
Dist. of Columbia	23	190	8.26	3,000	.....	5,168
Florida	.....	.....	.....	.....	.....	1,000
Georgia	5	40	8.00	27,560	29,950	5,200
Idaho	.....	.....	.....	.....	.....	.....
Illinois	82,526	643,997	7.80	19,500	117,040	1,028,581

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Clay products of the United States in 1895—Continued.

State.	Vitrified paving brick.			Fancy or ornamental brick (value).	Fire brick (value).	Drain tile (value).
	Quantity.	Value.	Average price per thousand.			
	Thousands.					
Indiana	22,313	$204,000	$9.14	$13,439	$12,510	$820,602
Iowa	31,704	243,928	7.69	2,300	5,920	290,515
Kansas	7,902	62,190	7.87	1,000	27,000	4,090
Kentucky	3,850	33,150	8.61	150	126,539	17,322
Louisiana	300	3,000	10.00	5,000	50	1,000
Maine	.....	.....	.....	4,400	37,501	5,168
Maryland	8	80	10.00	1,000	232,270	3,079
Massachusetts	100	800	8.00	91,675	187,710	.....
Michigan	1,300	12,755	9.81	5,850	3,575	200,893
Minnesota	2	16	8.00	500	2,000	2,775
Mississippi	.....	.....	.....	500	3,300	500
Missouri	6,816	54,640	8.01	1,500	484,415	15,820
Montana	22	330	15.00	380	69,035	137
Nebraska	475	3,800	8.00	3,202	.....	1,800
New Hampshire	.....	.....	.....	800	12,400	.....
New Jersey	2,500	30,000	12.00	179,828	456,825	14,024
New York	10,896	121,892	11.19	1,025	302,407	56,740
North Carolina	150	1,600	10.66	50	6,140	2,900
North Dakota	.....	.....	.....	.....	.....	.....
Ohio	96,555	787,878	8.16	57,767	696,175	884,638
Oklahoma *a*	.....	.....	.....	3,295	.....	.....
Oregon	400	3,800	9.50	45	15,486	4,000
Pennsylvania	36,268	305,035	8.41	48,032	2,250,790	13,320
Rhode Island	4,000	48,000	12.00	10,000	3,000	.....
South Carolina	.....	.....	.....	1,000	19,750	5,000
South Dakota	.....	.....	.....	.....	.....	.....
Tennessee	.....	.....	.....	356	24,956	6,850
Texas	1,492	12,466	8.36	1,024	7,060	.....
Utah	150	1,200	8.00	3,410	5,750	1,000
Vermont	.....	.....	.....	30,132	.....	2,980
Virginia	3,000	30,000	10.00	36,919	1,750	4,980
Washington	2,301	32,965	14.32	.....	12,500	3,175
West Virginia	62,330	449,388	7.21	4,262	4,000	140
Wisconsin	.....	.....	.....	3,425	1,200	32,314
Wyoming	.....	.....	.....	.....	.....	.....
United States.	381,591	3,130,472	8.20	652,519	5,279,004	3,450,961
Per cent of total	.....	4.79	.....	1.00	8.08	5.28

a—Includes Indian Territory and New Mexico.

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Clay products of the United States in 1895—Continued.

State.	Sewer pipe (value).	Ornamental terra-cotta work (value).	Terra-cotta lumber (value).	Tile (not drain) (value). *a*	Stoneware (value).	Miscellaneous (value). *b*	Total value.
Alabama	.....	.....	.....	.....	$9,480	.....	$301,341
Arizona	.....	.....	.....	.....	.....	.....	6,855
Arkansas	.....	.....	.....	$1,000	38,400	.....	243,959
California	$261,536	$48,300	.....	58,450	.....	$25,400	1,421,154
Colorado	76,000	.....	$1,000	8,750	350	47,044	553,383
Connecticut	4,500	44,563	.....	.....	2,800	67,500	831,925
Delaware	.....	.....	.....	.....	.....	.....	58,615
District of Columbia	64,631	.....	.....	2,795	.....	6,210	373,304
Florida	.....	.....	.....	.....	.....	3,000	114,015
Georgia	54,400	34,850	.....	2,530	6,000	5,285	867,355
Idaho	.....	.....	.....	.....	.....	300	18,890
Illinois	389,680	722,500	71,685	231,166	255,540	23,130	7,619,884
Indiana	42,000	52,600	60,000	139,463	11,400	111,800	3,117,520
Iowa	55,131	2,800	400	16,094	25,600	45,400	1,870,292
Kansas	.....	.....	300	500	1,000	2,900	246,647
Kentucky	25,000	.....	.....	75,000	30,120	61,750	839,198
Louisiana	.....	.....	.....	.....	.....	2,500	415,718
Maine	270,177	3,121	.....	.....	.....	.....	737,104
Maryland	.....	6,781	.....	12,000	.....	33,525	1,066,987
Massachusetts	.....	65,000	63,668	900	1,800	166,126	2,221,590
Michigan	76,000	.....	.....	2,900	.....	12,300	1,129,195
Minnesota	169,761	.....	49,000	570	246,115	20,434	1,100,135
Mississippi	.....	.....	.....	.....	1,500	1,500	194,750
Missouri	212,000	.....	25,300	94,504	8,400	375,714	2,799,218
Montana	3,517	30	.....	1,586	.....	1,355	204,193
Nebraska	.....	.....	.....	600	.....	.....	214,541
New Hampshire	.....	.....	.....	15,000	.....	.....	521,567
New Jersey	101,316	763,420	285,165	850,014	162,946	570,782	4,899,120
New York	133,000	336,000	.....	143,465	44,033	63,997	5,899,496
North Carolina	25,000	.....	.....	.....	3,600	45,000	400,983
North Dakota	.....	.....	.....	.....	.....	.....	48,000
Ohio	1,746,503	49,678	59,600	797,985	563,355	2,600,063	10,649,382
Oklahoma *c*	.....	.....	.....	.....	.....	.....	45,307

a Including hollow building tile or blocks, roofing tile, floor tile, encaustic and art tile.

b Including ball clay, paper clay, clay ballast (burned), vitrified brick for chemical use, locomotive arch brick, hollow brick, well brick, slab brick, fence posts, fence-post stubs, clay gas retorts and gas-house tiles, boiler and sugar kettle tiles, kiln and furnace tiles, sidewalk tile and blocks, blocks for building caves, foundation blocks, tank blocks, doorknobs, wall copings, crestings, stovepipe guards, glass-makers' pot clay, glass-melting pots, fire-clay retorts, pottery, wash and bath tubs, kitchen sinks, saggars, conduits for underground wires, flue linings, electrical porcelain specialties, crucibles, scorifiers, muffles, supports, slides, cuspidors, jardinieres, vases, earthenware, flowerpots, stone pumps, fire kindlers, insulators and insulator supplies, flue pipe, chimney tops, terra-cotta grave and lot markers, curbing, art faience, hitching posts, porcelain washboards, tobacco pipes, clay furnaces, etc.

c Includes Indian Territory and New Mexico.

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Clay products of the United States in 1895—Continued.

State.	Sewer pipe (value).	Ornamental terra-cotta work (value).	Terra-cotta lumber (value).	Tile (not drain) (value). *a*	Stoneware (value).	Miscellaneous (value). *b*	Total value.
Oregon	$40,500	.....	.....	$100	$500	$2,500	$138,543
Pennsylvania	360,475	$263,000	120,508	95,529	208,130	553,124	8,807,161
Rhode Island	.....	.....	.....	16,000	.....	.....	297,000
South Carolina	4,000	.....	.....	2,008	500	800	276,918
South Dakota	.....	.....	.....	.....	.....	.....	10,740
Tennessee	80,300	5,000	.....	.....	24,300	.....	522,534
Texas	4,450	300	5,000	519	46,600	44,000	1,030,446
Utah	.....	.....	.....	.....	.....	.....	112,586
Vermont	.....	.....	.....	.....	.....	.....	132,544
Virginia	1,000	.....	.....	700	3,025	13,000	855,768
Washington	85,700	24,000	.....	2,500	.....	1,200	265,445
West Virginia	196,000	250	.....	.....	3,000	12,000	895,777
Wisconsin	.....	.....	.....	.....	.....	1,200	944,196
Wyoming	.....	.....	.....	.....	.....	.....	8,525
United States	4,482,577	2,422,193	741,626	2,572,628	1,698,494	4,920,839	65,319,806
Per cent of total	6.86	3.71	1.14	3.94	2.60	7.53	100.00

a Including hollow building tile or blocks, roofing tile, floor tile, encaustic and art tile.

b Including ball clay, paper clay, clay ballast (burned), vitrified brick for chemical use, locomotive arch brick, hollow brick, well brick, slab brick, fence posts, fence post stubs, clay gas retorts and gas-house tiles, boiler and sugar kettle tiles, kiln and furnace tiles, sidewalk tile and blocks, blocks for building caves, foundation blocks, tank blocks, doorknobs, wall copings, crestings, stovepipe guards, glass-makers' pot clay, glass-melting pots, fire-clay retorts, pottery, wash and bath tubs, kitchen sinks, saggars, conduits far underground wires, flue linings, electrical porcelain specialties, crucibles, scorifiers, muffles, supports, slides, cuspidors, jardinieres, vases, earthenware, flowerpots, stone pumps, fire kindlers, insulators and insulator supplies, flue pipe, chimney tops, terra-cotta grave and lot markers, curbing, art faience, hitching posts, porcelain washboards, tobacco pipes, clay furnaces, etc.

As will be noted from these tables, the number of common brick made in 1896 was 5,701,269,000, valued at $29,664,043, or $5.20 per thousand, as compared with 6,017,965,000 in 1895, valued at $31,569,126, or $5.25 per thousand. In 1895 this class of brick constituted 48.33 per cent of the total value of the clay products, while in 1896 it constituted 47.58 per cent. In 1896, 271,105,000 pressed brick were made, valued at $3,386,931, or $12.49 per thousand, as compared with 339,204,000 in 1895, valued at $4,399,367, or $12.97 per thousand. In 1895 the pressed brick formed 6.74 per cent of the total value, and in 1896 it formed 5.43 per cent.

The vitrified-brick product also continued to decline, falling from 381,591,000 in 1895 to 347,167,000 in 1896, worth, respectively, $3,130,472 and $2,794,585. The average value per thousand was $8.20 in 1895 and $8.05 in 1896. In 1894 the product was 457,021,000, valued at

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$3,711,073. The States of Iowa, Illinois, Indiana, Ohio, and West Virginia which produced, in 1895, 295,428,000 vitrified paving brick, or 77.42 per cent of the entire product, in 1896 produced 210,371,000 vitrified paving brick, or only 60.60 per cent of the total. The only one of these middle western States to increase this class of product was Indiana, which went from 22,313,000 in 1895 to 41,292,000 in 1896. New York and Pennsylvania also show quite notable increases in this product. The percentage of the total product was 4.79 in 1895 and 4.48 in 1896.

The fancy or ornamental brick product showed a gain of from $652,519 in 1895 to $747,430 in 1896. The percentages of the total product of this variety of brick were 1 in 1895 and 1.20 in 1896.

The fire-brick product showed a decrease of $372,081, from $5,279,004 in 1895 to $4,906,923 in 1896, and the percentage of the total decreased from 8.08 in 1895 to 7.87 in 1896. Pennsylvania in 1896, as in 1894 and 1895, was by far the largest producer of fire brick, its product being valued at $2,083,414; that of New Jersey, the next largest producer, being $604,983.

The drain-tile product decreased from $3,450,961 in 1895 to $3,037,494 in 1896. The Illinois product of draintile decreased nearly 50 per cent, or from $1,028,581 in 1895 to $517,684 in 1896. Indiana also showed a large decrease in this product, while Iowa showed a gain of from $290,515 in 1895 to $648,906 in 1896. Its percentage of the total product was 5.28 and 4.87 in 1895 and 1896, respectively.

The sewer-pipe product increased from $4,482,577, or 6.86 per cent of the total product, in 1895 to $4,588,503, or 7.36 per cent of the total product in 1896. The States contributing most largely to this increase were Indiana, Maine, and Ohio.

Ornamental terra cotta decreased slightly, from $2,422,193 in 1895 to $2,228,983 in 1896. Its percentage of the total product was 3.71 in 1895, and 3.58 in 1896.

Fireproofing increased from $741,626 in 1895 to $1,704,904 in 1896. The large increase in this product is on account of its different classification, in 1895 only terra-cotta lumber being included, while in 1896 under the term fireproofing are included all kinds of hollow ware used for this purpose. Fireproofing other than terra-cotta lumber was included with tile in the report showing the product for 1895.

The tile product decreased from $2,572,628 in 1895 to $1,618,127 in 1896. This decrease has the same cause as the increase in the fireproofing product—i. e., the transferring of the hollow building tile or blocks from this column.

The value of miscellaneous products decreased from $4,920,839 in 1895 to $1,043,303 in 1896. This great decrease is due to the fact that in 1895 pottery wares which were included in this column are classified separately in 1896.

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The following table shows a comparison between the brick and tile industry in 1895 and 1896:

Value of brick and tile production in the United States in 1895 and 1896.

	1895.	1896.	Increase in 1896.	Decrease in 1896.
Common brick	$31,569,126	$29,664,043	.....	$1,905,083
Pressed brick	4,399,367	3,386,931	.....	1,012,436
Vitrified paving brick	3,130,472	2,794,585	.....	335,887
Fancy or ornamental brick	652,519	747,430	$94,911	.....
Fire brick	5,279,004	4,906,923	.....	372,081
Drain tile	3,450,961	3,037,494	.....	413,467
Sewer pipe	4,482,577	4,588,503	105,926	.....
Ornamental terra cotta	2,422,193	2,228,983	.....	193,210
Fireproofing *a*	741,626	1,704,904	963,278	.....
Tile, not drain	2,572,628	1,618,127	.....	954,501
Total	58,700,473	54,677,923	1,164,115	5,186,665
Net decrease in 1896	.....	.....	.....	4,022,550

a Classed as terra-cotta lumber in 1895.

From this table it will be seen that the only product that notably increased in value in 1896 was fireproofing, which is probably due to a difference in the classification, in 1895 fireproofing being included in tile, not drain, and the marked decrease in the latter column is no doubt due to the same cause. However, the total value of these products is not thus affected, and the decrease in the total value of them is slightly over 6 per cent. On the other hand, the common and pressed brick products, the most important from the point of value of all clay products, suffered quite a heavy decline, $2,917,519, or only $60,434 less than the total decline in value of all the clay products in 1896.

The following table shows the rank of States, total value of products, and the percentage of the total product made by each State in 1896 and 1895:

Rank of States in output of clay products in 1896 and 1895.

1896.

Rank.	State.	Number of firms reporting.	Value.	Per cent of total product.
1	Ohio	1,021	$9,949,571	15.96
2	Pennsylvania	536	9,063,313	14.54
3	New York	295	6,414,206	10.29
4	Illinois	836	5,863,247	9.40
5	New Jersey	140	4,728,003	7.58
6	Missouri	290	2,680,245	4.30
7	Indiana	827	2,674,325	4.29
8	Massachusetts	123	2,262,974	3.63
9	Iowa	519	1,944,658	3.12

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Rank of States in output of clay products in 1896 and 1895—Continued.

1896—Continued.

Rank.	State.	Number of firms reporting.	Value.	Per cent of total product.
10	Maryland	137	$1,450,055	2.33
11	Connecticut	47	1,151,598	1.85
12	Michigan	238	1,005,405	1.61
13	Maine	117	956,931	1.53
14	Texas	149	915,753	1.47
15	Georgia	88	904,813	1.45
16	West Virginia	45	902,944	1.45
17	Virginia	114	879,526	1.41
18	Kentucky	125	830,809	1.33
19	Wisconsin	157	773,285	1.24
20	California	91	680,207	1.09
21	New Hampshire	64	598,169	.96
22	Minnesota	146	596,701	.96
23	Tennessee	101	537,325	.86
24	North Carolina	129	423,499	.68
25	Louisiana	59	402,412	.64
26	Alabama	80	372,185	.60
27	South Carolina	56	354,275	.57
28	District of Columbia	16	353,565	.57
29	Colorado	87	328,680	.53
30	Rhode Island	1	297,000	.48
31	Montana	28	276,311	.44
32	Kansas	71	260,087	.42
33	Mississippi	46	224,809	.36
34	Arkansas	71	216,332	.35
35	Washington	52	161,528	.26
36	Nebraska	110	144,373	.23
37	Utah	54	137,573	.22
38	Oregon	66	126,345	.20
39	Florida	35	122,144	.20
40	Vermont	18	83,274	.13
41	Delaware	26	61,003	.10
42	North Dakota	8	59,625	.10
43	Arizona	19	55,663	.09
44	South Dakota	11	53,004	.08
45	Oklahoma *a*	25	38,444	.06
46	Idaho	19	16,000	.03
47	Wyoming	5	9,659	.01
	United States	7,298	62,341,853	100.00

a Including Indian Territory and New Mexico.

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Rank of States in output of clay products in 1896 and 1895—Continued.

1895.

Rank.	State.	Number of firms reporting.	Value.	Per cent of total product.
1	Ohio	980	$10,649,382	16.30
2	Pennsylvania	513	8,807,161	13.48
3	Illinois	678	7,619,884	11.67
4	New York	280	5,889,496	9.02
5	New Jersey	130	4,899,120	7.50
6	Indiana	659	3,117,520	4.77
7	Missouri	221	2,799,218	4.29
8	Massachusetts	112	2,221,590	3.40
9	Iowa	412	1,870,292	2.86
10	California	94	1,421,154	2.18
11	Michigan	200	1,129,195	1.73
12	Minnesota	126	1,100,135	1.68
13	Maryland	65	1,066,987	1.63
14	Texas	136	1,030,446	1.58
15	Wisconsin	146	944,196	1.45
16	West Virginia	46	895,777	1.37
17	Georgia	76	867,355	1.33
18	Virginia	111	855,768	1.31
19	Kentucky	92	839,198	1.29
20	Connecticut	44	831,925	1.27
21	Maine	95	737,104	1.13
22	Colorado	81	553,383	.85
23	Tennessee	90	522,534	.80
24	New Hampshire	54	521,567	.80
25	Louisiana	44	415,718	.64
26	North Carolina	96	400,983	.61
27	District of Columbia	16	373,304	.57
28	Alabama	60	301,341	.46
29	Rhode Island	1	297,000	.46
30	South Carolina	51	276,918	.42
31	Washington	52	265,445	.41
32	Kansas	63	246,647	.38
33	Arkansas	54	243,959	.37
34	Nebraska	105	214,541	.33
35	Montana	18	204,193	.31
36	Mississippi	38	194,750	.30
37	Oregon	68	138,543	.21
38	Vermont	20	132,544	.20
39	Florida	28	114,015	.17
40	Utah	46	112,586	.17

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Rank of States in output of clay products in 1896 and 1895—Continued.

1895—Continued.

Rank.	State.	Number of firms reporting.	Value.	Per cent of total product.
41	Delaware	17	$58,615	.09
42	North Dakota	7	48,000	.07
43	Oklahoma[a]	21	45,307	.07
44	Idaho	14	18,890	.03
45	South Dakota	10	10,740	.02
46	Wyoming	5	8,525	.01
47	Arizona	9	6,855	.01
	United States	6,284	65,319,806	100.00

[a] Includes Indian Territory and New Mexico.

Every State and Territory except Nevada and Alaska participated in this total. Ohio continues to be the chief producing State when value of product is considered, though in 1896 her product was $699,811 less than in 1895, or $9,949,571, or 15.96 per cent of the total product; in 1895 it was $10,649,382, or 16.30 per cent of the total. Pennsylvania maintains her second position, with $9,063,313 worth of product, 14.54 per cent of the total, as compared with $8,807,161 in 1895, which was 13.48 per cent of the total. New York displaces Illinois in third place, with a product of $6,414,206, or 10.29 per cent of the total. In 1895 New York was fourth, with a product worth $5,889,496, or 9.02 per cent of the total. Illinois, as just stated, takes fourth place, with a product of $5,863,247, or 9.40 per cent of the total. In 1895 it was third, with a product valued at $7,619,884, or 11.67 per cent of the total. This is a decrease of $1,756,637—the largest decrease in any State. New Jersey retains fifth place, with approximately the same product, namely, $4,899,120 in 1895 and $4,728,003 in 1896. These figures were, respectively, 7.50 and 7.58 per cent of the total product of the country.

Indiana, which was sixth in 1895, was displaced in 1896 by Missouri. In 1896 these States had a product, respectively, of $2,674,325, or 4.29 per cent of the total, and $2,680,245, or 4.30 per cent of the total. In 1895 they produced, respectively, $3,117,520, or 4.77 per cent of the total, and $2,799,218, or 4.29 per cent of the total. In 1896 they both decreased in product, and Missouri leads Indiana by only a very slight margin—$5,920—so slight as to make them practically the same.

The other notable changes in the rank of States are: California, which was tenth in 1895, has dropped to twentieth place; Maryland, which was thirteenth in 1895, was tenth in 1896; Connecticut jumped from twentieth place in 1895 to eleventh in 1896. The changes in the rank of other States are not noteworthy, except perhaps in the case of Arizona, which went from forty-seventh place in 1895 to forty-third in

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1896, its product increasing from $6,855 in 1895 to $55,663 in 1896. The first nine States, including the great clay-working region between the Ohio and Missouri rivers, together with Pennsylvania, New York, New Jersey, and Massachusetts, produced 73.29 per cent of the total product in 1895 and 73.11 per cent in 1896. In 1895 the States of Pennsylvania, New York, New Jersey, and Massachusetts produced 33.40 per cent of the total, while in 1896 they produced 36.04 per cent of it. In 1895 the States of Ohio, Indiana, Illinois, Iowa, and Missouri produced 39.89 per cent of the total product; in 1896 they produced 37.07 per cent of the total.

The following table shows the average value per thousand of the several kinds of brick made in the United States in 1896, by States:

Average price of brick in 1896, by States.

COMMON.

State.	Price.	State.	Price.
Wyoming	$8.76	Washington	$5.48
Idaho	7.30	Maine	5.47
Delaware	7.09	District of Columbia	5.46
South Dakota	7.02	Mississippi	5.36
Montana	6.83	Michigan	5.34
Maryland	6.83	Louisiana	5.30
Oregon	6.34	Alabama	5.29
Rhode Island	6.25	California	5.27
Arkansas	6.11	Florida	5.13
Pennsylvania	6.10	New Hampshire	5.01
Nebraska	6.08	Missouri	5.00
Utah	6.08	Vermont	5.00
Virginia	5.96	Kentucky	4.99
North Dakota	5.90	Illinois	4.83
Texas	5.88	Ohio	4.83
Iowa	5.83	Georgia	4.64
Massachusetts	5.82	Indiana	4.59
Connecticut	5.79	Minnesota	4.54
Wisconsin	5.71	New York	4.45
Arizona	5.69	South Carolina	4.35
Colorado	5.59	New Jersey	3.99
Kansas	5.59	Average for United States	5.20
West Virginia	5.59		
Tennessee	5.56		
North Carolina	5.52		

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Average price of brick in 1896, by States—Continued.

PRESSED.

State.	Price.	State.	Price.
California	$33.13	Alabama	$10.50
Massachusetts	25.89	Arkansas	10.29
Arizona	23.21	North Carolina	9.86
New Jersey	21.77	Missouri	9.37
Maryland	21.35	Nebraska	9.32
Connecticut	21.11	Maine	9.23
Washington	19.88	Colorado	9.18
New York	16.22	Georgia	9.07
Idaho	15.00	Wisconsin	9.00
Rhode Island	15.00	Illinois	8.94
Virginia	14.90	Tennessee	8.48
Pennsylvania	14.03	Mississippi	8.40
Vermont	13.95	Louisiana	8.05
New Hampshire	13.42	Iowa	7.78
Montana	13.15	Minnesota	7.52
West Virginia	11.70	Oregon	7.50
District of Columbia	11.61	Michigan	6.41
Utah	11.33	South Carolina	6.19
Ohio	11.29	Kansas	6.13
Texas	11.05		
Indiana	11.01	Average for United States	12.49
Kentucky	10.54		

VITRIFIED PAVING BRICK.

Oregon	$15.00	Ohio	$8.57
Georgia	14.51	Pennsylvania	8.57
New Jersey	13.82	West Virginia	8.28
Maryland	12.80	Missouri	8.20
South Carolina	12.50	New Hampshire	8.00
Rhode Island	12.00	Illinois	7.98
North Carolina	11.87	Iowa	7.85
California	11.66	Kansas	7.39
Michigan	11.16	Tennessee	7.20
Alabama	11.13	Texas	6.57
Colorado	11.00	Nebraska	6.40
New York	10.94	Montana	5.81
Louisiana	10.00	Indiana	4.25
Kentucky	10.00	Virginia	4.14
District of Columbia	10.00		
Arkansas	10.00	Average for United States	8.05
Washington	9.85		

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As will be seen from the above table, the price of common brick in 1896 ranged from $8.76 in Wyoming to $3.99 in New Jersey, the average for the whole country being $5.20. In 1895 Idaho and South Carolina were the extremes, with average values of $8.41 and $4.29 respectively, while the average for the whole country was $5.25.

In 1896 the average value of pressed brick per thousand ranged from $33.13 in California to $6.13 in Kansas, the average for the whole country being $12.49 per thousand. In 1895 the extremes were Washington, with an average value of $32.64, and Minnesota, with an average value of $6.05, the average for the whole country being $12.97.

The vitrified paving brick ranged in value from $15 per thousand in Oregon to $4.14 in Virginia, the average for the whole country being $8.05 per thousand in 1896. In 1895 this product ranged in value from $15 per thousand in Montana to $7.21 in West Virginia, the average for the whole country being $8.20 per thousand. In Connecticut, Maine, and Minnesota small lots were made, undoubtedly in an experimental way, on which a very high value is placed, but which are not included on account of this high valuation.

The following table shows by States the number of idle and number of active works reporting in 1896, and the number of firms reporting in 1895:

Number of idle and active clay plants in the United States.

State.	Number of firms reporting in 1896.			Number of firms reporting in 1895.
	Idle.	Active.	Total.	
Alabama	29	51	80	60
Arizona	3	16	19	9
Arkansas	23	48	71	54
California	31	60	91	94
Colorado	38	49	87	81
Connecticut	6	41	47	44
Delaware	3	23	26	17
District of Columbia	4	12	16	16
Florida	16	19	35	28
Georgia	33	55	88	76
Idaho	9	10	19	14
Illinois	270	566	836	678
Indiana	271	556	827	659
Iowa	180	339	519	412
Kansas	37	34	71	63
Kentucky	45	80	125	92
Louisiana	15	44	59	44

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Number of idle and active clay plants in the United States—Continued.

State.	Number of firms reporting in 1896.			Number of firms reporting in 1895.
	Idle.	Active.	Total.	
Maine	45	72	117	95
Maryland	41	96	137	65
Massachusetts	24	99	123	112
Michigan	82	156	238	200
Minnesota	58	88	146	126
Mississippi	9	37	46	38
Missouri	84	206	290	221
Montana	9	19	28	18
Nebraska	58	52	110	105
New Hampshire	12	52	64	54
New Jersey	37	103	140	130
New York	33	262	295	280
North Carolina	17	112	129	96
North Dakota	2	6	8	7
Ohio	207	814	1,021	980
Oklahoma *a*	14	11	25	21
Oregon	14	52	66	68
Pennsylvania	79	457	536	513
Rhode Island	.....	1	1	1
South Carolina	10	46	56	51
South Dakota	2	9	11	10
Tennessee	19	82	101	90
Texas	24	125	149	136
Utah	17	37	54	46
Vermont	6	12	18	20
Virginia	28	86	114	111
Washington	30	22	52	52
West Virginia	6	39	45	46
Wisconsin	27	130	157	146
Wyoming	1	4	5	5
Total	2,008	5,290	7,298	6,284

a Including Indian Territory and New Mexico.

While this table shows an increase in the number of works that report in almost every State, it fails to show that many of those reported as active operated in many cases only a small portion of the year, which was undoubtedly the case.

In 1895 the total number of firms reporting was 6,284, while 7,298 were heard from in 1896. In spite of this fact, as already noted, the product decline.

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In the following table is shown the rank of the several States and Territories in the value of clay products from 1894 to 1896, inclusive:

Rank of clay-producing States in value of production in 1894, 1895, and 1896.

State.	1894.	1895.	1896.
Alabama	31	28	26
Arizona	46	47	43
Arkansas	34	33	34
California	16	10	20
Colorado	27	22	29
Connecticut	19	20	11
Delaware	43	41	41
District of Columbia	28	27	28
Florida	40	39	39
Georgia	20	17	15
Idaho	44	44	46
Illinois	2	3	4
Indiana	6	6	7
Iowa	8	9	9
Kansas	33	32	32
Kentucky	18	19	18
Louisiana	24	25	25
Maine	17	21	13
Maryland	11	13	10
Massachusetts	9	8	8
Michigan	10	11	12
Minnesota	15	12	22
Mississippi	38	36	33
Missouri	7	7	6
Montana	37	35	31
Nebraska	23	34	36
New Hampshire	26	24	21
New Jersey	5	5	5
New York	4	4	3
North Carolina	30	26	24
North Dakota	42	42	42
Ohio	1	1	1
Oklahoma *a*	41	43	45
Oregon	36	37	38
Pennsylvania	3	2	2
Rhode Island	29	29	30
South Carolina	32	30	27
South Dakota	45	45	44
Tennessee	22	23	23
Texas	13	14	14

a Includes Indian Territory and New Mexico.

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Rank of clay-producing States in value of production in 1894, 1895, and 1896—Continued.

State.	1894.	1895.	1896.
Utah	35	40	37
Vermont	39	38	40
Virginia	14	18	17
Washington	25	31	35
West Virginia	21	16	16
Wisconsin	12	15	19
Wyoming	47	46	47

This table is interesting as showing the very slight changes in the relative rank of the clay-working States in the value of their products, very few of the States varying more than one or two positions from one year to another.

POTTERY.

INTRODUCTION.

The statistical work on the clay-working industries not being considered complete without including the various grades of pottery made in the United States, for the year 1896 it was decided to include this branch of the industry in these statistics.

The following tables show the result of this canvass, and while satisfactory on the whole, it is regretted that the potters in some of the States, particularly New Jersey, were derelict in replying, so that the figures probably do not represent the full output of this State.

PRODUCTION AND VALUE.

In the following table is given a statement of the production of pottery ware in the United States in 1896, as shown by the canvass of the pottery industry covering the calendar year 1896.

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Pottery products of the United States in 1896.

State.	Earthenware (value.)	Stoneware (value.)	Yellow and Rockingham ware (value).	C. C. and white granite ware (value).
Alabama	$300	$6,125	.....	.....
Arkansas	2,500	20,000	.....	.....
California	13,189	3,833	.....	.....
Connecticut	33,460	13,240	.....	.....
District of Columbia	3,000	.....	.....	.....
Florida	300	2,000	.....	.....
Georgia	1,110	6,050	.....	.....
Illinois	2,050	399,432	$20,000	.....
Indiana	5,400	45,945	.....	.....
Iowa	4,840	37,870	125	.....
Kansas	.....	7,250	.....	.....
Kentucky	9,000	76,750	10,000	.....
Louisiana	100	500	.....	.....
Maine	250	.....	.....	.....
Maryland	16,746	10,950	.....	.....
Massachusetts	147,923	11,270	.....	$45,000
Michigan	20,150	.....	.....	.....
Minnesota	11,136	30,300	.....	.....
Mississippi	1,000	.....	.....	.....
Missouri	50,933	.....	.....	.....
New Jersey	213,616	2,600	7,000	358,175
New York	49,200	51,533	.....	15,000
North Carolina	1,880	13,075	.....	.....
Ohio	606,558	563,230	218,392	1,127,010
Oregon	1,000	6,500	300	.....
Pennsylvania	15,800	351,401	2,000	48,400
South Carolina	1,100	.....	.....	.....
Tennessee	1,300	36,361	.....	.....
Texas	2,400	55,681	.....	.....
Virginia	2,700	7,740	.....	.....
Washington	60	1,120	.....	.....
West Virginia	120,000	10,000	.....	95,047
Wisconsin	12,500	.....	.....	.....
United States	1,351,501	1,770,756	257,817	1,688,632
Per cent of total clay products	2.17	2.84	.41	2.71

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Pottery products of the United States in 1896—Continued.

State.	Sanitary ware (value).	Porcelain or china (value).	Porcelain electrical supplies (value).	Total.
Alabama				$6,425
Arkansas				22,500
California				17,022
Connecticut		$2,000		48,700
District of Columbia				3,000
Florida				2,300
Georgia				7,160
Illinois				421,482
Indiana	$75,000	2,000		128,345
Iowa	100		$100	43,035
Kansas				7,250
Kentucky				95,750
Louisiana				600
Maine				250
Maryland				27,696
Massachusetts			2,150	206,343
Michigan				20,150
Minnesota				41,436
Mississippi				1,000
Missouri				50,933
New Hampshire		17,000		17,000
New Jersey	376,151	2,600	109,000	1,069,142
New York	21,000	120,000	55,000	311,733
North Carolina				14,955
Ohio	139,160	245,000		2,899,350
Oregon				7,800
Pennsylvania		200,000		617,601
South Carolina				1,100
Tennessee				37,661
Texas				58,081
Virginia				10,440
Washington				1,180
West Virginia	18,412	167,248		410,707
Wisconsin				12,500
United States	629,823	755,848	166,250	6,620,627
Per cent of total	1.01	1.21	.27	10.62

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The following table shows the value of the material used in the pottery recorded in the previous table:

Materials used in American pottery in 1896.

State.	Domestic clay (value).	Imported clay (value).	Flint (quartz) (value).	Feldspar (value).	Total value.
Alabama	$662	.....	.....	.....	$662
Arkansas	750	$75	$500	.....	1,325
California	2,487	.....	10	$40	2,537
Connecticut	2,894	2,000	1,050	700	6,644
Delaware	33,473	.....	.....	.....	33,473
Dist. of Columbia	500	.....	.....	.....	500
Florida	75	.....	5	5	85
Georgia	2,216	.....	200	200	2,616
Illinois	41,709	355	.....	.....	42,064
Indiana	36,239	3,660	7,280	7,220	54,399
Iowa	5,522	617	2,500	.....	8,639
Kansas	825	.....	.....	.....	825
Kentucky	4,750	50	6,035	30	10,865
Louisiana	60	.....	5,500	.....	5,560
Maine	.....	.....	5,000	.....	5,000
Massachusetts	19,810	50	2	136	19,998
Michigan	1,706	.....	.....	.....	1,706
Minnesota	640	.....	.....	.....	640
Mississippi	30	.....	.....	.....	30
Missouri	4,610	164	.....	.....	4,774
New Hampshire	150	200	1,075	75	1,500
New Jersey	49,358	20,822	22,017	18,045	110,242
New York	35,659	2,000	330	680	38,669
North Carolina	31,561	.....	.....	.....	31,561
North Dakota	.....	.....	.....	.....	.....
Ohio	213,995	41,781	70,766	49,079	375,621
Oregon	1,354	.....	50	.....	1,404
Pennsylvania	85,401	35,356	55,489	11,792	188,038
South Carolina	60	.....	2,500	.....	2,560
Tennessee	3,647	16	1,500	.....	5,163
Texas	5,219	383	.....	.....	5,602
Virginia	1,058	.....	.....	.....	1,058
Washington	96	.....	.....	.....	96
West Virginia	21,000	14,400	4,000	9,000	48,400
Wisconsin	250	160	.....	.....	410
Total	607,766	122,089	185,809	97,002	1,012,666

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IMPORTS.

In the following tables will be found a statement of the clay and manufactured goods imported into the United States in recent years:

Classified imports of clay during the calendar years ending December 31 from 1885 to 1896.

Kind.	1885.		1886.		1887.	
	Long tons.	Value.	Long tons.	Value.	Long tons.	Value.
China clay or kaolin.	10,626	$83,722	16,590	$123,093	23,486	$141,360
All others:						
Unwrought.....	9,736	76,899	13,740	113,875	17,645	139,405
Wrought.....	3,554	29,839	1,654	20,730	2,187	22,287
Total.....	23,916	190,460	31,984	257,698	43,318	303,052

Kind.	1888.		1889.		1890.	
	Long tons.	Value.	Long tons.	Value.	Long tons.	Value.
China clay or kaolin.	18,150	$102,050	19,843	113,538	29,923	$270,141
All others:						
Unwrought.....	20,604	152,694	19,237	145,983	21,049	155,486
Wrought.....	6,832	53,245	8,142	64,971	2,978	29,143
Total.....	45,586	307,989	47,222	324,492	53,950	454,770

Kind.	1891.		1892.		1893.	
	Long tons.	Value.	Long tons.	Value.	Long tons.	Value.
China clay or kaolin.	39,901	$294,458	49,468	$375,175	49,713	$374,460
All others:						
Unwrought	16,094	118,689	20,132	155,047	14,949	113,029
Wrought.....	6,297	56,482	4,551	64,818	6,090	67,280
Common blue...	.....	.....	5,172	59,971	4,304	51,889
Total	62,292	469,629	79,323	655,011	75,056	606,658

Kind.	1894.		1895.		1896.	
	Long tons.	Value.	Long tons.	Value.	Long tons.	Value.
China clay or kaolin.	62,715	$465,501	75,447	$531,714	76,718	$536,081
All others:						
Unwrought	13,146	98,776	18,419	125,417	13,319	88,029
Wrought.....	4,768	60,786	5,160	60,775	4,514	56,701
Common blue...	2,528	28,886	3,869	40,578	4,983	54,695
Total	83,157	653,949	102,895	758,484	99,534	735,506

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Earthenware, china, brick, and tile imported and entered for consumption in the United States, 1867 to 1896, inclusive.

Year ending—	Brown earthen and common stone-ware.	China and porcelain, not decorated.	China and decorated porcelain.	Other earth-en, stone, or crockery ware, glazed, etc.	Brick, fire brick, and tile.	Total.
June 30—						
1867	$48,618	$418,493	$439,824	$4,280,924	.....	$5,187,859
1868	47,208	309,960	403,555	3,244,958	.....	4,005,712
1869	34,260	400,894	555,425	3,468,970	.....	4,459,549
1870	47,457	420,442	530,805	3,461,524	.....	4,460,228
1871	96,695	391,374	571,032	3,573,254	.....	4,632,355
1872	127,346	470,749	814,134	3,896,664	.....	5,308,893
1873	115,253	479,617	867,206	4,289,868	.....	5,751,944
1874	70,544	397,730	676,656	3,686,794	.....	4,831,724
1875	68,501	436,883	654,965	3,280,867	.....	4,441,216
1876	36,744	409,539	718,156	2,948,517	.....	4,112,956
1877	30,403	326,956	668,514	2,746,186	.....	3,772,059
1878	18,714	289,133	657,485	3,031,393	.....	3,996,725
1879	19,868	296,591	813,850	2,914,567	.....	4,044,876
1880	31,504	234,371	1,188,847	3,945,666	.....	5,500,388
1881	27,586	321,259	1,621,112	4,413,369	.....	6,383,326
1882	36,023	316,811	2,075,708	4,438,237	.....	6,866,779
1883	43,864	368,943	2,587,545	5,685,709	.....	6,686,061
1884	50,172	982,499	2,664,231	(a)	$666,595	4,363,497
1885	44,701	823,334	2,834,718	.....	963,422	4,666,175
December 31—						
1886	37,820	865,446	3,350,145	.....	951,293	5,204,704
1887	43,079	967,694	3,888,509	.....	1,008,360	5,907,642
1888	55,558	1,054,854	4,207,598	.....	886,314	6,204,324
1889	48,824	1,148,026	4,580,321	.....	788,391	6,565,562
1890	56,730	974,627	3,562,851	.....	563,568	5,157,776
1891	99,983	1,921,643	6,288,088	.....	353,736	8,663,450
1892	63,003	2,022,814	6,555,172	.....	380,520	9,021,509
1893	57,017	1,732,481	6,248,255	.....	338,143	8,375,896
1894	47,114	1,550,950	5,392,648	.....	189,631	7,180,343
1895	61,424	2,117,425	8,055,473	.....	211,473	10,445,795
1896	41,585	1,511,542	7,729,942	.....	247,455	9,530,524

a Not separately classified after 1882.

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THE CLAY-WORKING INDUSTRY IN 1896.

By Heinrich Ries.

The clay-working industry of the United States for the year 1896 is marked by slow but steady progress in the methods of manipulation and the quality of the product rather than by any special innovations of large importance. The development has been along two different lines, namely, (1) improvements in the technology, and (2) the introduction of laboratory methods, such as are largely used abroad, for the investigation of the clays.

STRUCTURAL MATERIALS.

Throughout the country there is to be seen a more extended use of proper machinery for tempering the clay and molding the brick. The old practice of molding bricks by hand is rapidly disappearing, except in the Southern States. There the expansion of the brick industry is greatly hindered by the fact that on account of the ever-present mantle of impure, sandy residual clay, the bricks for any large building are usually made on the spot in a crude, cheap way. With few exceptions these bricks are of inferior quality and are not nearly so good as those made from river or swamp clays.

There is also to be noticed a decided increase in the number of permanent wall kilns, and of down-draft ones; and the old scove kiln is rapidly becoming a thing of the past.

A word should also be said concerning the continuous kiln. In the last three or four years kilns of this kind have been erected at numerous points. Theoretically this is the ideal method of burning, it being the most economical. There are many different patents, but their general principle is similar to that of the Hoffman.

Some are working successfully, but others have gone through more or less alterations in the method of firing or in the arrangement of flues, according as the manufacturer has thought that one or the other change might improve the working of the kilns. On the whole it may be stated that those in use in this country are moderately successful. They are now chiefly used for burning common brick, but front brick, paving brick, fire brick, and drain tile are also among the products burned in them.

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For the manufacture of pressed brick the use of the dry-press and the semidry-press process is extending. Red brick have given way, to a great extent, to buff, speckled, and white ones. The use of terra cotta is still extensive, and the manufacturers are improving in their ability to deliver goods whose dimensions agree closely with those ordered. A somewhat new departure in terra cotta is the molding of columns to adorn the doorways and windows of large buildings, and some recently erected in Baltimore are especially creditable. Glazed terra cotta has had little application so far, and is chiefly confined to Chicago.

THE TILE INDUSTRY.

The use of tiles for flooring, as a substitute for slate or marble and for decorative purposes, has grown so that there are now about fifteen firms engaged in the manufacture of tiling in this country. The product includes tiles for floors, walls (exterior and interior), mantels, hearths, stoves, soda fountains, etc. A mixture of clay is generally used to form the body of the tile, and many of the higher grades have kaolin in their composition. The clays used in the American tiles include kaolins from North Carolina, South Carolina, Florida, and Pennsylvania. Other clays are obtained from Pennsylvania, New Jersey, Ohio, Kentucky, Missouri, and Indiana. A small amount of English kaolin is used by some. Feldspar is used to flux the body, and quartz to prevent excessive shrinkage.

It is of course necessary that the proportions of clay shall be such that the shrinkage will be regular, and that the greatest possible proportion of the product shall be of exactly the required size. In the case of tile for flooring or exterior decoration, a vitrified or impervious body is especially important. For tiles having a plain surface, without superficial coloring, the color is varied by using different clays, or by the admixture of coloring matter to the clay.

When used for ornamental purposes, as around mantels or in stoves, the tiles are usually decorated. This decoration may consist of an enamel of different shades or color, or simply a glaze. Some tiles have a raised design which is imparted to them in the molding, and a transparent glaze over it, while others are decorated either by printing or by hand painting. These two latter styles are usually covered with a glaze.

A few firms produce a tile made in such a manner that the surface has the appearance of mosaic work. The Mosaic Tiling Company, of Zanesville, Ohio, has recently introduced an ingenious way of molding such tiles. A framework consisting of a rectangular series of tubes is set into the tile mold. If clays of different colors are put into these tubes, filling them up to a given depth, and the frame is lifted off, the different-colored clays, each being present in the form of small square columns set closely together, give a mosaic-like appearance to the surface. The clay is introduced into the tubes in the form of dry powder,

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and each color is put in by a different workman, who has a sheet of stiff paper, the size of the mold, and which contains square openings fitting over the tubes into which the clay of a given color is to be put. The design is thus made up of a series of small squares. After all the tubes are filled the framework is removed and the tile pressed in steel dies.

The following firms are engaged in the manufacture of tiling in this country:

American Encaustic Tiling Company, Zanesville, Ohio. Tiles for floors, walls, mantels, and mosaic tiles, the latter a recent introduction.

Beaver Falls Art Tile Company, Beaver Falls, Pennsylvania. Glazed, plain, enameled, and embossed tile.

Cambridge Tile Manufacturing Company, Covington, Kentucky. Glazed and enameled tile.

Columbia Encaustic Tile Company, Anderson, Indiana. Plain, glazed, enameled, and decorated tile.

Kensington and Hamilton Art Tile Company, Hamilton, Ohio Enameled, plain, and embossed tiles.

Kirkham Art Tile and Pottery Company, Barbertown, Ohio. Inoperative. Factory destroyed by fire.

Low Art Tile Company, Chelsea, Massachusetts. Enameled and embossed tile for soda fountains, stoves, and mantels.

Mosaic Tiling Company, Zanesville, Ohio. Mosaic tiling for exterior and interior decoration.

New York Vitrified Tile Company, Brooklyn, New York Vitreous and semivitreous tiles of different colors; chiefly for flooring.

Old Bridge Enameled Brick and Tile Company, Old Bridge, New Jersey Enameled, plain, and embossed tile.

Pennsylvania Tile Works, Aspers, Pennsylvania. Encaustic floor tile

Providential Tile Company, Trenton, New Jersey. White and colored glazed tile. Some decorated over glaze.

Star Encaustic Tiling Company, Pittsburg, Pennsylvania. Unglazed encaustic floor tiles in different colors.

Tarrytown Vitrified Tile Company, Tarrytown, New York. Vitrified floor tile.

Trent Tile Company, Trenton, New Jersey. Tiles for mantels and hearths. Glazed and decorated.

United States Encaustic Tiling Company, Indianapolis, Indiana. Glazed and enameled tile, also floor tile.

PAVING BRICK.

Little is to be said concerning this branch of the clay-working industry, except that it is progressing steadily. The use of auger machines is becoming the prevailing method of molding, and re-pressing is also extensively used, for, as experiments quoted below show, it improves the brick materially under certain conditions.

TESTS OF PAVING BRICK.

There has been some difference of opinion for a long period as to what constitute the requisite qualities of a paving brick. Engineers have frequently laid considerable stress upon the crushing test and the color. The latter is of no value as a guide, and the former is to

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be looked upon in the same way beyond certain limits. With a view, therefore, to determine what the requisite qualifications of a paving brick should be, and if possible to adopt a set of standard specifications, a committee was appointed by the National Brick Makers' Association two years ago, and after a series of exhaustive tests their report has recently been submitted.

The subjects which the committee took up for consideration were:

1. Rattling, as a measure of toughness and wearing power.
2. Absorption, as a measure of vitrification and resistance to freezing.
3. Cross breaking, as a measure of structural perfection and freedom from defects due to manufacture.
4. Crushing, as a further indication of the same factor.
5. Hardness, as a confirmatory test of vitrification.
6. Specific gravity, as a guide to the density and fineness of the material.

The rattler.—A series of experiments made by varying the charge, size of rattler, number of revolutions per minute, and time of rattling showed that—

1. Not less than 10 per cent nor more than 15 per cent of the volume of the rattler need be filled with the cubic contents of the charge.
2. It must be rattled for not less than 1,000 and preferably not less than 2,000 revolutions.
3. The length of the chamber is immaterial.
4. The diameter of the chamber must be between 26 and 30 inches.
5. The speed of revolution, between 24 and 36 revolutions per minute, is immaterial if the test is terminated when the requisite number of revolutions have been made.

The effect of cast iron and granite as abrasive and filling materials was also tested and found to be unsatisfactory. Large bricks showed less wear than small ones; normally burned, less than overburned or underburned ones.

Absorption test.—A series of tests showed that even after drying forty-eight hours at above 110° C. a brick continued to lose water, and that immersed brick showed an increased gain in weight even after six months' immersion, although the great bulk was taken in the first week.

Broken bricks absorb more water than whole ones, and small pieces from the interior of the brick absorb more proportionately than large ones.

The following conclusions were reached:

1. That to obtain accurate absorption figures, a hard brick will require not less than four days' drying and eight weeks' soaking.
2. That only roughly approximate figures are obtained within time limits which would be short enough to make the figures useful for ordinary competitive tests of material for immediate use.
3. That only rattled bricks should be used for the absorption test, as

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the absorptive power of brick in use is increased by its chipping and grinding under traffic.

4. No relation seems to exist between loss by rattling and percentage of absorption.

As a result of the committee's experiments the following specifications were adopted:

SPECIFICATIONS FOR ABRASION TEST.

I. *Dimensions of the machine.*—The standard machine shall be 28 inches in diameter and 20 inches in length, measured inside the rattling chamber. Other machines may be used, varying in diameter between 26 and 30 inches, and in length from 18 to 24 inches, but if this is done a record of it must be attached to the official report. Long rattlers may be cut up into sections of suitable length by the insertion of iron diaphragms at proper points.

II. *Construction of the machine.*—The barrel shall be supported on trunnions at either end; in no case shall a shaft pass through the rattling chamber. The cross section of the barrel shall be a regular polygon, having 14 sides. The heads and staves shall be composed of gray cast iron, not chilled or casehardened. There shall be a space of one-fourth of an inch between the staves for the escape of dust and small pieces of waste. Other machines may be used having 12 to 16 staves, with openings from one-eighth to three-eighths of an inch between the staves, but if this is done a record of it must be attached to the official report of the test.

III. *Composition of the charge.*—All tests must be made on charges composed of one kind of material at a time. No test shall be considered official where two or more different bricks or materials have been used to compose a charge.

IV. *Quantity of the charge.*—The quantity of the charge shall be estimated by its bulk and not by its weight. The bulk of the standard charge shall be equal to 15 per cent of the cubic contents of the rattling chamber, and the number of whole brick whose united volume comes nearest to this amount shall constitute a charge.

V. *Revolutions of the charge.*—The number of revolutions of a standard test shall be 1,800, and the speed of rotation shall be 30 per minute. The belt power shall be sufficient to rotate the rattler at the same speed whether charged or empty. Other speeds of rotation between 24 and 36 revolutions per minute may be used, but in this case a record of the speed must be attached to the official report.

VI. *Condition of the charge.*—The bricks composing a charge shall be dry and clean, and, as nearly as may be possible, in the condition in which they are drawn from the kiln.

VII. *Calculation of the results.*—The loss shall be calculated in percentage of the weight of the dry brick composing the charge, and no result shall be considered as official unless it is the average of two distinct and complete tests, made on separate charges of brick.

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SPECIFICATIONS FOR ABSORPTION TEST.

1. The number of bricks for a standard test shall be five.

2. The test must be conducted on rattled bricks. If none such are available, the whole bricks must be broken in halves before treatment.

3. The bricks should be dried for forty-eight hours at a temperature ranging from 230° to 250° F. before weighing for the initial dry weight.

4. The bricks should be soaked for forty-eight hours, completely immersed, in pure water.

5. After soaking, and before weighing, the bricks must be wiped dry from surplus water.

6. The differences in weight must be determined on scales sensitive to 1 gram.

7. The increase in weight due to water absorbed shall be calculated in percentage of the initial dry weight.

The commission which drew up these specifications considers that any brick which will satisfy the requirements of reasonable mechanical tests will not absorb sufficient water to prove injurious to it in service, and that for such brick the absorption test should be abandoned as unnecessary, if not actually misleading.

SPECIFICATIONS FOR CROSS-BREAKING TESTS.

1. Support the brick on edge, or as laid in pavement, on hardened steel knife edges, rounded longitudinally to a radius of 12 inches and transversely to a radius of one-eighth inch, and bolted in position so as to secure a span of 6 inches.

2. Apply the load to the middle of the top face through a hardened steel knife edge, straight longitudinally and rounded transversely to a radius of one-sixteenth inch.

3. Apply the load at a uniform rate of increase until fracture ensues.

4. Compute the modulus of rupture by the formula.

$$f = \frac{3\ w\ l}{l\ b\ d^2},$$

in which

f=modulus of rupture in pounds per square inch;

w=total breaking load in pounds;

l=length of span in inches=6;

b=breadth of brick in inches;

d=depth of brick in inches.

5. Samples for test must be free from all visible irregularities of surface or deformities of shape, and their upper and under faces must be practically parallel.

6. Not fewer than ten bricks shall be broken, and the average of all be taken for a standard test.

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SPECIFICATIONS FOR CRUSHING TEST.

1. The crushing test should be made on half bricks, loaded edgewise, or as they are laid in the street. If the machine used is unable to crush a full half brick, the area may be reduced by chipping off, keeping the form of the piece to be tested as nearly prismatic as possible. A machine of at least 100,000 pounds' capacity should be used, and the specimen should not be reduced below 4 square inches of area in cross section at right angles to the direction of load.

2. The upper and lower surfaces should preferably be ground to true and parallel planes. If this is not done they should be bedded in plaster of paris while in the testing machine, which should be allowed to harden ten minutes under the weight of the crushing planes only, before the load is applied.

3. The load should be applied at a uniform rate of increase to the point of rupture.

4. Not less than an average obtained from five tests on five different bricks shall constitute a standard test.

It was resolved by the commission that "from the experimental work done so far by this commission, or by others so far as is known to us, in the application of the cross-breaking and crushing tests to paving brick, it is not possible to show any close relationship between the qualities necessary for a good paving material and high structural strength as indicated by either of these tests."

EFFECT OF STRUCTURE ON WEARING POWER OF PAVING BRICK.[1]

Recent experiments by Prof. Edward Orton, jr., on bricks made from the same shale, but molded on different machines and burned together in the same kiln, show that end-cut bricks possess a decided superiority over side-cut bricks, and also show the marked advantage of re-pressing end-cut and the disadvantage of re-pressing side-cut bricks.

Rattling tests made by Prof. Edward Orton, jr., on paving bricks.

END-CUT BRICKS.

Description.	Loss in weight at the end of—		Average modulus of rupture.
	1,000 revolutions.	2,000 revolutions.	
	Per cent.	*Per cent.*	*Pounds.*
Re-pressed	18.23	26.67	2,525
Plain	21.05	28.48	2,425
Average of both	19.54	27.00	2,463

[1] Clayworker, February and March, 1897.

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Rattling tests made by Prof. Edward Orton, jr., on paving bricks—Continued.

SIDE-CUT BRICKS.

Description.	Loss in weight at the end of—		Average modulus of rupture.
	1,000 revolutions.	2,000 revolutions.	
	Per cent.	*Per cent.*	*Pounds.*
Re-pressed	26.51	35.30	2,347
Plain	22.73	31.42	2,346
Average of both	24.43	32.90	2,347

DRY-PRESSED BRICKS.

Coarse	19.40	25.20	2,507
Medium	23.80	28.26	2,740
Fine	20.07	29.71	2,687
Average of all	21.09	27.72	2,644

TESTS OF BUILDING AND OTHER BRICK.

A large series of shearing, crushing, and absorption tests have been made at the Watertown (Massachusetts) Arsenal on material obtained mostly from the World's Columbian Exposition. They represent samples from a considerable area, and on account of their completeness are of considerable value. (Tests of metals, 1894, United States War Department.)

Tests made to show relative strength of bricks according to the direction in which tested.

BRICKS TESTED FLATWISE.

Height.	Surface area.	Ultimate strength.		Average.
		Total.	Per square inch.	
Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
2.16	27.63	308,400	11,162	11,173
2.10	27.26	367,800	13,492	
2.19	27.77	298,500	10,749	
2.21	27.90	259,200	9,290	

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Tests made to show relative strength of bricks, etc.—Continued.

BRICKS TESTED EDGEWISE.

Height.	Surface. area.	Ultimate strength.		Average.
		Total.	Per square inch.	
Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
3.58	16.37	124,800	7,623	8,978
3.60	17.15	159,100	9,277	
3.57	16.98	114,000	6,714	
3.48	16.54	203,400	12,297	

BRICKS TESTED ENDWISE.

7.73	7.37	59,200	8,032	6,927
7.72	7.83	45,700	5,837	
7.75	7.85	51,600	6,573	
7.71	7.54	54,800	7,268	

Tests to determine relative strength of bricks tested singly, in pairs, threes, fours, and fives, set in plaster-of-paris joints and compressed surfaces.

Number in pile.	Height of pile.	Sectional area.	Ultimate strength.		Average.
			Total.	Per square inch.	
	Inches.	*Sq. inches.*	*Pounds.*	*Pounds.*	*Pounds.*
1	2.20	28.95	458,500	15,837	12,469
1	2.12	29.56	269,000	9,100	
2	4.40	29.41	178,500	6,069	6,440
2	4.35	29.33	199,800	6,812	
3	6.48	29.14	127,200	4,365	5,096
3	6.60	29.10	169,600	5,828	
4	8.75	29.29	122,100	4,168	4,478
4	8.88	29.22	139,900	4,788	
5	10.95	28.94	131,100	4,530	4,131
5	10.85	29.60	110,500	3,733	

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Compression tests of bricks.

Description.	Height.	Sectional area.	First crack.	Ultimate strength.		Absorption by weight.
				Total.	Per square inch.	
Medium hard-burnt bricks from St. Louis Hydraulic Press Brick Co., St. Louis, Mo.:	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*
Medium red	2.28	35.36	156,000	186,200	5,266	18.0
Dark red	2.27	33.49	283,000	339,900	10,149	.....
Paving stock	2.14	33.17	489,000	582,400	17,558	10.1
Do	4.04	17.59	185,000	105,400	5,992	10.1
No. 6 stock, dark red	2.35	34.23	315,000	364,300	10,643	.....
No. 10 stock, dark red	2.30	32.68	376,000	571,000	17,472	.....
No. 500 stock, buff speckled	2.32	33.87	268,000	319,200	9,424	.....
No. 503 stock, light chocolate	2.28	33.54	223,000	289,100	8,620	.....
Light chocolate with dark speckles	2.32	34.20	318,000	455,900	13,330	.....
Dark buff, speckled	2.35	34.32	265,000	305,700	8,907	.....
Light buff	2.32	34.32	207,000	279,500	8,144	9.6
Brown	2.40	34.52	261,000	305,900	8,861	15.4
Chicago Hydraulic Press Brick Co., Chicago, Ill.:						
Brown	2.31	34.44	156,000	165,100	4,794	14.6
Red	2.33	34.52	174,000	192,400	5,574	14.8
Do	4.07	19.30	100,200	100,200	5,192	.....
Omaha Hydraulic Press Brick Co., Omaha, Nebr.:						
Red, shade 5	2.33	33.49	380,000	452,000	13,511	.....
Red, shade 7	2.41	33.95	368,000	438,200	12,907	11.4
Northern Hydraulic Brick Co., Minneapolis, Minn.:						
Dark red	2.32	34.61	168,000	259,900	7,509	14.8
Do	2.32	34.35	248,000	260,200	7,575	.....
Findlay Hydraulic Press Brick Co., Findlay, Ohio:						
12, dark red	2.31	33.12	238,000	320,800	9,686	.....
18, dark red	2.27	33.13	259,000	409,900	12,372	.....
14, dark red	2.27	33.21	243,000	372,000	11,201	.....
Eastern Hydraulic Press Brick Co., Philadelphia, Pa.:						
Light buff	2.21	32.52	332,000	481,900	14,818	.....
Buff	2.20	31.99	335,700	519,900	16,252	5.5
Buff (darker)	2.18	33.13	328,000	447,000	13,492	7.9
Gray	2.22	32.44	295,000	454,000	13,995	.....
Light chocolate	2.22	32.24	355,000	486,200	15,081	.....
Do	3.94	18.18	166,000	180,800	9,945	5.5
Philadelphia and Boston Face Brick Co., Boston, Mass.:						
Salmon color (for inside)	2.40	35.57	102,000	141,100	3,967	19.2
Light red	2.28	34.36	182,000	221,500	6,845	11.0
Do	3.99	18.41	84,000	108,200	5,877	.....
Dark red	2.28	32.04	222,000	251,060	7,836	10.0
Do	2.22	30.02	267,000	366,100	12,195	.....
Chocolate brown	2.24	31.40	204,000	243,800	7,764	.....
Do	3.90	17.03	182,000	289,900	17,023	.....
Cream color	2.28	32.20	105,000	112,100	3,481	.....
Buff	2.22	30.81	280,000	320,600	10,406	.....
Do	3.91	17.62	83,800	183,800	4,756	.....
Gray	2.28	32.08	123,200	23,200	3,840	15.2
Brooke Terra Cotta Co., Lazearville, W. Va., dry-press bricks:						
No. 4, dark buff	2.42	34.58	564,000	800,000	23,135	6.7
No. 5, medium dark buff	2.42	35.10	234,000	423,900	12,077	8.8
No. 10, light buff	2.35	33.11	158,000	607,200	18,339	12.2

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Compression tests of bricks—Continued.

Description.	Height.	Sectional area.	First crack.	Ultimate strength.		Absorption by weight.
				Total.	Per square inch.	
Kelly Brick and Tile Co., Minneapolis, stiff mud bricks:	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*
Light straw color	2.32	28.92	151,000	238,900	8,261	.....
Do	2.32	29.04	182,000	221,500	7,627	.....
Do	2.33	28.45	218,000	249,900	8,784	.....
Mather Brick Co., Mankato, Minn.:						
Dry-press bricks	2.27	34.40	350,000	379,900	11,043	13.7
Soft mud, outer portion of kiln	2.27	29.08	27,500	28,200	970	26.7
Rain-washed, arch bricks, scove kiln	2.19	27.61	72,100	72,100	2,611	.....
Bricks from near top of scove kiln	2.33	29.43	48,000	48,200	1,638	.....
From center of kiln	2.29	29.01	28,000	28,500	982	25.4
Hard burnt	2.32	28.97	42,500	45,700	1,577	24.0
Hard burnt, 4 feet higher in kiln	2.34	28.33	68,200	68,200	2,407	21.5

Transverse tests of bricks.

[Distance between supports, 6 inches.]

Locality and description.	Ultimate strength.	
	Total.	Modulus of rupture.
St. Louis Hydraulic Press Brick Co.:	*Pounds.*	*Pounds.*
Dark red	1,645	754
No. 10 stock	1,939	833
Chicago Hydraulic Press Brick Co.:		
Red	1,102	455
Brown	742	308
Northern Hydraulic Brick Co., Minneapolis, Minn.:		
Dark red	1,100	455
Omaha Hydraulic Press Brick Co., Omaha, Nebr.:		
Shade 6	3,216	1,244
Eastern Hydraulic Press Brick Co., Philadelphia, Pa.:		
Shade 200	2,110	936
Shade 300	1,660	756
Philadelphia and Boston Face Brick Co., Boston, Mass.:		
Light red	1,686	785
Chocolate brown	1,548	741
Dark red	2,160	1,043
Cream	1,284	568
Buff	1,926	858
Gray	810	358

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Shearing tests of bricks from various localities.

Locality.	Description.	Absorption.	Cracked.	Ultimate strength.	
				Total.	Per square inch.
ARKANSAS.		*Per ct.*	*Pounds.*	*Pounds.*	*Pounds.*
.....	Paving brick, decomposed shale.	1.4	143,000	287,100	9,469
.....	....do	2.6	62,000	112,900	6,752
.....	Facing brick, light red....	12.9	54,000	169,800	5,094
.....	Fire brick, deep salmon color.	21.5	78,000	123,100	3,465
.....	Shale brick	.....	280,000	791,000	24,634
COLORADO.					
Golden Pressed and Fire Brick Co., Denver.	Red face brick	15.3	142,000	149,980	4,408
Do.....	Cream face brick	14.8	172,000	212,100	6,180
Do.....	Dark-buff face brick	7.2	214,000	299,800	8,936
Do.....	Buff face brick	10.6	209,000	231,000	6,638
FLORIDA.					
Fernandina.....	Red brick.....	11.4	76,100	87,300	2,665
Do.....	.....do	13.9	148,000	177,200	5,077
IDAHO.					
Albany Falls	Face brick, light red.....	21.6	217,000	237,000	6,530
Do.....	Hard burnt.....	5.9	508,000	697,600	22,561
Do.....	Medium hard burnt.....	16.1	339,000	365,900	10,535
ILLINOIS.					
Utica Fire Brick Co., Utica....	Repressed brick.....	12.9	57,000	171,400	4,244
	Cream-colored brick.....	9.2	72,000	154,200	3,966
Bushnell Pressed Brick Co., Bushnell.	Buff brick.....	10.8	202,000	223,000	7,297
	Building brick.....	10.7	201,000	209,900	6,916
G. T. Walters, Chatsworth.....	Light-red building brick .	11.7	130,000	228,000	6,881
KENTUCKY.					
Louisville Fire Brick Works, Louisville.	Fire brick	9.4	61,000	188,200	4,709
Do.....	.....do	9.3	96,000	204,400	4,937
Do.....	Archway brick	7.0	181,000	306,000	9,681
MINNESOTA.					
J. Lind & Co., Barnum.....	Red brick.....	13.80	36,000	80,200	2,742
F. X. Goulet, Staples.....	.....do	13.60	102,000	176,100	5,791
Peter Becker, Belleplaine.....	Buff brick	30.00	46,800	46,800	1,507
F. A., New Ulm.....	Pearl-colored brick.....	10.9	92,000	154,100	4,196
O. R. Mather, Pelican Rapids..	Buff brick	26.7	106,000	111,300	3,475
F. Hathreggen, Carlton.....	.....do	19.6	109,000	214,200	6,833
Dangs & Wiest, Blakely.....	.....do	17.9	38,000	117,400	4,206
Hess & Moog, St. Cloud	.....do	28.1	98,000	140,000	4,416
P. Becker, Belleplaine.....	.....do	24.5	74,000	77,600	2,583
A. C. Ochs, Springfield.....	.....	11.1	63,000	212,000	7,402
J. A. McKay, Alexandria.....	.....	17.7	37,500	40,100	1,311
M. Mueller, Stillwater.....	Red brick.....	15.00	87,000	90,050	2,944
St. Louis River Slate Brick Co.	Dry-pressed shale brick...	8.50	238,000	249,200	7,246
Do.....	.....do	9.30	202,000	208,500	5,990
J. Lind, Barnum.....	Red brick.....	14.40	45,000	73,900	2,442
F. X. Goulet, Staples.....	Red pressed brick.....	15.40	132,000	159,000	5,298

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Shearing tests of bricks from various localities—Continued.

Locality.	Description.	Absorption.	Cracked.	Ultimate strength.	
				Total.	Per square inch.
IOWA.		*Per ct.*	*Pounds.*	*Pounds.*	*Pounds.*
Fort Dodge Clay Works	Buff brick	9.2	138,000	249,500	8,449
J. C. Holman & Bro., Sargents Bluff.	Building brick	10.1	86,000	196,100	6,350
Do	Paving brick	1.6	88,000	271,000	9,485
Davenport Paving Brick and Tile Co.	do	1.1	71,000	301,800	9,280
Muscatine T. C. Lumber Co.	do	1.4	97,000	329,600	11,257
WASHINGTON.					
Everett Electric Brick Co.	Soft-burnt brick	18.00	104,000	126,200	3,984
Do	Hard-burnt	5.20	69,000	216,950	7,846
Denny Clay Co	Face brick	5.60	250,000	505,800	12,573
Do	Fire brick	12.00	59,900	104,980	2,765
Puget Sound Brick T. & T. C. Co	Building brick	12.20	114,000	170,200	4,767
C. A. Sherman, Spokane	Dark cream brick	23.50	89,900	98,800	2,694

The following are the results of some tests made by H. Williams, M. E., at Cornell University, on bricks from New York State, made by different methods from the same clay. Half bricks were tested in each case, and plaster of paris put between surfaces of bricks and plates of machine.

	Ultimate strength.	
	Total.	Per square inch.
	Pounds.	*Pounds.*
1. Wire-cut brick	59,800	3,385
2. Red brick, dry-clay process, Glens Falls	34,660	3,580
3. Stiff mud, side cut, re-pressed, buff, Glens Falls	104,360	6,510
4. Soft mud, re-pressed red brick, Glens Falls	117,100	5,365
5. Dry-pressed buff brick, Glens Falls	83,680	5,800
6. Soft-mud brick, W. W. Parry, Rome	115,300	4,470
7. Stiff mud, re-pressed, W. W. Parry, Rome	240,000	8,760

TESTS OF PAVING BRICK MADE AT PEORIA, ILLINOIS.

A number of instructive tests are usually contained in the annual report of the department of public works of Peoria, Illinois. This city has perhaps the best testing laboratory in the Central States. Situated in a region abounding in paving-brick factories, whose product is often of superior quality, it is of interest to quote here many of the tests made by the city engineer in 1895 and given in his report issued the past year.

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The abrasion test was made by placing not more than twelve bricks in an iron rattler 24 inches in diameter and 3 feet long, together with 300 pounds of smoothly worn scrap iron, the pieces of which vary from one-fourth to 5 pounds. The rattler was revolved one hour at the rate of 15 revolutions per minute. The transverse tests were made in a Riehle tension and compression machine without grinding the surfaces parallel, to procure an even pressure and consequently greater modulus of rupture. The absorption test was made on the rattled bricks.

Brick tests made by the city engineer of Peoria, Illinois.

Manufacturer.	Average absorption, 48 hours.	Average modulus of rupture.	Abrasion, average after 1 hour.
	Per cent.	*Pounds.*	*Per cent.*
Springfield Paving Brick Co	1.22	2,436	8.89
Do	1.94	2,337	6.07
Do	3.25	2,307	11.16
Portsmouth, Ohio	.26	.....	4.14
Nelsonville Sewer Pipe Co	.55	.....	4.46
Anderson & Barr Clay Co	2.43	.....	9.39
Do	2.22	2,206	11.21
Do	2.05	1,902	11.81
Galesburg Brick and Terra Cotta Co	.62	2,253	8.15
Do	1.86	2,195	9.46
Do	.92	3,092	8.27
Purington Paving Brick Co	1.13	2,185	5.95
Do	3.27	2,197	9.79
Do	1.26	3,074	9.32
Do	4.31	2,550	9.91
Imperial Shale Brick Co	.45	3,267	3.16
Athens Brick Co	2.43	.....	8.21
Bronaugh, Virden, Ill	2.66	.....	9.19
Spurck Paving Brick Co	1.06	2,966	9.21
Do	2.57	2,354	10.52
Do	2.44	2,615	8.08
Do	1.27	2,323	6.44
T. B. Townsend Brick and Concrete Co	.94	2,572	7.00
Galesburg Paving Brick Co	.41	4,316	8.33
Do	2.34	2,869	8.99
Do	1.60	3,138	6.92
Ottawa, Ill	1.13	1,872	10.54
Evansville Pressed Brick Co	.75	4,496	7.35
Do	1.39	3,227	7.88
Do	2.66	2,870	8.36
Do	.85	3,686	9.41
Do	.....	3,658	5.05
Utt Bros., Springfield	5.30	.....	13.64
Elcock & Sultzaberger	1.95	1,664	5.15
Streator Tile Co	1.68	.....	11.26
Wabash Clay Co	5.24	1,521	10.16

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The following are samples tested in 1894, and are from factories whose product was not tested in 1895:

Manufacturer.	Average absorption, 48 hours.	Average modulus of rupture.	Abrasion, average after 1 hour.
	Per cent.	*Pounds.*	*Per cent.*
Grape Creek Clay Works	1.68	1,908	11.16
Do	5.43	1,232	12.32
Do	3.51	2,081	3.57
Seaman Clay Co	1.01	981	11.19
Ottawa Fire Clay and Brick Co	2.95	.....	7.06
Streator, Ill	5.50	.....	7.66
Ottawa Fire Clay and Brick Co	3.93	839	4.37
Do	4.11	790	11.74
Do	4.55	1,355	24.48
Ulrichsville Fire Clay Co	4.96	1,278	15.35
Abingdon Brick and Tile Co	3.70	.....	11.44
St. Louis Press Brick Co	.13	2,917	9.92
Do	.47	2,797	6.20
Do	.83	2,668	5.53

FIRE BRICK.

In some experiments recently made by Mr. J. D. Pennock[1] to determine the heat conductivity, expansion, and fusibility of refractory brick there were used bricks made of Grecian magnesite, American magnesite, silica brick, and coke-oven tiling made in Belgium.

In the charts and detailed figures given by Mr. Pennock it is shown that the Grecian magnesite conducts heat the most readily, the American next, then the silica brick, while the coke-oven brick is the poorest conductor. The poor conductivity of the coke-oven brick is thought to lie in its greater purity and density.

Expansion tests on fire brick.

	Expansion of core.	Expansion per 12-inch brick.
	Inch.	*Inch.*
Grecian magnesite	0.07	0.11
Do	.07	.11
American magnesite	.067	.10
Do	.057	.088
Coke-oven tiling	.05	.076
Do	.05	.076

[1] Trans. Am. Inst. Min. Eng., September, 1896.

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The expansion test was made by supporting a core of the brick in a horizontal position. One end was against a support and the other against a movable lever. The core was heated by means of burners placed underneath.

Analyses of fire brick used in above tests.

	Grecian magnesite.	American magnesite.	Silica brick.	Coke-oven tiling.
SiO_2	2.16	3.10	94.07	69.89
$Fe_2O_3+Al_2O_3$	.72	6.64	3.66	27.75
CaO	4.20	3.76	1.39	.27
MgO	93.03	86.50	.19	.17

The specific gravities and weight per cubic foot were—

Specific gravity of fire brick.

	Specific gravity.	Weight per cubic foot.
		Pounds.
Grecian	3.54	170.2
American	3.44	160.9
Coke-oven tiling	2.56	109.9
Silica brick	2.54	111.4

POTTERY AND POTTERY CLAYS.

The energies of the American potters during 1896 have been directed chiefly to bettering their wares and lowering the prices, causing keen competition. In the lower grades, such as whiteware, no new developments of importance have occurred beyond the usual number of new shapes and decorative designs. Some of the potters are very successful in producing glazes which do not seem to craze. Two new potteries for the manufacture of whiteware have begun operations, one at East Liverpool, Ohio, and a second at East Palestine, Ohio. There has also been contemplated the erection of a pottery near Black Rock, Arkansas, and Montgomery, Alabama.

Among the finer grades of ware is to be noticed the continued successful production of Belleek porcelain at Trenton, New Jersey. The Willetts Manufacturing Company has been especially fortunate in this branch of the industry, and has recently engaged to some extent in the application of underglaze delft decoration to their Belleek ware. In the line of ornamental wares the Ceramic Art Company, of Trenton, has brought forth some praiseworthy results in loving cups and tankards with blue or brown decoration. The manufacture of sanitary wares has assumed important proportions, and at Trenton one new factory for their manufacture has been started.

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A recent and perhaps new departure has been made by C. Wingender & Bro., of Haddonfield, New Jersey, in the production of tankards, jardinieres, etc., of blue and gray stoneware, with relief decorations, after the style of that made in Germany. The venture is perhaps still in the experimental stage, but shows indications of a successful future.

Raw materials.—Most of the Florida kaolin is still mined at Edgar, the large tract along the Palatlakaha River remaining as yet undeveloped.

In western North Carolina the Harris mines at Webster remain in operation, and those near Sylva have produced some during the past year. Between these two there has been opened a new kaolin deposit on the land of Mr. George Springer, jr. The vein is 20 feet in width and of excellent quality. Another very promising vein has been found 12 miles north of Rockingham, North Carolina. No mining has been done, but considerable exploiting has been carried on.

CHROMOLITHOGRAPHY IN CERAMICS.[1]

The adaptation of chromolithographic printing to ceramics has been quite recently successfully attempted, and may very possibly supersede line engraving. The great advantage of the chromolithographic decoration lies in the high excellence of the ornament that may be used and the purity of the color that may be obtained. By this means the design of a first-class artist may be reproduced with all its original delicacy and softness. This new method does away with the filling in of prints, which is often apt to be of unequal quality. Up to the present time chromolithographic work has been used only for overglaze decoration, but experiments are being made with it in underglaze ornamentation. The difficulties in the latter case are porosity of the "biscuit" ware, rough surface. The greatest difficulty is said to be this: In printing from engravings, the "print" is really a relatively thick line of color; just in proportion as the engraver cuts deeply into the plate, so is the quantity of color "taken up." Now "underglaze plates" are cut much more deeply than "enamels," and if the "transfer" or printed paper is examined under a microscope the underglaze prints are seen to consist of raised (as we have previously said), relatively thick ridges of color, laid with the point of the ridge uppermost. It is this depth or strength of cutting that enables the underglaze prints to produce their strong patterns, for, owing to the action of the glaze, if only a thin film of color, as is used in chromolithography, were applied to the ware, the decoration would be so faint as scarcely to be seen. The number of colors is small which have a strong staining power when applied only in a thin coat. This is the chief difficulty. At present the best chromolithographic work is done by the French, and by some Staffordshire potters.

[1] Jour. Soc. Arts, Sept. 18, 1896, p. 322.

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THE TESTING OF CLAYS.

For some time it has been customary in this country to confine the laboratory investigation of clay to a chemical analysis of it, with perhaps the burning of a hand-molded bricklet in an assayer's muffle.

While the chemical analysis of a clay is important and gives us some clue to its character, still it is by no means possible to obtain from it a complete explanation of the possible applications of the sample under consideration.

The investigation of a clay must therefore also include an examination of its physical properties. This line of work has been carried on by many German observers, prominent among whom are Seger, Bischof, Cramer, Olchewsky, etc., and their labors have done much toward showing what an important help a knowledge of the physical properties of the clay may be in determining its character.

The modern investigation of a clay should consequently include, first, a rational analysis from which may be computed pretty closely the percentage of clay base, quartz, and feldspar in the clay; second, the determination of the plasticity, amount of water required to make a plastic mass, the tensile strength, shrinkage in drying and burning, points of incipient fusion, vitrification and viscosity; and, third, a mechanical analysis, together with a petrographic examination of the clay for the purpose of gaining information concerning either its physical properties or the derivation of the material forming the deposit. In this country the lines of work laid down above are of comparatively recent introduction. The Missouri Geological Survey has been the first one to issue a report on these lines, and the State surveys of North Carolina and Alabama have similar ones in press.

Prof. H. A. Wheeler deserves much credit for the manner in which the Missouri work has been done.

The plasticity of clays is of such importance that it has always seemed desirable to have some numerical means of expressing the relative plasticity of any given clay. Only two methods have done this. Both assume that as plasticity is due to the interlocking of the particles, the tensile strength of the dried clay will be an index of the plasticity when wet. In the first method, that of Jochum,[1] the clay is formed into a bar, which, when dry, is supported at two ends, and cross broken. The second method, or that of Olchewsky,[2] involves the molding of the clay into briquettes (as in cement testing) and pulling these apart in the regular testing machine. It is this latter method which has been adopted by Professor Wheeler on the Missouri clays and also by the writer on those of Alabama and North Carolina. In the preliminary tests by Wheeler, clay ground to different degrees

[1] Keramik (No. 11, 1869); Bischof, Feuerfeste Thone, 1895, p. 90.
[2] Töpfer Zeitung, 1882, No. 29.

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of fineness was tested in order to determine if possible the relation between plasticity and fineness, with the following results:

Tests of tensile strength of clays in different grades of fineness.

Size of mesh.	Water used	Tensile strength.		Plasticity ratio.
		Maximum.	Average.	
	Per cent.	*Pounds.*	*Pounds.*	
20	18.0	190	142	100
20–40	19.3	196	182	103
40–50	20.4	182	172	96
70–100	17.5	183	176	96
100 and smaller	78.6	143	135	71

The above would, therefore, indicate that the highest strength was obtained between 20–40 mesh.

The filling of the mold requires considerable care to prevent vitiation of the results. Professor Wheeler tamps in the clay little by little. In the case of very plastic clays the writer has obtained better results by approximately forming the chunk of clay and then pushing it into the mold, and by pressure of the hand causing it to fill out all parts of the mold. Professor Wheeler also suggests three very convenient terms to indicate the physical changes which a clay undergoes in burning. They are:

1. Incipient vitrification, or the point at which the clay has nearly reached its maximum shrinkage and hardness of steel;
2. Complete vitrification, or impermeability;
3. Viscous vitrification, or complete failure of the clay; viscosity.

The determination of these changes is of course more or less approximate, as no sharp line can be drawn between them, but the second is generally midway between the first and the third.

Some interesting studies in the physical examination of clays have been carried on during the past year by Russian investigators, whose conclusions are the same as those subsequently arrived at by Wheeler. The first is an article by W. Aleksiejew, on Material for the Classification of Russian Clays.[1] In this the author remarks that while sand grains often decrease the plasticity, still there are clays free from sand which are nonplastic. The clay from Borowitschi, for example, has 4.45 per cent free silica and 38.01 per cent combined silica, 41.1 per cent Al_2O_3, 1.81 per cent Fe_2O_3, 0.24 CaO, and 0.09 MgO. With such a small percentage of silica its leanness can not be ascribed to sand. Neither are the clay particles cemented by amorphous silica, as with some clays of the Urals, because boiling in soda does not change the

[1] Zap. imp. russk. techn. obschtsch., May, 1896, vol. 30, pt. 6–7.

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Borowitzer clay. A similar property is shown by the kaolin from Irkutsk, which has 44.35 per cent of SiO_2, 38.03 Al_2O_3, and traces of CaO and MgO. Under the microscope these nonplastic clays differ from the plastic ones only in the size of their particles. Mr. Aleksiejew believes that it is by this very condition, which in turn is influenced probably by the method of formation, and perhaps also through the structure of the feldspar forming the clay, that the plasticity is effected. Experiment showed that by rubbing the clay in an agate mortar the plasticity was increased. The author believes that by such manipulation many lean clays could be improved.

The second paper is by P. A. Kremiatscheuski, on The Clays of Southern Russia and the Properties of Clays in General.[1] While the facts brought out in this paper are not all new, still they are corroborative of results already obtained in this line of work. The author states that a study of the Russian clays emphasizes the relation existing between chemical and physical properties, and that plasticity varies with size of grain and is not dependent entirely on the mineral kaolinite.

SEGER'S CONES.

In most branches of the clay-working industry in this country the completion of the burning is generally determined by the appearance of the interior of the kiln and amount of "settle." Only in the pottery kilns has some form of test piece usually been used, such as a ring coated with fusible clay, which, when melted, indicated the completion of the firing. As clays show a wide range in their fusibility, it is desirable to have some inexpensive means, as nearly accurate as possible, for measuring the various temperatures. The most thoroughly accurate pyrometer thus far invented is the thermoelectric pyrometer of Le Chatelier. This, however, on account of its high price, is beyond the reach of many, although there is no reason why a very cheap form of it should not be constructed.

A method of extended application abroad, which is just beginning to come into use in this country, is the Seger cone method. These cones consist of a mixture of kaolin and fluxes[2] (SiO_2, K_2O, B_2O_3, Na_2O, PbO, Fe_2O_3, CaO). Seger made up a series of 20 mixtures, so graded as to have a difference of 52° F. (29° C.) in their fusion points. They are numbered from 1 to 20, and later to 36, No. 1 fusing at 2,102° F. (1,150° C.), and No. 36 at 3,362° F. (1,850° C.). Later, another or minus series was made up by Cramer,[3] which goes from 2,066° F. (1,130° C.) to 1,094° F. (159° C.), and is represented by Nos. 01 to 022. Knowing the temperature at which the clay used produces the best product, the burning of a kiln is judged by placing in the kiln a cone corresponding most closely to that temperature and continuing the firing until the cone softens, bends over, and the tip touches the base.

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[1] Zap. imp. russk. techn. obschtsch., 1896, vol. 30, pt. 6–7, p. 187.
[2] Thomindustrie Zeitung, 1886, pp. 135–229.
[3] Ibid., 1892, p. 155.

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For practical purposes these cones are very successful, although their use has been perhaps somewhat unreasonably discouraged by some. The full series can be obtained from Messrs. Seger and Cramer, of Berlin, for 1 cent each (or about 2½ cents each, including duty and expressage), or Nos. .010–10 can be obtained for 1 cent each from Prof. E. Orton, jr., of Columbus University. Recently this series of cones has been restandardized by Seger and Cramer, and as the new table has not yet been printed in the United States, it is given below:[1]

Composition and fusing points of Seger cones.

No. of cone.	Composition.	Fusing point.	
		° *F.*	° *C.*
0.022	$\left\{\begin{matrix}0.5\ Na_2O\\0.5\ PbO\end{matrix}\right\}$ ..... $\left\{\begin{matrix}2.0\ SiO_2\\1.0\ B_2O_3\end{matrix}\right\}$	1,094	590
.021	$\left\{\begin{matrix}0.5\ Na_2O\\0.5\ PbO\end{matrix}\right\}$ $0.1\ Al_2O_3$ $\left\{\begin{matrix}2.2\ SiO_2\\1.0\ B_2O_3\end{matrix}\right\}$	1,148	620
.020	$\left\{\begin{matrix}0.5\ Na_2O\\0.5\ PbO\end{matrix}\right\}$ $0.2\ Al_2O_3$ $\left\{\begin{matrix}2.4\ SiO_2\\1.0\ B_2O_3\end{matrix}\right\}$	1,202	650
.019	$\left\{\begin{matrix}0.5\ Na_2O\\0.5\ PbO\end{matrix}\right\}$ $0.3\ Al_2O_3$ $\left\{\begin{matrix}2.6\ SiO_2\\1.0\ B_2O_3\end{matrix}\right\}$	1,256	680
.018	$\left\{\begin{matrix}0.5\ Na_2O\\0,5\ PbO\end{matrix}\right\}$ $0.4\ Al_2O_3$ $\left\{\begin{matrix}2.8\ SiO_2\\1.0\ B_2O_3\end{matrix}\right\}$	1,310	710
.017	$\left\{\begin{matrix}0.5\ Na_2O\\0.5\ PbO\end{matrix}\right\}$ $0.5\ Al_2O_3$ $\left\{\begin{matrix}3.0\ SiO_2\\1.0\ B_2O_3\end{matrix}\right\}$	1,364	740
.016	$\left\{\begin{matrix}0.5\ Na_2O\\0.5\ PbO\end{matrix}\right\}$ $0.55\ Al_2O_3$ $\left\{\begin{matrix}3.1\ SiO_2\\1.0\ B_2O_3\end{matrix}\right\}$	1,418	770
.015	$\left\{\begin{matrix}0.5\ Na_2O\\0.5\ PbO\end{matrix}\right\}$ $0.6\ Al_2O_3$ $\left\{\begin{matrix}3.2\ SiO_2\\1.0\ B_2O_3\end{matrix}\right\}$	1,472	800
.014	$\left\{\begin{matrix}0.5\ Na_2O\\0.5\ PbO\end{matrix}\right\}$ $0.65\ Al_2O_3$ $\left\{\begin{matrix}3.3\ SiO_2\\1.0\ B_2O_3\end{matrix}\right\}$	1,526	830
.013	$\left\{\begin{matrix}0.5\ Na_2O\\0.5\ PbO\end{matrix}\right\}$ $0.7\ Al_2O_3$ $\left\{\begin{matrix}3.4\ SiO_2\\1.0\ B_2O_3\end{matrix}\right\}$	1,580	860
.012	$\left\{\begin{matrix}0.5\ Na_2O\\0.5\ PbO\end{matrix}\right\}$ $0.75\ Al_2O_3$ $\left\{\begin{matrix}3.5\ SiO_2\\1.0\ B_2O_3\end{matrix}\right\}$	1,634	890
.011	$\left\{\begin{matrix}0.5\ Na_2O\\0.5\ PbO\end{matrix}\right\}$ $0.8\ Al_2O_3$ $\left\{\begin{matrix}3.6\ SiO_2\\1.0\ B_2O_3\end{matrix}\right\}$	1,688	920
.010	$\left\{\begin{matrix}0.3\ K_2O\\0.7\ CaO\end{matrix}\right\}$ $0.2\ Fe_2O_3$ $\left\{\begin{matrix}3.50\ SiO_2\\0.50\ B_2O_3\end{matrix}\right\}$ $0.3\ Al_2O_3$	1,742	950
.09	$\left\{\begin{matrix}0.3\ K_2O\\0.7\ CaO\end{matrix}\right\}$ $0.2\ Fe_2O_3$ $\left\{\begin{matrix}3.55\ SiO_2\\0.45\ B_2O_3\end{matrix}\right\}$ $0.3\ Al_2O_3$	1,778	970
.08	$\left\{\begin{matrix}0.3\ K_2O\\0.7\ CaO\end{matrix}\right\}$ $0.2\ Fe_2O_3$ $\left\{\begin{matrix}3.60\ SiO_2\\0.40\ B_2O_3\end{matrix}\right\}$ $0.3\ Al_2O_3$	1,814	990
.07	$\left\{\begin{matrix}0.3\ K_2O\\0.7\ CaO\end{matrix}\right\}$ $0.2\ Fe_2O_3$ $\left\{\begin{matrix}3.65\ SiO_2\\0.35\ B_2O_3\end{matrix}\right\}$ $0.3\ Al_2O_3$	1,850	1,010
.06	$\left\{\begin{matrix}0.3\ K_2O\\0.7\ CaO\end{matrix}\right\}$ $0.2\ Fe_2O_3$ $\left\{\begin{matrix}3.70\ SiO_2\\0.30\ B_2O_3\end{matrix}\right\}$ $0.3\ Al_2O_3$	1,886	1,030
.05	$\left\{\begin{matrix}0.3\ K_2O\\0.7\ CaO\end{matrix}\right\}$ $0.2\ Fe_2O_3$ $\left\{\begin{matrix}3.75\ SiO_2\\0.25\ B_2O_3\end{matrix}\right\}$ $0.3\ Al_2O_3$	1,922	1,050

[1] The table given in Langenbeck's Chemistry of Pottery and the Missouri clay report are earlier than the revised table of fusions, and therefore the figures are incorrect, especially for the higher and lower number of the series.

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Composition and fusing points of Seger cones—Continued.

No. of cone.	Composition.	Fusing point.	
		° *F.*	° *C.*
.04	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $0.2\ Fe_2O_3$ $\left\{\begin{matrix}3.80 & SiO_2\\0.20 & B_2O_3\end{matrix}\right\}$	1,958	1,070
.03	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $0.2\ Fe_2O_3$ $\left\{\begin{matrix}3.85 & SiO_2\\0.15 & B_2O_3\end{matrix}\right\}$	1,994	1,090
.02	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $0.2\ Fe_2O_3$ $\left\{\begin{matrix}3.90 & SiO_2\\0.10 & B_2O_3\end{matrix}\right\}$	2,030	1,110
.01	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $0.2\ Fe_2O_3$ $\left\{\begin{matrix}3.95 & SiO_2\\0.05 & B_2O_3\end{matrix}\right\}$	2,066	1,130
1	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $0.2\ Fe_2O_3$ $4\ SiO_2$	2,102	1,150
2	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $0.1\ Fe_2O_3$ $4\ SiO_2$	2,138	1,170
3	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $0.05\ Fe_2O_3$ $4\ SiO_2$	2,174	1,190
4	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $0.5\ Al_2O_3$ $4\ SiO_2$	2,210	1,210
5	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $0.5\ Al_2O_3$ $5\ SiO_2$	2,246	1,230
6	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $0.6\ Al_2O_3$ $6\ SiO_2$	2,282	1,250
7	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $0.7\ Al_2O_3$ $7\ SiO_2$	2,318	1,270
8	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $0.8\ Al_2O_3$ $8\ SiO_2$	2,354	1,290
9	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $0.9\ Al_2O_3$ $9\ SiO_2$	2,390	1,310
10	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $1.0\ Al_2O_3$ $10\ SiO_2$	2,426	1,330
11	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $1.2\ Al_2O_3$ $12\ SiO_2$	2,462	1,350
12	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $1.4\ Al_2O_3$ $14\ SiO_2$	2,498	1,370
13	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $1.6\ Al_2O_3$ $16\ SiO_2$	2,534	1,390
14	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $1.8\ Al_2O_3$ $18\ SiO_2$	2,570	1,410
15	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $2.1\ Al_2O_3$ $21\ SiO_2$	2,606	1,430
16	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $2.4\ Al_2O_3$ $24\ SiO_2$	2,642	1,450
17	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $2.7\ Al_2O_3$ $27\ SiO_2$	2,678	1,470
18	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $3.1\ Al_2O_3$ $31\ SiO_2$	2,714	1,490
19	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $3.5\ Al_2O_3$ $35\ SiO_2$	2,750	1,510
20	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $3.9\ Al_2O_3$ $39\ SiO_2$	2,786	1,530
21	$\left\{\begin{matrix}0.3 & K_2O\\0.7 & CaO\end{matrix}\right\}$ $4.4\ Al_2O_3$ $44\ SiO_2$	2,822	1,550

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Composition and fusing points of Seger cones—Continued.

No. of cone.	Composition.	Fusing point.	
		° *F.*	° *C.*
22	$\left\{\begin{matrix}0.3 & K_2O \\ 0.7 & CaO\end{matrix}\right\}$ 4.9 Al_2O_3 49 SiO_2	2,858	1,570
23	$\left\{\begin{matrix}0.3 & K_2O \\ 0.7 & CaO\end{matrix}\right\}$ 5.4 Al_2O_3 54 SiO_2	2,894	1,590
24	$\left\{\begin{matrix}0.3 & K_2O \\ 0.7 & CaO\end{matrix}\right\}$ 6.0 Al_2O_3 60 SiO_2	2,930	1,610
25	$\left\{\begin{matrix}0.3 & K_2O \\ 0.7 & CaO\end{matrix}\right\}$ 6.6 Al_2O_3 66 SiO_2	2,966	1,630
26	$\left\{\begin{matrix}0.3 & K_2O \\ 0.7 & CaO\end{matrix}\right\}$ 7.2 Al_2O_3 72 SiO_2	3,002	1,650
27	$\left\{\begin{matrix}0.3 & K_2O \\ 0.7 & CaO\end{matrix}\right\}$ 20 Al_2O_3 200 SiO_2	3,038	1,670
28	..... Al_2O_3 10 SiO_2	3,074	1,690
29	..... Al_2O_3 8 SiO_2	3,110	1,710
30	..... Al_2O_3 6 SiO_2	3,146	1,730
31	..... Al_2O_3 5 SiO_2	3,182	1,750
32	..... Al_2O_3 4 SiO_2	3,218	1,770
33	..... Al_2O_3 3 SiO_2	3,254	1,790
34	..... Al_2O_3 2.5 SiO_2	3,290	1,810
35	..... Al_2O_3 2 SiO_2	3,326	1,830
36	..... Al_2O_3 1.5 SiO_2	3,362	1,850

DEPOSITS OF USEFUL CLAY.

ALABAMA.

The recently issued report on the valley regions of Alabama,[1] by Prof. H. McCalley, deals chiefly with the Paleozoic strata. Within this region, Professor McCalley states, are porcelain, potters', and other plastic clays, and loamy brick clays. The refractory clays belong to the Lauderdale chert and Tuscaloosa formations. The former, which have been derived from the disintegration of argillaceous or siliceous strata, are often gritty and are commonly called chalk. Similar clays may occur in the siliceous (Knox) dolomite and chert group. The Tuscaloosa refractory clays are white to dark and very plastic, but have been seen only in a few places near the Mississippi line; but this may be due to an extensive Lafayette covering.

The potters' clays underlie the coal seams, and also form mottled and reddish beds in the Tuscaloosa formation, and are eminently plastic.

The Coastal Plain formations of Alabama are especially rich in deposits of high-grade clays. Many of them are kaolins, whose composition approaches closely to that of kaolinite. Fine-grained stoneware

[1] Geol. Survey, Alabama, Pt. 1, 1896.

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clays also occur at a number of localities, and many of them will probably be found applicable for other grades of vitrified ware.

Prof. Eugene A. Smith, the State geologist, has recently had a number of these clays tested both chemically and physically. The tests were made by the writer, and, with Professor Smith's permission, they are given herewith, in tabulated form:

Analyses of Alabama clays.

Locality.	Silica, SiO_2.	Alumina, Al_2O_3.	Water, H_2O.	Ferric oxide, Fe_2O_3.	Calcium oxide, CaO.	Magnesia, MgO	Alkalies.	Moisture.	Total fluxes.
KAOLINS.									
Valley Head, Dekalb Co	47.00	38.75	12.94	.95	.70	Trace.	Trace.	.....	1.65
Rockrun, Cherokee Co	60.50	20.55	7.20	.30	.90	.65	2.70	.70	4.55
Pegram, Colbert Co	64.90	25.25	8.00	Trace.	Trace.	Trace.	.....	.90	.....
Chalk Bluff, Marion Co	47.20	36.50	13.35	2.56	Trace.	Trace.	.....	.50	2.56
Briggs Fredericks, Marion Co.	65.49	24.04	7.50	Trace.	1.26	Trace.	Trace.	.30	1.26
Pearces Mill, Marion Co	56.28	32.50	11.05	.20	Trace.	Trace.	Trace.	.20	.20
STONEWARE CLAYS.									
Prattville, Autauga Co	62.60	26.98	8.60	.72	.40	.36	.65	.70	2.13
W. Doty, Fayette Co	65.58	19.23	5.50	4.48	Trace.	Trace.	.....	1.40	4.48
Shirleys Mills, Fayette Co	72.20	17.42	7.40	2.40	Trace.	Trace.	.56	.12	2.96
J. W. Williams, Pegram, Colbert Co	66.45	18.53	8.68	2.40	1.50	1.25	Trace.	.78	5.15
Roberts Hill, Coal Fire Creek, Pickens Co	68.23	20.35	6.10	3.20	.34	Trace.	.74	1.06	4.28
J. B. Green, Fernbank, Lamar Co	69.50	13.00	6.70	6.40	.25	Trace.	Trace.	3.40	6.65
H. Wiggins, east of Fayette Court-House, Fayette Co	63.27	19.68	6.05	3.52	1.36	Trace.	1.20	3.75	6.02
FIRE CLAYS.									
J. W. Williams, Pegram, Colbert Co	80.55	10.50	5.85	1.53	.34	Trace.	.....	1.70	1.87
Flint clay, Choctaw Co	86.30	5.12	6.60	1.60	.46	.....	.....	.....	2.06

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Physical tests of Alabama clays.

	Per cent water added to make paste.	Pounds per square inch.		Per cent air shrinkage.	Per cent fire shrinkage.	Degrees Fahrenheit.			Color when burned.	Plasticity.	Specific gravity.
		Average tensile strength.	Maximum tensile strength.			Incipient fusion.	Vitrification.	Viscosity.			
KAOLINS.											
Valley Head, De Kalb Co.	33	25	27	2	6	2,300	2,500	2,700	White ..	Lean..	2.34
Rich Run, Cherokee Co.	30	9	12	4	12	2,000	2,200	2,400	...do	..do ...	2.32
Pegram, Colbert Co	30	40	53	7	4	2,200	2,400	2,600	...do	..do ...	.....
Chalk Bluff, Marion Co.	24	13	17	4	3	2,300	2,600	2,700	...do	..do ...	2.44
Briggs Fredericks, Marion Co.	25	14	16	2.5	2.5	2,300	2,500	2,700+	...do	..do ...	1.76
Pearce's Mill, Marion Co.	25	12	20	3	12	2,300	2,500	2,700+	...do	..do ...	2.33
STONEWARE CLAYS.											
Prattville, Autauga Co.	20	26	36	6	6	1,950	2,150	2,400	Bluish white.	Slight.	2.37
W. Doty, Fayette Co...	34.3	116	155	7	6	2,000	2,200	2,400	Red	Strong	.....
Shirley's Mills, Fayette Co.	34.2	106	123	10	4	2,000	2,200	2,400	Yellow white.	Good .	2.28
J. W. Williams, Pegram, Colbert Co.	26	30	35	5	10	2,150	2,300	2,500	...do	Lean..	2.39
Roberts Hill, Coal Fire Creek, Pickens Co.	21.8	117	142	4	8	2,000	2,200	2,400	Buff	Good .	2.17
J. B. Green, Fernbank, Lamar Co.	32.6	152	185	10	7	1,900	2,100	2,300	Red.....	High .	2.30
H. Wiggins, E. of Fayette C. H., Fayette Co.	34	232	300	14	8	1,900	2,100	2,300	...do	..do ...	2.32
FIRE CLAY.											
J. W. Williams, Pegram, Colbert Co.	28.6	46	.....	10	3	2,150	2,350	2,500	White ..	Lean..	.....
Flint Clay, Choctaw Co.	15	5	.....	2	6	2,300	2,500	2,650	Yellow ..	..do ...	.....

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CALIFORNIA.

According to the recent report of the State mineralogist, the clay-working industry is developed in eighteen counties, viz, Alameda, Amador, Butte, Contra Costa, Kern, Los Angeles, Marin, Mono, Placer, Riverside, Sacramento, San Joaquin, San Luis Obispo, Santa Clara, Santa Cruz, Shasta, Solano, and Tulare.[1]

The brick clays are naturally the most developed. Those in Butte County are a surface loam. In Contra Costa County sedimentary clays form the foothills south and west of Mount Diablo. These latter are also said to be applicable to the manufacture of terra cotta, front brick, sewer pipe, and roofing tiles, and are to be utilized by the recently established Mount Diablo Pottery and Paving Brick Company. Around Los Angeles the Pliocene formations are used for the manufacture of brick, and in Mono County, at Bodie, the clay deposits are said to be 60 to 80 feet thick. Sandy clays abound in the San Joaquin Valley, but at Benicia, in Solano County, a shale is used.

Carbondale, in Amador County, continues to be the important source of the stoneware and fire clay mined in the State. The annual shipment amounts to about 16,000 tons, and goes to Alameda, San Jose, Sacramento, and Los Angeles. At Lincoln, Placer County, two rather interesting sections of the clay pits are given, No. 1 being from the south pit, 1 mile north of the pottery, and No. 2 from the north pit.

Vertical section of south clay pit, Lincoln, Placer County, California.

	Feet.
Soil	1
Volcanic breccia	12
Light sandy clay	8
Fine sand	4
Sandy yellow clay	7
Sandy clay with gravel	6
Clay	

Vertical section of the north clay pit, Lincoln, Placer County, California.

	Feet.
Soil, etc	2
Volcanic breccia	10
Fire clay (for fireproofing)	10
Pipe clay (sewer pipe, etc.)	6
Fine white terra cotta clay	20

Of the clay products, common brick are the most important, and at many localities they are burned in continuous kilns, of Hoffmann or Boehnke type, with coal slack or wood fuel. Around Los Angeles the use of oil fuel has been found very economical.

Pottery and terra cotta are manufactured at East Oakland, stove linings at Bernicia, and dry-pressed brick at Lincoln and Vallejo.

[1] XIII Rept., p. 612.

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COLORADO.

The clay resources of Colorado are little known, and not much has been published concerning them, for, owing to the rather small demand for clay products in the Rocky Mountain region, there has been little to encourage their development until recently. At present the chief product is common brick and refractory goods, nearly all of the pressed brick, terra cotta, and pottery used in Colorado coming from other States.

The clay-bearing formations of Colorado are:

1. The loess and alluvial deposits;
2. Mesozoic formations, or Jurassic and Cretaceous shales and clays.
3. Tertiary clays.

Loess and alluvial deposits.—The loess forms an extensive deposit of variable thickness, stretching from the foothills on the eastern side of the Rocky Mountains eastward, and resting frequently on the upturned beds of the Jura-Cretaceous formation. It is generally a highly siliceous clay, and in its lower portion often contains a pebbly stratum. The thickness is variable, generally 5 to 8 feet above the gravel. The loess is lean, very sandy, loose clay, possessing little plasticity.

In many of the broader valleys of Colorado the streams are bordered by terraces, often underlain by a sandy clay, suitable for common brick manufacture. Such clays are abundant along the valley of the Arkansas River from Pueblo westward, and along the Grand River at Glenwood Springs, Grand Junction, and also near Aspen, etc.

Mesozoic formations.—Extending along the eastern edge of the Rocky Mountain chain is a great series of interbedded shales, sandstones, and limestones of Juratrias and Cretaceous age, the beds of which are tilted at a high angle. The Juratrias rocks contain some shale which has not been utilized. The Cretaceous beds overlie the Juratrias and consist of the following divisions:[1]

1. The Dakota shales and sandstones;
2. The Benton shales and limestone;
3. The Niobrara limestones;
4. The Pierre shales;
5. The Fox Hills shales.

The Dakota consists of shales and sandstones, the latter usually yellowish gray. They are often interbedded with shales and clays, the latter and sometimes the former having refractory qualities. The shales are frequently arenaceous, and both the clays and the shales sometimes contain enough vegetable matter to make them brown or black. The Benton group carries large quantities of shale and a central limestone member. The upper, or Carlile, shale is of importance

[1] The underground water of the Arkansas Valley in eastern Colorado, by G. K. Gilbert: Seventeenth Ann. Rept. U. S. Geol. Survey, Part II, 1896, p. 561.

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to brickmakers and is being used at La Junta. The Pierre and Fox Hills groups both carry shales, but they are not utilized.

Tertiary clays.—The extensive clay deposits underlying much of the region around Denver are probably of this age. Their chief use will no doubt be for the manufacture of pressed brick and vitrified wares. So far as known, no refractory beds occur in this formation; but, though of great thickness, they have been little developed.

BRICK CLAYS.

All of the common brick manufactured in the State are made from either the loess or the alluvial clays found in the broader valleys. These clays are similar in character wherever found. They are all lean, gritty, coarse-grained clays, possessing, naturally, little plasticity.[1] A sample of the loess from the yard of the Merchant Brick Company, of Denver, was tested with the following results:

It was a lean clay, very porous, and required 14.5 per cent of water to make a workable paste.[2] In water it slacks easily and quickly into its component grains. Bricklets made from the clay shrunk 6 per cent in drying and an additional 3 per cent in burning. Air-dried briquettes made from this clay had an average tensile strength of 55 pounds per square inch, and a maximum of 66 pounds. Incipient vitrification occurred at 2,000° F., complete vitrification at 2,100°, and viscosity at 2,200°. The burned clay was red. When underburned it is porous and very similar to much of the product seen at many of the smaller yards. In fact, this holds true of most of the common brick made within the State.

The loess brick clays are most extensively worked around Denver, there being about 15 manufacturers of common brick. Other yards using the loess are located at Colorado Springs, Pueblo, Trinidad, Boulder, Loveland, Greeley, and several other places. The sandy clays underlying the river terraces are worked at a number of points, among which are Glenwood Springs, Aspen, Florence, and Grand Junction. In the case of the terrace clays, there is more chance of finding beds which are less sandy, for where the river has been broad there are often spots in which the conditions are such that only the finer sediment, or clay comparatively free from sand, would have been deposited. As small beds of sandy or residual clay are to be found in almost any valley within the State, brickyards are numerous, and on account of this abundance of clay, though of poor quality, few of these plants are permanently located. It is cheaper usually to move a hand-power brickmaking outfit to supply some temporary market than to ship the brick.

All of the yards, with the exception of a few around Denver, temper their clay in a simple horsepower pugging machine, and mold the bricks

[1] For analyses of the loess and other Colorado clays, see Bull. U. S. Geol. Survey No. 148, 1897, p. 297.

[2] It may be here stated that physical tests have been made of samples collected by the writer from the more important localities.

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by hand. The burning is done in scove kilns. The hand molding and careless burning often produce a very inferior grade of brick, and where better machinery and methods are used there is a marked improvement in the quality of the products. No pressed brick are made from the loess in Colorado. It is of interest to state, in this connection, that the brick used in the construction of the Pearce turret roasting furnaces in Denver are made from the loess, and were found to stand the expansive action of the heat better than those made from other clays in that region. These brick were made with care, and are very creditable.

CLAYS FOR PRESSED BRICK.

Golden, Jefferson County.—The Golden Pressed and Fire Brick Company is making pressed brick from a red, decomposed shale adjoining the yards, about a mile and a half north of Golden. The mellowed shale is a fine-grained, gritty clay of only moderate plasticity. It required 22 per cent of water to make a plastic paste, and the bricklets made from this paste shrank 8 per cent in drying and 4 per cent in burning, making a total shrinkage of 12 per cent. Incipient fusion takes place at 1,850° F., vitrification at 1,950° F., and viscosity at 2,050°–2,100° F. The clay burns to a bright red, but the color deepens very considerably when complete vitrification is reached. The tensile strength of air-dried briquettes is quite low, varying from 55 to 67 pounds per square inch. The bed is fully 100 feet thick across the nearly vertical dip, and is well exposed at the brickyard, where the bank is about 40 feet high. It is interbedded with coal on the east and with sandstone and fire clay on the west. A speckled brick is obtained by mixing fire clay with the shale.

All of the pressed brick made at this yard are molded on either a Boyd or a Bucyrus dry-press machine. They are set directly in the kiln, which is a continuous one of Boehnke's patent. It consists essentially of the usual endless tunnel, which is divisible into chambers by means of paper partitions. These are simply to prevent the air and heat from passing at once through the entire length of the kiln. Each chamber holds 22,000 bricks. The coal slack for burning is obtained from the company's mine near by, and is charged from the top of the kiln, through four openings in the roof of each chamber. From 250 to 300 pounds of coal are required to burn a chamber of brick. When the initial chamber is started a fire is built in the doorway leading into this chamber, and about three days are required to reach the maximum temperature. After the kiln is once started and a chamber has been burned the heat from it is conducted into the next one, which requires ten hours' coaling in addition to bring it also to the maximum temperature. A chimney 100 feet high is connected with the flues, and the draft has to be accelerated at times by means of a small blower.

Boulder, Boulder County.—To the east and southeast of the railroad station are beds of brownish-gray, hard, gritty shale, with conchoidal fracture and massive bedding. Concretions of carbonate of iron and

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sand are not uncommon, and the upper portions of the bank are softened by weathering and stained with limonite. At Davis's brickworks in Boulder the bank is 20 feet high and the shale layers dip 25° east. It presents a similar appearance at the yard of the Boulder Pressed Brick Company. The shale burns to a red product. Both of these firms manufacture front brick by the dry-press process, drying the brick in the kiln. There are considerable quantities of these shales in the vicinity of Boulder, and they form a good supply for the manufacture of pressed brick. Considerable clay underlies the low hills to the east of Boulder, but little of it has been mined except at Byrnes Junction, where several openings have been made to supply Mr. C. H. Coy's brickworks in Denver. This clay burns to a red color and was found adapted to dry-pressed bricks.

La Junta, Otero County.—The Carlile shale of the Cretaceous outcropping at this locality consists of a thinly laminated, soft, greenish-gray shale. A sample of this material from Mr. J. McNeen's yard was found to shrink 13 per cent in drying and 2 per cent additional in burning. The addition of 30 per cent of water gave a very plastic mass. The average tensile strength of air-dried briquettes was 145 pounds per square inch, with a maximum of 156 pounds. Incipient fusion occurred at 1,800° F., vitrification at 1,950° F., and viscosity at 2,100° F. The clay burns to a light-red color, with a somewhat speckled appearance. The plasticity of the clay is very marked. Although the shales of the Benton group are extensively developed in the far West, La Junta is the only locality at which they are utilized.

The excessive shrinkage in drying would have to be counteracted in most lines of clay-product manufacture, but when made into brick by the dry-press process, as at La Junta, the air shrinkage is, of course, minimized. With the future development of the clay-working industry in the West these shales should come into extended use.

FIRE CLAYS AND POTTERY CLAYS.

As these occur in such close association, it is best, perhaps, to consider them together. The "hogbacks" of Dakota sandstone extending along the eastern base of the foothills contain, as previously mentioned, numerous interbedded shales and clays. These beds have been commercially developed chiefly at Golden, owing, no doubt, to its proximity to Denver, which is the center of the Colorado clay-working industry. It may be said of these refractory and semirefractory clays in general that they are seldom of great extent, nor are they always thick, 6 to 8 feet being the average, and 16 feet the maximum, known to the writer. The beds are therefore to be regarded as lenses. Even then sections in pits within half a mile of each other may be totally different. On the other hand, a bed may be apparently quite persistent, as the black-shale fire clay at Golden, which is found at several points for a distance of fully 4 miles.

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The localities at which these Dakota clays and shales have been thus far developed are Golden, Morrison, Carbondale, Parkdale, and Delhi.

A good idea of the mode of occurrence of these beds may perhaps be gained by a description of the pits around Golden.

Golden.—About 2 miles south of Golden, along the highroad, are Mr. C. P. Hoyt's pits. These have been worked for several years to supply the stoneware factory at Denver and some sewer-pipe works. The layers dip nearly 90°. Six beds of clay are exposed, and, beginning at the south, they are—

Section of clay beds 2 miles south of Golden, Colorado.

	Feet.
1. Sandy clay	5
2. Sandy clay, with some carbonaceous matter	8
3. Dark clay 2 feet and sandy clay 4 feet	6
4. Unopened	7
5. Sandy clay	6
6. Shale clay, with much organic matter in spots	6

To the south of Hoyt's pit and 3 miles southwest of Golden station, on the land of Mr. H. M. Orahood, is a large bed of pottery clay, leased by the Queen City Pottery Company. The bed, which has the usual vertical dip, is 9 feet wide and has been worked to a depth of 30 feet. The clay in places contains much organic matter, and these portions are highly plastic. Occasional horses of sandstone occur. As the dark plastic clay is abundant, a sample of it was tested, with the following results: It is a fine-grained, sometimes gritty clay, requiring 31 per cent of water to give a plastic mass. The tensile strength of air-dried briquettes ranged from 160 to 164 pounds per square inch. The shrinkage in drying was 12 per cent, with an additional 4 per cent in burning. Incipient fusion occurred at 2,100° F., vitrification at 2,250° F., and viscosity at 2,400° F. The clay burns to a dense grayish-white body. It is, therefore, a very good stoneware clay.

There are three mines of fire clay at Golden, and all three are apparently on the same bed. The first is 1½ miles south of Golden, on the Santa Fe property, and is operated by Mr. C. P. Hoyt. The fire clay is a hard, black, fine-grained shale with conchoidal fracture. It forms a bed about 10 feet thick between the Dakota sandstones, and dips steeply to the southward. A tunnel through the underlying sandstone leads into it. From this tunnel the bed has been followed southward for 800 feet and northward for some distance. Toward the south end the fire clay has been displaced 22 feet by a fault, and 60 feet at the north end. Only the upper half of the bed is worked, as the lower half contains too much iron. Between the fire clay and hanging wall is an 8-inch layer of kaolin, which is quite persistent throughout the mine. Its thinness, of course, makes it of no commercial value. The two other mines are both in a hogback, which begins about 2 miles north of Golden. The one nearest the south end is that of the Denver Fire Clay Company. Their fire clay is similar in appearance to Hoyt's, but the bed is 18 feet thick and dips 60° east. About two-thirds of the

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vein is worked, but the upper half is considerably stained by iron. Of the lower portion, which is mined, the under 3 feet, nearest the foot wall, is used for scorifiers and crucibles, and the balance for fire brick. Siliceous laminæ are not uncommon in the clay, and there is an 8-inch layer of kaolin next to the foot wall, but it contains a noticeable quantity of iron.

The Golden Pressed and Fire Brick Company's bed of fire clay is in the same layer at the north end of the hogback. It also dips east, and is similar to the preceding. It appears to be a common characteristic of these fire-clay seams that about one-half of the layer is more or less ferruginous. Pyrite was also noticed, occasionally forming dendrites on the surfaces of cracks in the clay.

Parkdale.—Next to Golden this has been the most important locality thus far in the State for producing fire clays. The beds which have been worked are all east and northeast of the depot and none of them more than a mile and a half distant from it. They are nearly all beds of black-shale fire clay, seldom more than 4 feet thick, and interbedded with the Dakota sandstone. The shale is brittle and not massive, as is that at Golden. Two parties have been mining at this locality—Mr. W. H. Murry and the Standard Fire Brick Company. On the former's property the first opening is in a bed of greenish-gray, fine-grained clay, locally known as kaolin. This bed appears to be at the base of the section, and rests almost directly on the granite. The bed is about 30 feet thick, but the upper 15 feet are quite heavily charged with detrimental impurities. Thin streaks of gypsum and siliceous concretions are also found in the clay. Very little of this has been used for fire brick, but much has been shipped to Denver, where it is washed and sold to paper mills. This same clay is also known as fuller's earth.

The second opening on Mr. Murry's land is known as the Flint fire-clay bed, and is about half a mile north of the station. It consists of a 6-foot bed, capped by red sandstone. The clay is a hard, brittle, black shale, often stained with iron along the fractures and becoming very siliceous toward the foot wall.

The third opening is a few hundred feet west of the preceding one, and in a ravine. There are several beds of fire clay, interbedded with sandstone, and the section from north to south across the steeply southerly dipping beds is as follows:

Section of clay beds near Parkdale, Colorado.

	Feet.
1. Granite	50
2. White sandstone	50
3. Fire clay	4
4. Red sandstone	20
5. Fire clay	4
6. Red sandstone	50

No. 3 is fairly free from visible traces of iron, but No. 5 contains a considerable quantity, and is also quite siliceous.

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A fourth bed of fire clay outcrops about one mile north of the station. It is black, due to organic matter, and moderately plastic, but little of it has been used. It is interbedded with a limestone and dolomitic sandstone.

The Standard Fire Clay Company's property lies south of Mr. Murry's, in a gulch north of the railroad. The clay is the same dark, grayish-black shale, dipping 15° northwest between the sandstones and forming a bed 4 feet thick. It pinches out to the north. There are few visible traces of iron in the clay, and it is more massive than Murry's bed. The fire clay also outcrops at several points along the road from the Standard Company's mine down to the railroad.

Delhi.—During the last year several excellent beds of fire clay have been found in this vicinity, and are being exploited by the Standard Fire Clay Company. The quality of the material seems to be better than any found previously within the State.

VITRIFIED WARES.

Two firms—Mr. C. H. Coy and the Golden Pressed and Fire Brick Company—have made attempts to put forth paving brick. The product was very fair, but the market poor, and this branch of the industry is practically at a standstill. Mr. Coy made his from a mixture of Golden fire clay and Byrnes Junction brick clay. The Golden works used a similar mixture, and burned them in the upper portion of the fire-brick kiln.

Sewer pipes are manufactured by one firm, the Denver Sewer Pipe and Fire Clay Company. A mixture of plastic clays from Golden and shale fire clay from Platte Canyon station is used.

Stoneware is at present made by only one firm, the Queen City Pottery Company. The clays used are all obtained from the pits on Orahood's land, 2 miles south of Golden. The wares are mostly stoneware crocks, jars, and other domestic articles, and are glazed with either salt or Albany slip. A slip clay found south of Golden has been experimented with to some extent. It burns to a translucent or transparent glaze, but was not found thoroughly satisfactory.

REFRACTORY WARES.

There is considerable demand in Colorado and neighboring States for fire brick and assayers' goods, such as scorifiers, muffles, and crucibles, and two firms, one at Denver, the other at Pueblo, have a rather large business in this line.

Fire brick are made at Golden by the Golden Pressed and Fire Brick Company; at Denver by the Denver Sewer Pipe and Fire Clay Company and the Denver Fire Clay Company. The latter firm obtains its clay from mines at Golden already mentioned. The fire brick are molded in a Bucyrus auger side-cut machine and re-pressed. The crucibles and scorifiers are molded in steel dies on hand-power machines; they are

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dried on pallets and burned in the same kiln with the fire brick, the scorifiers being tucked in among the bricks and the crucibles nested on the edges of the bag walls, which do not extend more than 18 inches above the floor of the kiln. The latter is 10 feet in diameter.

The Standard Fire Clay Company, located at Pueblo, manufactures fire brick, coke-oven brick, muffles, scorifiers, and crucibles. The coke-oven brick are made from the Parkdale clays already described, while the better grades of fire brick have up to the present time been made from Golden clay. They are molded by hand, re-pressed, and burned in circular down-draft kilns.

The scorifiers and crucibles made from the Colorado clays bear an excellent reputation, and are used not only in the West but also in the East.

INDIANA.

The State geologist of Indiana, Prof. W. S. Blatchley, has given timely recognition to the clay resources of his State by the publication of a preliminary report on the clays and clay-working industries of the coal-bearing counties.[1]

In speaking of the Indiana clays in general, Professor Blatchley states that the residual clays include (1) rock kaolins of Lawrence and adjoining counties, and (2) surface clays of the driftless area of southern Indiana.

The sedimentary clays embrace (1) shales and fire clays of Paleozoic age, (2) alluvial clays along the streams, and (3) drift clays of northern and central Indiana.

The counties covered by the report are Fountain, Vermilion, Parke, Vigo, Clay, Owen, Sullivan, Greene, Knox, Daviess, Martin, Dubois, Pike, Gibson, Vanderburg, Warwick, Spencer, and Perry. These counties were chosen because the Coal Measures underlying their area are usually accompanied by beds of fire clay and shale.

The following type section from the Indiana Coal Measures is given:

Type section from the Indiana Coal Measures.

	Feet.	Inches.
1. Soil and surface drift clay	9	0
2. Blue compact shale	27	0
3. Dark bituminous shale	3	2
4. Coal	2	7
5. Fire clay	4	4
6. Drab siliceous shale	18	0
7. Sandstone	6	3
8. Dark bituminous shale	1	0
9. Coal	4	8
10. Fire clay	3	10

The fire clays (Nos. 5 and 10) are universally present. Nos. 3 and 8 are also widespread, but generally have an overwhelming amount of bituminous material. Nos. 2 and 6 are considered, taken as a whole, to be the most valuable of the clay beds in the State.

[1] Twentieth Ann. Rept. Indiana Geol. Survey.

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The potter's clays of Parke County have been utilized for some time. Clay County is the center of the clay-working industry of Indiana, and several active works are located at Brazil. Huntingburg, Dubois County, has been an important source of good potter's clays, and is so still.

Professor Blatchley gives numerous sections and makes an interesting feature of a number of rational analyses.

The products made from the Indiana clays include stoneware, sewer pipe, drain tile, pressed and common brick, and paving brick.

The nature of the recent information about the indianaite, or kaolin, of Lawrence County is interesting. According to Professor Blatchley, the deposits of this material have not been worked since 1892, and prior to that date it was used only for sizing paper.

IOWA.

Volume V of the Iowa Geological Survey discusses the clays of the several counties of which it treats. In Jones County the loess and alluvium occur in unlimited quantities, the former supplying material for brickmaking and the latter for drain tile. Three formations in Washington County furnish clay materials, viz, the Kinderhook, Des Moines, and Pleistocene, but at present only the latter is used. The Maple Mill shale, the lower member of the Kinderhook, is considered as promising for the manufacture of both building and paving brick, and could perhaps be used for sewer pipe if more siliceous clays were added to lessen its shrinkage.

The Coal Measures in Washington County furnish practically no shales.

The Pleistocene formations suitable for clay products are the alluvium, loess, and drift. There are two well-marked divisions of the latter, consisting of an upper yellow clay and a lower blue clay; the last is the better of the two. The loess, which is largely used, shows the normal characteristics, and the alluvium is found along all the large rivers.

Boone County contains abundant supplies of clay. The clay-shales and bituminous shales of the Coal Measures are well exposed along the Des Moines River and tributaries south and west of Boonesboro. The alluvial clays and drift are abundantly used by the brickmakers, but the shales have given successful results with building brick, fire brick, tile, and pottery.

In Woodbury County all of the geological formations are stated to be clay-bearing. The bedded ones include the Dakota and Benton Cretaceous. The former is well exposed at Sargents Bluff, while the latter is best seen at Cedar Bluff, where it consists of two members, of which the lower one is the purer and the same as that worked at Riverside.

The drift of Woodbury County is unimportant as a clay producer, but the loess occurs in considerable thickness and purity. Alluvial clays are likewise abundant.

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The clay products of the county include building and paving brick, tile, and pottery. In Warren County the loess is well adapted to brick and pottery. Analyses of the loess from Indianola are given in the table at the end of this report.

The Coal Measure clays, while present in Warren County, are somewhat variable in character.

Appanoose County furnishes both loess and Coal Measure clays.

MISSOURI.

There has recently been issued by the Missouri Geological Survey a detailed and elaborate report, prepared by Prof. H. A. Wheeler, setting forth well the extensive clay resources of the State. The deposits found include chinaware clays, flint and plastic fire clays, stoneware clays, shales, terra-cotta and pipe clays, paving-brick clays, and building-brick clays.

The chinaware clays.—The kaolins of Missouri all occur south of the Missouri River, in limestones of Paleozoic age. The belt is worked in Cape Girardeau and Bollinger counties, and extends into Howell County. Other openings are in Morgan and Cooper counties, and in Lawrence County near Aurora. The Missouri kaolins are residual, and are unique in having been derived from the limestones, the igneous rocks of the region containing only impure china clay.

The kaolins are usually highly siliceous, but this is not exceptional.

Flint clays.—The flint clays of Missouri often approach closely in composition kaolinite. They occur in the central part of the State, and especially in the east-central part, being abundant in the counties of Warren, Montgomery, Callaway, Osage, Franklin, Crawford, and Phelps. Their geological horizon may be Carboniferous, Silurian, or Ordovician. In form the deposits are crater-like, occupying depressions in the limestone varying from 50 to 200 feet in diameter and 15 to 50 feet in depth. The average of twelve samples of these flint clays showed under 2 per cent of total impurities. They also run high in alumina, viz, 39.86 to 43.22 per cent, and water 14.06 to 14.94 per cent, thus resembling pholerite[1] in composition. They are devoid of plasticity, with high specific gravity (2.33 to 2.45) and low tensile strength (10 to 38 pounds per square inch).

Incipient vitrification generally begins at 2,300°, but they do not fail under 2,700°, and so are well adapted to stand high temperatures.

Plastic fire clays.—All of these occur in the Coal Measures under the seams of coal. Their usual characters are massive, dense, hard, and plastic. They shrink 3 to 9 per cent in drying and 2 to 9 per cent in burning, and in most cases these two operations can be carried on rapidly. Their fusibility ranges from 2,500° to 2,800°.

The most refractory beds are just above the Lower Carboniferous, but

[1] Pholerite is an amorphous variety of kaolinite.

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extensive beds of so-called fire clay occur in the Upper Coal Measures. The chief seams of the former which are worked are in St. Louis, Audrain, Callaway, and Boone counties. The counties in which they are likely to be found are Clark, northeast Lewis, south Scotland, east Adair, Macon, and Randolph, west Shelby and Monroe, south Ralls, Howard, Chariton, Carroll, and Saline, and west Pettis and Benton.

The beds around St. Louis are important and extensively worked, with an average thickness of 5 to 8 feet. A notable feature of the clay is its high percentage of fusible impurities—viz, above 5 per cent—combined with refractoriness. This, however, is explained by the great coarseness of the clay. Certain portions are of sufficiently good quality for glass-pot manufacture.

Potter's or stoneware clays.—By this term Wheeler designates those clays which are too fusible for fire clay, but good for stoneware, sewer pipe, or other wares requiring a vitrified body. The pottery trade is chiefly supplied by small works scattered over the State. Their trade is mostly local, and Calhoun and Clinton, in Henry County, are the only localities where larger works are established.

The Missouri stoneware clays occur principally in four geological formations:

1. In pockets in Paleozoic limestones in the southern half of the State. They are of local occurrence and have originated in the same manner as the flint clays.

2. As seams of semifire clay in the coal measures of the northwestern half of the State. They are shales or fire clay and are most extensively developed in Henry County.

3. As beds in the Tertiary, in the southeastern corner of the State. Much of this clay is good for stoneware of local demand. Mr. Wheeler considers that the magnitude of these beds and their accessibility make them the most promising.

4. As local beds, in the drift in the northern part of the State. These are apt to be variable in quantity and quality, and hence unreliable.

Shales.—These form an important basis of the Missouri clay-working industry. They occur in so many counties that it is best to refer to the report for information concerning them. Important deposits exist around Kansas City and St. Louis.

The manufacture of terra cotta, roofing tile, sewer pipe, drain tile, and flower pots is generally dependent on the same grades of clay, either shales, potter's clay, or good grades of brick clay. Terra cotta and sewer pipe are extensively produced around Missouri.

The paving-brick industry is represented by thirteen plants, located in the central and western portion of the State. The material used is mostly shale.

Brick clays.—These include (1) loess clays, (2) glacial clays, (3) residual clays, and (4) alluvial clays.

The first are the most important in Missouri. They make a good grade of brick and are easily worked. They are also uniform in quality

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and abundant. The loess clays are common, especially along the Missouri and Mississippi rivers, and their structure is generally nonstratified and columnar. The loess overlies the drift and varies in thickness, at times being as much as 200 feet along the Missouri River near the Iowa line. It fringes all the larger rivers in the northern half of the State, but is mostly absent in the southern half. The loess clays have a tensile strength varying from 112 to 205 pounds per square inch.

The glacial clays are of variable character. The residual clays are usually very tenacious and crack in burning. The alluvial clays are likewise variable. The gumbo clays are chiefly used for railroad ballast. The northern portion of the State is rich in such clays and poor in rock ballast.

The following table is a résumé of the physical tests made on the more important clays:

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Physical tests of Missouri clay.

Material.	Locality.	Average tensile strength.	Plasticity by feel.	Water used.	Shrinkage.		Incipient fusion.	Complete.	Viscous.	Specific gravity.	Total fluxes.
					Air.	Fire.					
		Pounds.		*Per cent.*	*Per cent.*	*Per cent.*	° F.	° F.	° F.		*Per cent.*
Kaolin	Glen Allen	12	Lean	23.2	4.0	8.4	2,200	2,500	.....	1.89	1.89
Do	Cape Girardeau	23	Very lean	28.7	2.4	6.3	2,300	2,600	.....	2.02	1.27
Gumbo	Norborne	380	Very plastic	22.3	9.6	1.4	1,600	1,750	1,900	2.01	13.41
Shale	Billings	98	Plastic	23.1	7.3	5.8	2,000	2,200	2,400	2.16	6.62
Flint clay	Leasburg	8	Very lean	15.1	3.1	11.6	2,350	2,700	2,700	2.85	2.89
Sewer pipe	Deepwater	64	Lean	17.0	5.9	2.3	1,900	2,100	2,300	1.90	4.95
Ball clay	De Soto	198	Plastic	23.4	7.7	9.8	1,800	2,100	2,400	1.69	3.93
Do	Regina	99	....do	22.7	7.7	12.2	1,800	2,100	2,400	1.90	5.15
Shale	Knobnoster	109	....do	19.1	5.8	5.2	2,000	2,150	2,300	....	4.84
Stoneware	Clapper	92	....do	15.3	5.0	5.2	2,100	2,400	2,700	2.43	16.4
Gumbo	Clifton	319	Very plastic	17.0	8.5	1.5	1,600	1,750	1,900	1.98	.....
Paving-brick shale	Moberly	92	Lean	17.0	5.2	3.5	1,850	2,050	2,250	2.41	9.31
Glasspot clay	Christy, St Louis	168	Very plastic	6.0	7.7	5.1	2,200	2,400	2,700	2.13	4.81
Fire clay	Parker & Russel, St. Louis	129	Plastic	14.2	6.6	4.0	2,250	2,450	2,700	2.44	5.14
Do	Evens & Howard	78	Lean	15.0	6.3	5.4	2,250	2,450	2,650	2.41	5.76
Brick clay	Hydraulic Pressed Brick Co., St. Louis.	173	Plastic	17.1	5.3	5.5	1,800	1 950	2,050	1.98	9.90
Stoneware clay	Lakeman	161	Very plastic	17.5	17.5	4.8	2,000	2,200	2,500	2.38	2.41

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NEW YORK.

There has been some interest manifested during the past year in the occurrence of buff-burning clays to be found within the State. The Cretaceous clays occurring on Staten Island, which burn to a buff ware, owing to their lack of coloring impurities have been used more or less for some years, and the clays of similar age, occurring on the north shore of Long Island at Glen Cove, Elm Point, and Little Neck, near Northport, produce a burned ware of yellowish white color. Most of the clay in the Hudson Valley burns red, but at Glens Falls there has been found a local variation in the character of these clays, a high lime percentage exerting a strong influence on the color of the ware.

Other buff-burning clays are found at Canandaigua (The Hydraulic Press Brick Company), Newfield (Mr. T. C. Campbell), and at Owasco. They all owe their character to the presence of a considerable percentage of lime.

The shale formations of New York are destined to become of considerable importance in the near future.

The most important of these shale formations are the Hamilton and Chemung. The northern limit of the former, which is lower geologically, is approximately along a line extending from Albany to Buffalo. The average width of this belt is about 15 miles. The Chemung shale underlies the area to the south and extends two-thirds of the distance to the southern boundary of the State. Dry-pressed brick are made from the Hamilton shale at Jewettville, Erie County, and paving brick from shale of the same age obtained at Cairo, Greene County. The Chemung shale is utilized at Angola, Erie County, for sewer pipe, fireproofing, and terra cotta; at Jamestown, Chautauqua County, and Hornellsville, Steuben County, for paving brick; at Alfred Center, Allegany County, for roofing tile, and at Corning, Steuben County, for dry-pressed brick and terra cotta.

At the request of Prof. James Hall, New York State geologist,[1] the writer has made a number of tests of the shale from these several localities, which are tabulated below:

Physical tests of shale clays of New York.

Locality.	Per cent of water required to make paste.	Tensile strength per square inch.		Plasticity by feel.	Shrinkage in—		Incipient fusion.	Complete vitrification.	Complete fusion.
					Drying.	Burning.			
	Per ct.	*Aver.*	*Max.*		*Per ct.*	*Per ct.*			
Hornellsville	20	35	39	Lean	2.7	5.3	1,900	2,050	2,200
Angola	21.4	91	95	Slightly plastic.	4	10	1,900	2,050	2,200
Alfred Center	22	61	62	Plastic	4	9	1,900	2,050	2,150
Jamestown	18.5	16	22	Lean	4	7.5	1,950	2,100	2,200
Cairo (clay and shale mixture).	23	97	100	Good	.5	9	1,900	2,050	2,150

[1] Rept. N. Y. State geologist, 1896.

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In every case the product burns to a rather deep red when heated to complete vitrification.

OHIO.

According to Prof. E. Orton, jr., no important developments have occurred in the clay-working industry of Ohio during 1896.

At Canton a device has been perfected by Mr. O. Giessen for drying brick by the waste heat of cooling kilns. His method is simply to exhaust the hot air from a cooling kiln, mingle it with the proper quantity of cold external air and blow this mixture into the drier. It is working very well. The method is especially applicable on large plants and on a clay which will stand plenty of ventilation in drying. For a tender clay this plan is not applicable.

In the stoneware industry there is a growing tendency among Ohio potters to use white and colored glazes instead of the well-known Albany slip. While promising and acceptable, the new color has not yet been thoroughly perfected. Enamel bricks are being made, but the industry is not active.

Roofing tile may be looked for among the important products of Ohio in the future, especially those of the shingle type. One new plant, making interlocking tile, has been started at Zanesville.

An important matter is the continued success of the school for clay workers at Columbus and the recent establishment of a $250 fellowship for the investigation of problems of interest to clay workers.

WYOMING.

Some attention has been attracted by the discovery from time to time of deposits of so-called "mineral soap." The deposits of this material at Osage and San Pedro, west of Newcastle, were visited last summer and the material found to be a yellowish white, fine-grained clay, possessing little plasticity when wet, but, on the contrary, forming a somewhat gelatinous mass, which when dried becomes a curious mass of curled fragments. The cracks in the clay were frequently found to be filled with beautiful specimens of fibrous gypsum. At Osage this clay was underlain by black shale and covered by a thin layer of sandstone heavily cemented by iron. The clay itself was 3 or 4 feet thick.

Prof. W. C. Knight, the State geologist, informs the writer that this "mineral soap" clay is an abundant associate of the Fort Benton shales in several counties of the State. He has kindly furnished me the first three of the following six analyses.

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Analyses of "mineral soap" clay from Wyoming.

	1.	2.	3.	4.	5.	6.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
SiO_2	59.78	61.08	65.24	63.25	58.74	51.26
Al_2O_3.....	15.10	17.12	15.88	12.629	22.83	27.10
MgO	4.14	1.82	5.34	3.973	1.17	2.15
CaO	0.73	2.69		4.121	.75	1.14
Fe_2O_3	2.40	3.17	3.12	3.705	1.83	.....
Water	16.26	12.10	9.79	6.91	11.57	Undet.
Na_2O.....	.....	.20	.....	3.55	3.11	8.74
SO_3	.....	.88	.....	.....	.....	.....
Total ..	98.41	99.08	101.37	98.128	100.00	90.39

1. From Rock Creek. Analyzed by U. P. R. R. chemist.
2. From Cook County. Mr. H. Westphal, analyst.
3. Natuna County. Prof. W. C. Knight, analyst.
4. From Pedro, 7 miles west of Newcastle. Prof. W. C. Knight, analyst.
5. From D. Lincsott, Rockcreek, Wyo.
6. From Clifton, near Newcastle, Wyo.

From the above analyses it will be noticed that this clay contains a large percentage of water, possibly due to the presence of hydrated silica, as its action when mixed with water would suggest. This large amount of water causes it to shrink excessively and crack in burning, and, together with its lack of plasticity, has shut it out from the clay-working industry.

What few uses the "mineral soap" clay has had are varied. It is used to some extent at Custer City as an adulterant of soap. The Rock Creek material has been used as packing for horses' hoofs, and Professor Knight states that some of it has been shipped to paper manufacturers in the East. There is an additional use to which it might perhaps be put, and that is for the manufacture of hydraulic lime, which is made from limestone and clay with much hydrous silica.

LITERATURE.

In the past year or two there have appeared a number of articles and books on ceramics in general, or on special branches of it. The titles of the more important ones are given below.

BISCHOF, C.—Die feuerfeste Thone. Wiesbaden, 1896 (new edition).
BLATCHLEY, W. S.—The clays of the coal-bearing counties of Indiana. Ind. Geol. Survey, XX.
BRANNER, J. C.—Bibliography of clays and the ceramic arts. Bull. U. S. Geol. Surv., No. 147.
CALVIN, S.—Vol. V, Ia. Geol. Survey.
CRAMER, E., and HECHT, H.—Seger's gesammelte Schriften. Berlin, 1895.
CRAWFORD, J.—Notes on California clays. 13 Ann. Rep. Calif. State Mineralogist.

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FERRY, C.—Notes on fire clays. Mineral Industry, Vol. IV.
GRIFFIN, H. R.—Clay Glazes and Enamels. Indianapolis, 1896.
HOLMES, J. A.—Notes on clays of North Carolina. Trans. Amer. Inst. Min. Eng. 1895, Vol. XXVI.
LANGENBECK, C.—The Chemistry of Pottery. Easton, Pa. 1895.
MAYBERY, C., and KLOOS, A.—On the composition of some American kaolins. Jour. Chem. Soc., 1895.
MCCALLEY, H.—Report on the Valley region. Ala. Geol. Surv., Pt. 1, 1896, p. 68.
PENNOCK, J. D.—On the expansion and conductivity of fire bricks. Trans. Amer. Inst. Min. Eng., Sept. 1896.
PHILIPS and HOOPER. Pottery and Porcelain Marks (nearly all foreign). New York, 1896.
WHEELER, H. A.—Vitrified Paving Brick. Indianapolis, 1895.
WHEELER, H. A.—The clays of Missouri. Mo. Geol. Surv , Vol. XI, 1896.

CLAY ANALYSES.

In "Mineral Resources of the United States, 1894," a table was given of American clay analyses, which contained nearly all the analyses published up to that time, as well as a number of unpublished ones. Since then so many additional ones have been collected that it has been deemed desirous to compile a supplementary table. The present one contains analyses of residual clays, kaolins, fire clays, pottery clays, pipe clays, brick clays, shales, and paving brick clays.

Analyses of clays.

RESIDUAL CLAYS.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Missouri:		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Railway cut at Tiptop, Iron Co.		90.05		4.63	2.31	Trace.	Trace.	Undetermined.	2.72		.....	Missouri Geol. Sur., Vol. XI, p. 564.
Morris Shaft, Lincoln Co		72.35		15.86	2.25	1.09	1.48	.....	3.05	1.46	Loss 2.46	Missouri Geol. Sur., 1872, Vol. II, p. 288.
Colbert Shaft, Lincoln Co		65.35		21.20	2.05	.52	1.27	.....	4.83	2.14	2.64	Do.
KAOLIN.												
Alabama:												
12 miles southwest of Jacksonville, Calhoun Co.		45.77		39.45	.....	.79	.....	.....	13.96	.....	.....	G. H. Biwan, analyst.
Florida:												
Bartow, Lake Co	Washed	49.30		34.50	.65	.....	1.90	1.40	12.25	.....	.....	Furnished by A. H. Parslow, Tampa, Fla.
4 miles south of Leesburg, Lake Co.		46.11		39.55	.35	.....	.14	.....	13.78	.....	SO_2 .07	Circular of Standard Kaolin Co.
Indiana:												
Lawrence Co	Nonplastic white kaolin	44.75		38.69	.95	.37	.30	.35	15.17	.....	.....	Indiana Geol. Sur., XX, p. 105.
Missouri:												
Glen Allen, Ballinger Co	Used for white ware	72.30		18.94	.40	.68	.39	.42	7.04	.....	.....	Mo. Geol. Sur., Vol. XI, p. 563.
Do		63.50		24.55	.....	1.60	.48	.....	7.30	2.20	.....	From Glen Allen Kaolin Washing Co.
Brook's Land, Cape Girardeau Co.	Used for white ware	91.05		5.04	.69	.24	.22	.12	.....	.....	.....	Mo. Geol. Sur., XI, p. 536.
M. E. L. & M. Co., near Chilton, Carter Co.	Kaolin washed, not worked.	73.82		18.16	1.32	Trace.	.21	.24	6.16	.....	.....	Ibid.

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Analyses of clays—Continued.

KAOLIN—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Missouri—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Stirling (Macy place), Howell Co.	Washed, not worked	57.75		27.60	2.09	.24	.31	.60	11.33	.....	.....	Ibid., p. 564.
West Plains (Yates Bank), Howell Co.	Not worked	60.55		24.77	.84	.25	.41	.68	52.86	.....	.....	Do.
Aurora, Lawrence Co.	Halloysite	44.12		37.02	.33	.19	.....	.24	.....	.....	.....	Mo. Geol. Sur, Vol. XI, p. 566.
Porter and Coates Shaft, Aurora, Lawrence Co.	Halloysite not worked	34.53		6.41	2.59	2.20	.....	.....	7.19	9.97	ZnO. 37.23	Ibid., p. 566.
Louisville Shaft, Aurora, Lawrence Co.	.....do	32.44		5.53	2.17	2.58	38.90	.....	6.94	11.65	.....	Do.
Arnold Land, Thayer, Oregon Co.	Kaolin (washed) not worked.	81.18		12.14	1.88	.16	.14	.18	4.52	.....	.....	Do.
Trusty Land, Winons, Shannon Co.	Not worked	56.74		27.29	6.87	.26	.18	1.21	6.20	1.20	.....	Ibid., p. 570.
North Carolina:												
Grover Cleveland Co		55.24		30.84	.84	.08	.02	Trace.	12.89		.....	W. M. Bowran, anal.
Harris Mine, near Webster, Jackson Co.		41.62	2.28	40.66	.14	.....	.....	.46	14.00	.84	.....	J. A. Holmes, T. A. I. M. E. Vol. XX.
Pennsylvania:												
Glen Loch, White Land Kaolin Co., Chester Co.		50.96		33.30		.....	2.42	.....	8.95	.....	.....	A. E. Barnes, anal.
South Carolina:												
Aiken		44.94		39.18	.52	.....	.....	.....	13.38		TiO_2 .65 P_2O_5 .12	U. S. G. S. Bull. No. 148, p. 290.

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Analyses of clays—Continued.

FIRE CLAYS.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Alabama:		*Per ct*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Chalk Bluff, Marion Co	White clay	47.20		37.76	0.91	Trace.	Trace.	Trace.	14.24	.....	.....	Ala. Indus. and Sci. Soc., 1895, p. 50.
Arkansas:												
Black Rock, Lawrence Co		84.24		11.50	.08	.52	.02	.42	3.98	.....	.....	Jour. Chem. Soc., Vol. XVII, October, 1896.
Colorado:												
Golden, Jefferson Co		49.54		34.04	*a*.88	.61	.36	Trace.	13.91	.....	*b*.27	Furnished by Golden Pressed and Fire Brick Co.
Indiana:												
Leather Wood Creek, ½ mile from Bloomingdale, Parke Co.		73.82		16.06	1.10	.70	.70	.....	8.12		.....	Ind. Geol. Surv., Vol. XX, p. 49.
Mecca (S. L. McCune), Parke Co	Under clay No. 16	63.00		23.57	*a*.46 1.87	.44	.89	2.69	6.45	.....	*c*1.10	Ibid., p. 133.
West Montezuma (J. Burns), Vermilion Co.	Under clay No. 10	83.44		10.36	*a*.28 .27	.36	.14	.74	3.15	.....	*c*1.29	Do.
Iowa:												
Crills Mills	Cretaceous clay	67.14		19.93	2.39	.55	.25	1.28	5.59	2.98	.....	G. C. Patrick, anal., furnished by Iowa Geol. Sur.
Kentucky:												
1½ miles east of Pryorsburg, Graves Co.		56.40		30.00	.....	.40	Trace.	5.27	7.93		.....	R. Peters, anal.
Maryland:												
Mount Savage Union Mining Co., Allegany Co.		56.15		33.295	.59	.17	.115	.....	9.68		.....	Otto Werth, anal.

a Iron determined as FeO. *b* Organic matter. *c* Titanic acid.

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Analyses of clays—Continued.

FIRE CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Michigan:		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Flushing, Genesee Co	Used for fire brick	70.55		21.20	3.20	1.90	1.50	1.65	.....	.....	.....	Saginaw Clay Mfg. Co.
Missouri:												
Mexico, Audrain Co	Used for buff fire brick	53.77		30.90	1.74	.39	.32	.49	12.68	.....	.....	Missouri Geol. Surv., Vol. XI, p. 563.
Do	do	51.40		33.64	1.26	.71	.....	1.28	11.48	.....	.....	Do.
Do	do	55.12		30.71	1.51	.54	Trace.	1.37	10.56	.....	.....	Do.
Vandalia, Audrain Co	Washed fire clay	53.77		32.52	1.42	.28	.22	.52	12.34	.....	.....	Do.
Columbia (Fay's Bank), Boone Co.	Used for stoneware	61.22		25.17	1.47	.31	Trace.	1.88	8.14	1.66	.....	Do.
Fulton, Callaway Co	Used for fire brick	47.30		37.54	1.48	.57	.....	.50	12.76	.....	.....	Do.
New Bloomfield, Callaway Co	Not worked	48.60		35.65	1.95	.51	.26	.49	12.48	.....	.....	Do.
Leasburg, Crawford Co	Flint clay for fire brick	43.82		38.24	.23	1.93	.....	.73	14.94	.....	.....	Missouri Geol. Surv., Vol. XI, p. 564.
Sankey Mine	Flint clay not worked	50.18		33.03	2.31	.24	.68	2.06	10.43	1.45	.....	Do.
Dry Branch, Franklin Co	Flint clay for fire brick	42.60		41.88	.62	.28	.20	.54	14.00	.....	.....	Do.
Drake, Gasconade Co	Flint clay not worked	40.50		43.22	.31	1.11	Trace.	.51	14.15	.....	.....	Do.
Owensville, Gasconade Co	do	44.70		35.92	3.35	3.00	.21	.29	12.20	.42	.....	Do.
Baker's Shaft, Lincoln Co	.....	34.40		18.62	Trace.	15.27	6.25	.....	.....	.....	Loss 23.08	Missouri Geol. Surv., 1872, Vol. II, p. 288.
Clapper (Williamson), Monroe Co.	Used for stoneware	70.30		20.35	.15	.67	.33	.49	7.12	.79	.....	Missouri Geol. Surv., Vol. XI, p. 566.
Do	do	67.76		21.90	.69	.96	.24	.24	7.80	.43	.....	Mo. Geol. Sur., Vol. XI, p. 566.
High Hill, Montgomery Co	Flint clay for fire brick	45.12		40.40	.47	.29	Trace.	.30	13.34	.....	.....	Do.
Versailles, Morgan Co	Not worked	68.94		21.18	.78	.61	.43	.66	7.08	.....	.....	Do.

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Analyses of clays—Continued.

FIRE CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Missouri—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Linn (Gostang), Osage Co	Flint clay not worked	47.87		37.14	.83	.42	.58	.50	13.18	.37	.....	Mo. Geol. Sur., Vol. XI, p. 568.
St. James (Buskett Bank), Phelps Co.	.....	51.05		34.28	.39	Trace.	Trace.	.11	14.33	.....	.....	Do.
Do	.....	46.33		40.07	.50	1.26	.24	.....	13.40	.....	.....	Do.
Do	.....	47.306		38.173	.823	.058	.09	1.41	13.60	.....	.....	Do.
Rolla (Buskett Bank), Phelps Co	Flint clay	61.408		25.551	.281	1.32	1.43	.....	9.78	.....	.....	Do.
Do	.....do	63.39		22.75	.82	.22	.05	.89	8.00	3.27	.....	Do.
Bartold (Jamieson's), St. Louis Co.	Fire clay for fire brick	53.90		28.85	4.19	1.01	.11	.85	11.61	1.75	SO_3 .22 a 1.05	Do.
Do	Washed fire clay for clay pots.	55.61		27.36	2.73	.87	.07	.71	11.13	2.26	SO_3 .51 a 1.36	Do.
St. Louis	Silica clay	72.17		18.72	1.20	.20	.11	.....	6.56	1.68	.....	Furnished by H. Burden, 2d.
St. Louis, Chrysty Clay Co	Washed fire clay	64.35		21.16	2.63	.61	.30	.51	8.94	2.63	a 1.07	Mo. Geol. Sur., Vol. XI, p. 568.
Do	.....do	60.66		24.51	2.28	.....	.46	.70	11.39	.....	.....	From Christy Clay Co.
Do	Used for fire brick	61.73		23.56	.516	.55	.15	1.00	9.25	2.94	SO_3 .56 a 1.96	Mo. Geol. Sur., XI, p. 568.
St. Louis, Laclede Mine	.....do	57.34		24.68	2.60	.90	.40	.67	11.55	2.86	SO_3 .54 a 1.60	Mo. Geol. Sur., XI, p. 570.

a Titanic acid.

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Analyses of clays—Continued.

FIRE CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Missouri—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
St. Louis, Evans & Howard...	Used for fire brick.....	59.36		23.26	3.06	.65	.42	.63	10.20	2.74	SO_3 .35	Mo, Geol. Sur., XI, p. 570.
											a1.01	
St. Louis, Parker & Russell...	Fire brick and gas retorts.	67.47		19.33	2.56	.41	.07	1.07	7.73	2.72	SO_3 .24	Do.
St. Louis, Columbia B. road (Sattler).	Washed clay for glass pots	52.98		28.87	2.48	.51	.87	1.01	11.42	3.68	.....	Do.
St. Louis, Jamieson French Fire Clay Co.	Washed pot clay.....	52.52		31.40	2.34	.40	.42	.61	.....	.....	b12.42	From the company.
Columbia B. road, St. Louis....	Not worked.....	51.66		30.78	2.90	1.22	.88	.99	11.86	4.06	a1.85	Mo. Geol. Surv., XI, p. 568.
Do.....	.....	53.54		28.21	4.00	1.01	.11	.76	13.26	.....	.....	Do.
Coffin & Co., Gratiot.....	Washed for glass pots....	55.00		29.62	2.18	.91	.29	.27	11.61	.....	.....	Do.
Do.....	.....do	56.01		31.68	1.13	1.17	.21	.09	8.77	.74	c.20	Do.
Do.....	Fire brick	48.27		31.35	4.97	2.13	.21	1.28	8.42	1.27	2.10	Do.
Do.....	.....do	56.47		28.24	2.26	1.00	.32	.45	11.44	.....	.....	Do.
Higgins Pit, Lakeman, Shelby Co.	Used for stoneware.....	58.50		30.50	2.34	1.20	.51	.30	6.74	.40	.....	Mo. Geol. Surv., XI, p. 570.
Do.....	.....	67.60		18.97	1.25	.20	Trace.	.96	10.03	1.42	.....	Do.
Chiles Bank, Warren Co.....	Flint clay.....	46.18		38.12	.32	.54	Trace.	1.20	14.01	.....	.....	Mo. Geol. Surv., XI, p. 572.
Kelly's Pit, Warren Co.....	.....do	43.56		41.48	.35	.45	.....	.20	14.05	.....	.....	Do.
National Pit, Warren Co.....	.....	44.34		40.80	.27	Trace.	.35	.20	14.18	.....	.....	Do.
Do.....	Sandy clay.....	78.44		14.08	1.56	Trace.	.37	.18	5.62	.....	.....	Do.
Do.....	Fire clay.....	56.69		27.18	1.68	1.08	1.60	2.74	9.68	.....	.....	Do.
Do.....	.....do	55.60		28.22	1.02	.81	1.22	2.62	10.64	.....	.....	Do.

a Titanic acid. b Ignition. c Organic matter.

Analyses of clays—Continued.

FIRE CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Missouri—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
National Pit, Warren Co.	Fire clay	53.14		28.54	1.32	.70	1.01	.97	14.56	.....	.....	Mo. Geol. Sur., XI, p. 572.
Do	do	52.60		27.54	1.60	1.22	2.24	2.14	13.68	.....	.....	Do.
New Jersey:												
Millville, Cumberland Co.	Crossley's clay	77.15		15.65		Trace.	.75	.....	5.35	.....	.....	Furnished by H. Burden, 2d.
South Amboy, Middlesex Co.	H. C. Perrine & Co	61.76		26.14		.80	.....	.....	9.60	.....	.....	Do.
Woodbridge, Middlesex Co.	Crossley's clay	75.74		18.34		.06	.66	.....	4.58	1.70	.....	Do.
S. I. Terra Cotta Lumber Co., Woodbridge, Middlesex Co.	.....	56.62		31.50		1.15	Trace.	.....	9.74	.....	.....	Do.
Valentine & Co., Woodbridge, Middlesex Co.	.....	56.82		32.40		.15	.....	.....	10.04	.....	.....	Do.
Do	.....	64.90		25.28		.52	.....	.....	6.68	.....	.....	Do.
Cleveland Brick Co., Grover, Hunterdon Co.	Sandy clay, burns white	55.24		30.840	.84	.08	.02	Trace.	12.89	.....	.....	Wm. Bowran, anal.
							a 2.05					
Ohio:												
Freeman Fire Clay Co. Freeman, Jefferson Co.	.....	66.75		19.95	4.25	.60	1.00	.....	5.40	.....	.....	Furnished by company.
Means, Kyle & Co., Hanging Rock, Lawrence Co.	No. 2 fire clay	58.72		25.34	2.34	b .60	a .43	2.28	8.95	.....	.....	Do.
Martha L. Lacey, Irondale, Jefferson Co.	.....	52.00		24.00	3.00	.....	.....	.....	10.00	.....	.....	Furnished by M. L. Lacey.
Massillon, Stark Co.	.....	61.58		24.14	1.20	.45	.70	.....	11.93	.....	.....	From Massillon Stone and Fire Brick Co.
Canton, Stark Co.	For fire brick	69.85		19.43	.51	.12	.10	2.59	7.35	.....	.....	From Royal Brick Co.

a Magnesia determined as $MgCO_3$.

b Lime determined as $CaCO_3$.

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Analyses of clays—Continued.

FIRE CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Ohio—Continued.		*Per ct.*	*Per ct*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Dover Fire Brick Co., Strasburg, Tuscarawas Co.			50.09	36.06	1.01	.38	.12	Trace.	12.40	.....	.....	J. H. Cremer, anal. for company.
Pennsylvania:												
Lockhaven, Clinton Co.	Soft clay		50.80	32.28	1.77	.05	.47	4.56	.....	.....	*a* 8.94	Queen's Run Fire Brick Co., P. W. Shimer, anal.
											b 1.25	
Do.	Hard clay		45.65	36.36	1.19	.08	.....	1.30	.....	.....	*a* 13.01	Do.
											b 2.64	
Salina, Westmoreland Co.			43.75	40.966	.769	Trace.	.....	.....	14.41	.....	.....	Kier Bros., Pittsburg, Pa.
Valley Forge, Chester Co.	M. J. Bean's clay		71.88	19.26		1.50	1.04	.....	5.40	.....	.....	Furnished by H. Burden, 2d.
Brady's Run, B. R. Fire Brick Co.			68.92	22.38	.980	.19	.172	.....	6.14	.....	.....	F. G. Frick, anal.
Manown, Allegheny Co.			64.17	29.75	2.60	.40	.12	.....	.....	.....	.....	From Manown Mfg. Co.
Hunker Station			41.75	40.09	.65	.03	1.02	.....	13.20	.....	.....	From Westmoreland Fire Brick Co.
Arthurs, Clarion Co.			42.56	43.16	Trace.	.44	.15	.....	13.99	.24	.....	From Erskine & Co.
Pittsburg, Allegheny Co.	Silica brick		96.79	.93	.14	1.86	.....	.....	.....	.14	.....	From Stuart Fire Brick Co.
South Dakota:												
Rapid City, Pennington Co.	C. A. Marshall's		87.05	6.56	.64	.95	1.243	3.008	.....	.....	.....	Furnished by F. C. Smith.
Do.	Dark clay, base of hill		83.30	12.30	.80	1.30	Trace.	2.70	.....	.....	.....	Do.
Texas:												
Bowie, Montague Co.			60.48	24.60	2.43	.89	.75	.....	.....	.....	.....	Montague Coal Mining Co.

a Ignition. *b* Titanic acid.

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Analyses of clays—Continued.

PIPE CLAYS.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Indiana:		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Cannelton, Perry Co., Wm. Clarke.	Under-clay	65.83		22.94	2.64	.308	.858	.....	7.434	.....	.....	Ind. Geol. Surv., XX, p. 125.
Worthington, Greene Co	S. Davis's	63.25		24.81	3.04	.48	1.01	.....	7.33	.....	.....	Ind. Geol. Surv., XX, p. 90.
Missouri:												
Dickey Sewer Pipe Co., Deep-water, Henry Co.	Used for sewer pipe	60.12		21.35	7.06	.52	1.08	3.43	6.32	1.05	.....	Mo. Geol. Surv., XI, p. 564.
Laclede Mine, St. Louis	do	59.96		15.76	7.72	.60	.93	3.66	7.70	.....	SO_3 .73	Mo. Geol. Surv., XI, p. 570.
Minnesota:												
Red Wing, Goodhue Co	do	69.84		23.07	.48	.11	.14	Trace.	6.35	.....	.....	From J. H. Rich, sewer pipe works.
Ohio:												
Walker's Station, Columbiana Co.	Under-clay	54.53		27.88	2.41	0.42	0.68	3.43	8.87	.....	a 1.26	Ind. Geol. Surv., XX, p. 133.
POTTERY CLAYS.												
Alabama:												
Tuscaloosa Co	Tuscaloosa Cretaceous	66.122		24.781	Trace.	.....	.....	.....	6.287	.....	.....	Rept. on Valley Regions, Ala. Geol. Surv., XX, p. 180.
Indiana:												
Huntingburg, Dubois Co	Used for stoneware	69.23		18.97	b 0.55 1.57	0.12	0.36	2.60	5.46	.....	a 1.50	Ind. Geol. Surv., XX, p. 109.
Maryland:												
Cecil Co	E. Silknitter's mine	61.60		29.32	.28	.....	.40	8.40		.....	.....	R. Oberholtzer, anal.

a Titanic acid.

b = iron determined as FeO.

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Analyses of clays—Continued.

POTTERY CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Missouri:		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Wear Mine, Minden, Barton Co.	Not worked	50.94		24.24	7.18	.95	1.60	3.60	11.58	.....	.....	Mo. Geol. Surv., XI, p. 563.
Waltman's, Barton Co	Stoneware clay	65.32		22.63	1.81	.25	.67	1.72	7.42	.....	.....	Do.
Moore Place, Guthrie, Callaway Co.	Used for stoneware	48.92		32.90	3.10	.40	.30	.82	13.58	.....	.....	Do.
Do	....do	47.13		34.98	2.92	.37	.32	.52	13.88	.....	.....	Do.
Harrisonville, Cass Co		63.93		19.73	3.69	.53	1.21	3.40	7.53	.....	.....	Do.
Do	Washed clay, not worked	64.62		19.98	2.91	.44	1.31	3.25	7.42	.....	.....	Do.
Union, Franklin Co		44.14		39.86	.46	.77	.46	.76	13.84	.....	.....	Mo. Geol. Surv., XI, p. 564.
Calhoun, Henry Co	Used for stoneware	71.94		17.60	2.35	.62	.56	1.50	5.27	1.01	.....	Do.
Dunlap Pit, Clinton, Henry Co.	....do	67.49		21.11	2.45	.17	.63	2.83	5.95	1.04	.....	Do.
Frowein Pit, Clinton, Henry Co.	....do	64.97		22.64	3.28	.61	.80	2.74	5.50	1.20	.....	Do.
Grant farm, Clinton, Henry Co.	Not worked	59.33		25.09	4.09	.84	1.17	2.74	8.74	.....	.....	Do.
Missouri Clay Co., Deepwater, Henry Co.	Used also for sewer pipe	72.86		12.99	2.95	.35	.47	1.18	4.76	2.02	.....	Do.
Do	....do	74.02		15.26	2.02	.48	.51	2.37	3.69	.49	.....	Do.
Fields Creek, Henry Co	Used for stoneware	55.39		25.79	4.83	.53	.31	3.39	8.60	1.25	.....	Do.
Gilkerson Ford, Henry Co	Not worked	86.98		14.72	2.48	.65	.58	2.32	.86	.46	.....	Do.
Chancy Shaft, Joplin, Jasper Co	....do	60.98		21.83	1.93	.42	1.95	4.69	8.48	.....	.....	Mo. Geol. Surv., XI, p. 566.
Mammoth Mine, Desoto, Jefferson Co.	Ball clay for white ware	49.04		34.85	.71	1.33	1.04	.85	12.33	.....	.....	Do.
Mandel's Pit, Regina, Jefferson Co.	....do	45.97		36.35	1.08	1.14	1.09	1.84	12.36	.....	.....	Do.
Strasburg Mine, Mayview, Lafayette Co.		48.12		17.04	3.82	9.90	2.65	2.97	14.98	.....	SO_3 .27	Do.

Analyses of clays—Continued.

POTTERY CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Missouri—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Priceland, Versailles, Morgan Co.	Not worked	54.10		24.00	4.01	1.31	1.25	4.01	11.64	.....	.....	Mo. Geol. Surv., XI, p. 566.
Lanigan Shaft, Moberly, Randolph Co.	Used also for paving brick	66.24		20.32	2.30	.63	.48	2.04	7.80	.....	.....	Mo. Geol. Surv., XI, p. 568.
Rennebergs, Allenton, St. Louis Co.	Not worked	60.07		22.81	2.71	1.65	1.55	4.42	6.48	.....	.....	Mo. Geol. Surv., XI, p. 570.
Oer Pit, Slater, Saline Co	.....	50.36		32.34	3.90	1.04	.37	2.01	8.25	1.69	.....	Do.
Chariton River, Glenwood, Schuyler Co.	.....	53.54		15.39	4.17	8.54	2.17	3.20	12.78	.....	.....	Do.
Anderson Place, Commerce, Scott Co.	Used for stoneware	71.78		17.01	2.01	.34	.43	.78	8.13	.....	.....	Do.
Dexter, Stoddard Co	do	68.50		20.81	1.79	.77	Trace.	.53	7.62	.....	.....	Do.
BRICK CLAYS.												
Alabama:												
Tuscaloosa Co	Pinkish clay. Tuscaloosa Cretaceous.	68.108		10.858	14.471	.....	.....	.....	7.085	.....	.....	Ala. Geol. Surv., Report on Valley Region, p. 180.
NE. ¼ of NW. ¼ of S. 24, T. 1, R. 14 W.	.....	59.65		27.04	4.75	.....	.....	.....	.....	.....	.....	Ibid. J. M. Pickel, anal.
Elmore Station, Elmore Co	River terrace clay	60.81		21.69	3.43	0.17	0.57	2.15	7.26	3.60	SO_3 0.10	Ala. Ind. & Sci. Soc., V, 1895.

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Analyses of clays—Continued.

BRICK CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Alabama—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Elmore Station, Elmore Co	River terrace clay	61.15		24.81	2.43	.30	.39	2.30	6.45	1.70	SO_3 .11	Ala. Ind. & Sci. Soc., V, 1895.
Montgomery, Montgomery Co	do	62.75		21.15	4.00	.72	.32	2.28	6.00	2.70	SO_3 .11	Do.
Illinois:												
Lasalle, Lasalle Co	Red clay	62.00		18.10	9.10						a 5.66	Lasalle Pressed Brick Co.
Do	Buff clay	68.30		18.30							SO_3 .14 a 6.00	Do.
Indiana:												
Kosciusko Co		43.10		20.78	4.77	b 20.51	10.80					Dr. Hurty, anal. Ind. Geol. Survey, 1885–86, p. 43.
Terre Haute, Vigo Co	Used for brick, but good for vitrified ware.	66.11		13.78	5.35	1.67	1.78	3.26	6.38	9.25		Ind. Geol. Surv., XX, p. 76.
SE. ¼, sec. 4, T. 20 N., R. 8 W	Was used for roofing tile. Cracked in burning.	73.20		13.38	2.19	.97	1.01					Ibid., p. 59.
Princeton, Gibson Co	Yellow surface clay. Used for pressed brick.	71.20		18.56	c .15 1.34	.14	.52	1.58	6.30			Ibid., p. 114.
Vincennes, Knox Co	Burns yellow white	65.315		28.473	3.120	.179	2.741			.17		Ibid., p. 95.
Under-clay 8, S. L. McCune, Mecca, Parke Co.		54.46		25.71	c .91 5.51	.24	.83	3.01	8.50		d 1.20	Ibid., p. 133.
Evansville, Vanderburg Co	Wm. Schnute's yard	77.93		12.16	4.48	.347	.571		4.501	(e)		Ibid., p. 119.

a Ignition. b Lime determined as $CaCO_3$. c = iron determined as FeO. d Titanic acid. e And volatile matter.

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Analyses of clays—Continued.

BRICK CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Indiana—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Cayuga, Vermilion Co.	Dry-press brick—mixture of shales 3 and 4.	65.78		14.79	8.03	.54	1.42	3.79	4.98	.....	[a] 1.00 CO_2 .26	Ind. Geol. Surv., XX, p. 129.
Do	Bastard shale No. 5. Makes buff dry-press brick.	55.09		20.76	[b] 4.01 3.00	1.51	1.18	2.70	7.01	.....	[a] 1.20 CO_2 3.04	Do.
Iowa:												
Bridgewater, Adair Co.	Alluvium	77.13		10.95	2.36	2.08	.83	1.33	2.22	1.45	.....	G. C. Patrick, anal.
Gillett brickyard	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	Furnished by Ia. Geol. Surv.
Guthrie Center, Guthrie Co.	Brick and tile loess clay, W. E. Barry yard.	68.62		14.98	4.16	1.48	1.09	3.36	3.55	2.78	MnO .64	G. C. Patrick, anal. Furnished by Ia. Geol. Surv.
West Union, Fayette Co.	.....	35.60		14.08		15.25	11.03	3.94	2.08	.....	P_2O_5 .43 CO_2 18.25	L. A. Youtz, anal.
Indianola, Warren Co.	Loess clay, plastic	63.31		16.57	4.06	1.11	1.10	3.16	6.89	3.76	MnO .49	G. C. Patrick, anal. From Ia. Geol. Surv.
Do	Gray or yellow loess clay.	72.24		12.58	4.02	1.40	.99	4.14	5.33	1.70	.....	Do.
Lime Creek	Mason City shale	54.64		14.62	5.69	5.16	2.90	5.89	3.74	.85	MnO .76 CO_2 4.80	G. C. Patrick, anal. From Ia. Geol. Surv.
Red Oak, Montgomery Co.	Cretaceous clay	69.75		18.68	1.94	1.07	.95	2.96	3.85	1.33	.....	Do.
Spencer, Clay Co.	Altered loess	52.42		13.04	6.24	7.98	2.24	8.08	4.06	2.67	CO_2 7.57	Do.

[a] Titanic acid.

[b]=iron determined as FeO.

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Analyses of clays—Continued.

BRICK CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Louisiana:		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
New Orleans	Sandy clay	16.36	48.27	14.07	4.06	.....	1.67	6.97	7.06	.....	.....	J. A. Blaffer & Son.
Maryland:												
East of Baltimore	Red sandy, 8 feet from top.	77.62		12.30	4.10	.52	.46	.....	4.58	.....	.....	Furnished by Cromwell Bros., of Baltimore.
Do	Gray, less sandy, 22 feet from top.	72.02		16.66	1.38	.12	.85	.....	6.35	.....	.....	Do.
Do	Blue, no sand, 38 feet from top.	71.66		16.92	1.82	.....	.93	.....	6.14	.....	.....	Do.
Massachusetts:												
Clayton, Berkshire Co	Brick and terra cotta clay.	50.00		44.00	a 1.07	.024	.....	1.24	.....	.....	.....	White Brick and Terra Cotta Co.
Michigan:												
Springport Township, Jackson Co.	G. H. Wolcott's yard	52.26		22.95	8.15	4.48	1.32	.....	10.56	.....	.....	Mariner & Hoskins, anals.
Missouri:												
Creighton, Cass Co	.....	59.65		37.27	1.13	.....	Trace.	.17	1.80	1.00	.....	Creighton Brick and Tile Co.
Norborne, Carroll Co., Davy Clay Ballast Co.	Gumbo clay, for ballast	54.90		18.03	6.03	2.88	1.10	3.40	6.90	6.75	.....	Mo. Geol. Surv., Vol. XI, p. 563.
Jefferson City, Cole Co	Makes red brick	74.39		12.03	4.06	1.50	1.52	3.01	3.17	.....	.....	Ibid., p. 563.
Boonville, Cooper Co	do	81.11		11.62	3.90	2.37	1.47	3.14	6.71	.....	.....	Do.
Gilkerson Ford, Henry Co	Not worked	74.72		15.72	4.32	.50	1.08	2.34	4.74	1.61	.....	Mo. Geol. Surv., Vol. XI, p. 564.
Hartwell, Henry Co	do	60.93		21.51	6.72	.52	.88	2.34	5.30	1.85	.....	Do.
Kansas City, Jackson Co., Diamond Brick and Tile Co.	Shale clay	54.80		23.73	8.67	.64	2.23	3.80	6.00	.....	.....	Do.
	Average of 7 analyses	56.81		25.77	6.06	1.02	1.58	.....	.....	.....	.....	

a=iron determined as FeO.

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Analyses of clays—Continued.

BRICK CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Missouri—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Kansas City, Jackson Co	For red brick	72.00		11.97	3.51	1.80	1.12	3.25	6.42	.....	.....	Do.
Do	....do	74.60		12.26	3.37	1.69	1.12	3.26	2.70	.....	.....	Do.
Hannibal, Marion Co	Not worked	73.80		13.19	3.43	.86	.68	2.94	5.26	.....	.....	Mo. Geol. Surv., XI, p. 566.
Clifton, Randolph Co., Davy Clay Ballast Co.	For railroad ballast	62.80		17.22	5.21	.98	.78	3.63	7.82	2.06	.....	Mo. Geol. Surv., XI, p. 568.
Moberly, Randolph Co., Moberly B. T. & E. Co.	For paving brick also	65.01		19.30	4.91	1.40	.40	2.60	5.51	1.03	.....	Do.
St. Peters, St. Charles Co	Not worked	61.19		15.48	5.49	1.95	1.56	2.82	9.02	3.11	.....	Do.
St. Louis Hyd. Pressed Brick Co.	Red brick	73.92		11.65	4.74	1.45	.60	3.13	3.08	2.18	.....	Mo. Geol. Surv., XI, p. 570.
Prospect Hill, St. Louis Co	Also for roofing tile	60.70		18.22	7.58	2.68	Trace.	3.67	7.77	.....	.....	Do.
St. Louis	Alluvium Mo. Riv. settlings.	51.68		23.65	6.63	1.40	.20	2.23	8.75	5.14	.....	
Nebraska:												
Omaha, Douglas Co	Red clay	72.53		12.05	4.28	1.03	1.20	3.10	3.36	2.45	.....	From Omaha Hydraul. Pressed Brick Co.
Do	Buff clay	79.50		11.61	2.57	.....	.68	1.29	3.50	.85	.....	
New Jersey:												
Millville, Cumberland Co	Phila. Fire Proofing and Brick Co.	75.30		17.82	4.78	.....	.....	.....	.....	.....	.....	Furnished by H. Burden, 2d.
Whippany, Morris Co	.....	64.62		13.74	9.86	.85	1.33	3.65	4.65	.....	a 1.85	From Whippany Clay Mfg. Co.
New York:												
Richfield Springs, Otsego Co	.....	49.65		23.82		6.48	Trace.	.....	.....	.....	b 16.18	U. S. G. S. Bull. No.
Alfred Center, Allegany Co	Chemung shale	53.20		23.25	10.90	1.01	.62	2.70	6.30	.....	.....	From C. T. Harris.

a Titanic acid. b Ignition.

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Analyses of clays—Continued.

BRICK CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
New York—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Canandaigua, Ontario Co.	For hydraulic dry-press brick, Quaternary clay.	45.12		12.76	5.44	a23.32	5.42	.....	.....	.....	.....	R. Chauvenet & Bro., anal.
Do	do	46.55		12.66	4.92	14.02	4.67	2.05	.90	.....	CO_2 14.62	H. A. Wheeler, anal.
Croton Point, Westchester Co.	Blue clay	51.61		19.20	8.19	7.60	1.25	5.32	7.25 and CO_2		.....	
Do	Yellow clay	56 75		20.15	8.82	3.14	1.20	4.50	5.52 and CO_2		SO_3	
E. Kingston, Ulster Co.	Champlain clay	55.45		18.91	7.39	5.40	3.39	.....	7.80	5.58	.74	From Terry Bros.
Do	do	61.65		15.24	5.61	5.67	2.80	.....	6.85	2.026	b 1.18	Do.
Ohio:												
Coal Grove, Lawrence Co	Brick and tile clay	56.90		28.00	1.50	.....	.....	.....	13.60	.....	.....	From Forestdale Brick and Tile Works.
Wickliffe, Lake Co.	Shale	58.26		24.64	7.29	.72	1.246	1.14	.....	6.704	.....	From Buckeye Brick Co.
Do	do	59.24		24.73	5.07	.60	1.714	2.13	5.16	.....	.....	Do.
Elyria, Lorain Co.	do	60.38		18.39	2.714	.94	1.00	9.12	1.66	.....	.....	From Loraine Brick Co.
Do	do	60.55		18.29	4.70	.20	.81	3.38	.....	.....	CO_2 1.49 SO_3 1.18	Do.
Pennsylvania:												
Titusville, Crawford Co.		51.01		20.93	6.831	3.01	2.511	4.372	3.84	.....	c 1.09 CO_2 5.78	Pa. Geol. Surv., No. 3, p. 108.

a=lime determined as $CaCO_3$. b Organic matter. c Titanic acid.

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Analyses of clays—Continued.

PIPE CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Pennsylvania—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Texas township, Wayne Co	Catskill red shale	59.26		19.877	10.071	.25	1.917	4.855	3.60	.....	SO_2 .012 P_2O_5 .158	Pa. Geol. Surv., No. 3, p. 109.
Cannelton, Beaver Co		67.67		18.28	1.03	.....	Trace.	3.08	7.66	.....	a 2.28	From J. W. Sutherin & Co.
South Dakota:												
Rapid City, Pennington Co	Fort Benton shale	63.59		20.309	b 2.952	.52	.612	1.402	3.80	.....	c 6.63	Furnished by F. C. Smith.
Tennessee:												
Powells Station, Knox Co	Clay	68.35		12.96	6.44	.23	1.00	2.14	7.80	.....	MnO .90	
Do	Shale	62.30		19.17	6.88	Tr.	.40	3.36	7.45	.....	.....	
West Virginia:												
Morgantown, Monongalia Co	Clay near river	73.88		12.73	5.78	.....	.10	1.67	4.04	1.12	.....	A. R. Whitehall, analyst.
Morgantown Brick Co	do	75.12		11.20	5.22	.....	.18	1.67	5.10	1.30	.....	Do.
Moundsville, Marshall Co		74.62		16.01	2.86	.32	.43	1.98	.....	6.62	.....	From Mound City Brick Co.
Wisconsin:												
Milwaukee		38.07		9.46	2.70	15.84	8.50	2.76	2.49	.....	CO_2 20.46	From the Chase Brick Co.
SHALES.												
Indiana:												
J. W. Shuster, Stone Bluff, Fountain Co.		68.46		16.08	b .06 1.02	0.99	0.05	3.71	7.04	.....	a 1.49	Ind. Geol. Surv., XX, p. 130.

a Titanic acid. b=iron determined as FeO. c Ignition.

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Analyses of clays—Continued.

SHALES—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Indiana—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
F. Landers, Stone Bluff, Fountain Co.		67.82		13.60	*a*.45 4.04	.57	.44	2.86	9.72	.....	*b* 1.10	Ind. Geol. Surv., XX, p. 130.
Near Air Line shops, Princeton, Gibson Co.		62.04		18.49	*a*.06 7.54	.16	.91	2.97	6.50	.....	*b* 1.30	Do.
Vincennes, Knox Co.		64.05		16.00	*a* 5.85 .89	.42	2.00	3.78	3.79	.....	*b* 1.00	Do.
Island Coal Co., Linton, Greene Co.	Shale No. 8, shaft 1	55.31		22.46	*a*.23 7.18	.66	.93	4.11	7.48	.....	*b* 1.15	Do.
S. L. McCune, Mecca, Parke Co.	Shale No. 5	58.83		22.34	*a* 1.44 5.13	.49	1.56	4.81	5.22	.....	*b*.70	Ind. Geol. Surv., XX, p. 129.
Do	Shale No. 9	59.02		20.93	*a* 1.56 4.45	.51	1.66	3.33	7.59	.....	*b* 1.10	Do.
Do	Shale No. 2	59.77		20.60	*a* 3.70 2.22	.64	1.98	3.95	4.53	.....	*b*.80	Do.
American Cannel Coal Co., Cannelton, Perry Co.	Shale No. 7	53.26		25 77	*a* 3.82 3.32	.32	1.90	2.98	7.00	.....	*b* 1.05	Ind. Geol. Surv., XX, p. 130.
Railroad cut near Lincoln, Spencer Co.	Mixture of shales	56.68		20.33	*a* 3.69 4.35	.57	2.09	3.78	6.54	.....	*b*.90	Do.
J. Burns, West Montezuma, Vermilion Co.	Shale No. 6	46.07		24.22	*a*.34 9.65	.19	1.31	3.42	9.76	.....	*b* 1.19	Do.
Do	Shale No. 11	56.32		24.34	*a*.24 5.60	.31	.54	5.19	6.33	.....	*b* 1.07	Do.
H. T. Thorp, Terre Haute, Vigo Co.		61.05		21.46	*a*.71 5.57	.25	.70	2.64	6.94	.....	*b* 1.20	Ind. Geol. Surv., XX, p. 129.

a=iron determined as FeO. *b* Titanic acid.

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Analyses of clays—Continued.

SHALES—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Indiana—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Rocky Run		55.20		14.40	9.40	6.12	.90	.52	8.60		MnO 1.80	Ind. Geol. Surv., XX, p. 57.
Missouri:												
Foster, Bates Co	Not worked	55.96		20.62	8.12	1.91	1.96	3.34	7.32			Mo. Geol. Surv., XI, p. 563.
Billings, Christian Co	Used for terra cotta	63.11		23.11	1.79	.42	.70	8.71	7.05			Do.
Boonville, Cooper Co	Not worked	53.24		23.62	9.02	1.17	1.41	4.38	6.94			Do.
Clinton, Henry Co	do	52.70		26.86	4.49	.57	.68	2.47	8.66	1.48		Ibid., XI, p. 564.
Town Creek Clinton, Henry Co	do	54.69		25.96	4.97	.18	.15	3.58	8.90	1.41		Do.
Gilkerson Ford, Henry Co	do	55.02		24.38	5.79	.58	1.50	3.32	8.88	1.08		Do.
Fields Creek, Henry Co	do	53.44		22.88	5.86	38	.69	3.02	11.95			Do.
Vickey Lands, Henry Co	do	59.06		23.05	7.31	.46	.86	2.80	6.03			Do.
North Bluff, Kansas City, Jackson Co.	Used for press brick	55.75		21.16	5.69	3.25	2.84	3.02	8.45			Do.
Briggs Shaft, Joplin, Jasper Co	Not worked	55.84		22.78	5 24	.73	1.26	4.10	9.84			Ibid., XI, p. 566.
Clear Fork, Johnson Co	do	60.82		23.98	4.37	.46	.45	3.16	6.60			Do.
Lexington, Lafayette Co		54.03		22.50	7.90	.85	2.70	4.12	7.54			Do.
Hannibal, Marion Co	Not worked	75.70		9.61	1.79	2.51	2.11	2.65	6.16			Do.
Minor's Land, Bowling Green, Pike Co.	do	66.57		15.32	3.82	3.20	1.03	2.94	6.42	1.42		Ibid., XI, p. 568.
Louisiana, Pike Co	do	57.01		24.43	5.77	1.40	.49	3.81	7 20	.43		Do.
Aldrich, Polk Co	do	46.26		10.76	2.65	11.08	7.84	3 17	8.02			Do.
Humansville, Polk Co	do	56.82		24.48	3.82	.83	1.81	3.80	8.16			Do.
Hammet's Farm, Huntsville, Randolph Co.	do	66.03		21 74	2.13	.50	1.01	1.64	6 00	1.34		Do.

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CEMENT.

PORTLAND CEMENT.

By SPENCER B. NEWBERRY.

PRODUCTION.

The product of Portland cement in the United States during the year 1896 amounted to 1,543,023 barrels, as compared with 990,324 barrels in 1895, an increase of 552,699 barrels, or nearly 56 per cent. It is probable, however, that the output for 1895 was somewhat underestimated, owing to the difficulty of securing reports of production from some of the most important factories. In order to obtain complete and accurate returns for the year 1896, the writer visited personally the chief centers of production soon after the close of the year, and obtained returns which are much more reliable than those of former years. This extraordinary increase is shown in all the chief producing districts, but is most marked in the region embracing Lehigh County, Pennsylvania, and Phillipsburg, New Jersey. The factories in that section have been greatly enlarged during the past two years, and several of them now show a production but little inferior to the leading factories of Germany and England. The cause of this rapid growth is probably to be found in the unlimited supply of natural cement material found at that locality. This is a limestone containing such an amount of clay as to be approximately a natural Portland cement mixture. The different strata are selected and ground together in such proportions as to give a material of correct chemical composition. Another advantage which the Lehigh County cement rock presents is its comparative freedom from magnesia.

Analyses of clays—Continued.

PAVING BRICK CLAYS—Continued.

Locality.	Remarks.	Silica.		Alumina.	Ferric oxide.	Lime.	Magnesia.	Alkalies.	Water.		Miscellaneous.	Firm names, authority, or analyst.
		Combined.	Free.						Combined.	Free.		
Missouri:		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Deepwater, Henry Co., Missouri Clay Co.		68.54		18.49	3.38	1.03	.88	2.37	4.62	1.52	.....	Ind. Geol. Surv., XX, p. 564.
Kansas City, Jackson Co		56.80		25.70	6.00	1.00	1.50	.....	.....	.....	.....	From Diamond Brick and Tile Co.
Boyd's Pit, Knobnoster, Johnson Co.		69.65		20.41	2.11	1.21	Tr.	8.52	5.34	.....	.....	Ind. Geol. Surv., XX, p. 566.
New York:												
Cairo, Greene Co		68.00		15.00	12.00	.....	.....	.....	5.00	.....	.....	From Catskill Shale and Paving Brick Co.
Pennsylvania:												
Corry		44.44		26.84	8.10	a12.84	b5.85	1.12	.....	.....	.....	From F. Stanford, Corry, Pa.
Michigan:												
Saginaw	Gray shale	63.00		21.80	8.80	1.70	2.00	2.65	.....	.....	.....	From Saginaw Clay Manufacturing Co.
Do	Black shale	54.50		30.75	3.50	1.05	1.69	3.00	5.51	.....	.....	Do.

a=lime determined as $CaCO_3$.

b=magnesia determined as $MgCO_3$.

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The following table shows the product of Portland cement in the United States during the years 1895 and 1896, by States:

Product of Portland cement in the United States in 1895 and 1896.

State.	1895.			1896.		
	Number of works.	Product.	Value, not including packages.	Number of works.	Product.	Value, not including packages.
		Barrels.			*Barrels.*	
California	1	16,283	$32,566	1	9,000	$18,000
South Dakota	1	6,497	12,994	1	24,000	48,000
Illinois	1	750	1,325	1	3,000	5,250
Indiana	.....	.....	.....	1	9,000	15,750
Michigan	.....	.....	.....	1	4,000	7,000
New York	4	159,320	278,810	7	260,787	443,175
New Jersey	2	155,000	232,500	2	247,100	370,650
Ohio	4	136,698	239,221	4	153,082	267,892
Pennsylvania	7	504,276	756,414	7	825,054	1,224,294
Texas	1	10,000	30,000	1	8,000	24,000
Utah	1	1,500	3,000	.....	.....	.....
Total	22	990,324	1,586,830	26	1,543,023	2,424,011

The relative development of the Portland cement industry in different sections of the United States presents some interesting features. The following table shows the number and production of the factories located in the chief producing regions in 1890, 1894, and 1896; also the relative percentage of the total American product which each section contributed.

Number of works and relative product of Portland cement at various localities in the United States during the years 1890, 1894, and 1896.

	1890.			1894.			1896.		
	Number of works.	Product.	Per cent.	Number of works.	Product.	Per cent.	Number of works.	Product.	Per cent.
		Barrels.			*Barrels.*			*Barrels.*	
New York	4	65,000	19.4	4	117,275	14.7	7	260,787	16.9
Lehigh County, Pa., and Phillipsburg, N. J.	5	201,000	60.0	7	485,329	61.2	8	1,048,154	68.1
Ohio	2	22,000	6.5	4	80,653	10.1	4	153,082	9.9
All other sections	5	47,500	14.1	9	115,500	14.0	7	81,000	5.1
Total	16	335,500	100.0	24	798,757	100.0	26	1,543,023	100.0

The above table shows that the Pennsylvania region, including Lehigh and Northampton counties, and the neighborhood of Phillipsburg, New Jersey, has for many years produced much more than half the Portland cement manufactured in the United States, and also that

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the industry is increasing in that section more rapidly than elsewhere. New York and Ohio show a steady and considerable growth, while the production in other parts of the country, taken collectively, shows a marked decline in number of works and total product during the past two years, and but little gain over the figures of seven years ago. It may, in fact, be stated that the Portland cement industry has never yet found a secure footing in any sections of the country except the three above mentioned. This may appear remarkable, in view of the immense consumption of Portland cement in Chicago, St. Louis, and all other cities in the central and northern portion of the country. The explanation is probably to be found in the occurrence of abundant and suitable materials in Pennsylvania, New York, and Ohio, and also in the superior shipping facilities which these sections afford. Small factories are in operation in Illinois, Indiana, Michigan, California, South Dakota, and Texas, but these show little or no growth and find only a local market for their product. Suitable materials for Portland cement are, however, found abundantly in these and other States, and the development of the industry on a large scale in various parts of the country may be confidently expected within the next few years.

IMPORTS.

The imports of Portland cement in 1896 were 2,989,597 barrels, a slight decrease from those of the preceding year. The amount of cement imported for the past six years has been remarkably uniform, the total of 1896 being almost exactly equal to that of 1891. The following table shows the imports, by countries, in 1895 and 1896:

Imports of cement into the United States in 1895 and 1896, by countries.

Country.	1895.	1896.
	Barrels.	*Barrels.*
United Kingdom	806, 884	742, 169
Belgium	708, 875	742, 237
France	22, 837	26, 714
Germany	1, 299, 919	1, 366, 909
Other Europe	141, 909	99, 184
British North America	10, 416	11, 334
Other countries	6, 555	1, 050
Total	2, 997, 395	2, 989, 597

The above table shows the continued increase in importation of cement from Germany and the decrease in the imports from Great Britain. During the past twenty years German cement has grown rapidly in favor in comparison with the English. This is due to the

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more careful methods employed in German factories, which have resulted in a steady advance in quality, uniformity, and fineness of grinding. The English manufacturers, on the other hand, have clung persistently to the old methods of manufacture, and have only within the past two or three years made any effort to keep up with modern requirements. In the meantime the largest share of the American trade has been secured by the Germans.

Large amounts of Portland cement, chiefly of inferior grade, are also imported from Belgium. In that country vast deposits of natural cement material occur, consisting of limestone containing nearly the correct proportion of clay and practically no magnesia, similar to that found in Lehigh County, Pennsylvania. A large part of the deposit is of such composition that it may be burned direct to Portland cement without any preliminary grinding or admixture. The cement produced is, however, quite variable in character, owing to slight fluctuations in the composition of the raw material. The cement industry of Belgium has been well described in the report of Consul Roosevelt.[1] It is stated in this report that three different products are made from the same stratum of rock, namely, artificial Portland, natural Portland, and Roman cement. The artificial Portland cement is made by grinding together the different grades of rock in such a manner as to give a mixture of correct composition, and is a product of high quality, similar to that produced in Germany. The natural Portland cement is made by burning such strata of rock as have approximately the correct composition. The Roman cement is made by burning at a low heat such portions of the rock as contain an excess of clay. Many manufacturers grind cinders or limestone with the Roman or natural cement, and thus give these inferior products the appearance and composition of true Portland cement. Such adulterated materials are largely purchased by unscrupulous exporters and shipped as artificial Portland. This may account for the unsatisfactory results which many Belgian cements have given in this country.

It will be noted in the above table that a relatively small but increasing amount of cement is imported from Canada, chiefly at the port of Detroit. This is from factories located at Owen Sound and Napanee, Ontario. From France a small amount of Lafarge cement and Teil hydraulic lime are imported. These are produced at the same factory at Lafarge, on the Rhone River, the Lafarge cement being simply the vitrified portions of the hydraulic lime, which resist slaking, and are separately ground. This cement is light in color, and is claimed to be especially suitable for pointing white stonework, as it does not stain the stone as other Portland cements generally do. The "other Europe" in the above table represents chiefly Denmark and Sweden. The Aalborg cement, from Denmark, is highly esteemed in this country, chiefly on account of the great fineness to which it is ground.

[1] U. S. Consular Reports No. 192, Sept., 1896, p. 184.

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RELATION OF DOMESTIC PRODUCTION TO IMPORTATION.

Owing to the great increase in the amount of Portland cement produced in this country during the past few years and the almost unchanged amount of imports, the proportion of domestic to imported cement consumed shows a gratifying growth, which appears strikingly in the following table:

Comparison of the domestic production of Portland cement with the imports.

	1891.	1893.	1895.	1896.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*
Production in the United States.	454, 813	590, 652	990, 324	1, 543, 023
Imports	2, 988, 313	2, 674, 149	2, 997, 395	2, 989, 597
Total	3, 443, 126	3, 264, 801	3, 987, 719	4, 532, 620
Exports	.....	14, 276	83, 682	85, 486
Total consumption	3, 443, 126	3, 250, 525	3, 904, 087	4, 447, 134
Percentage of total consumption produced in the United States	13. 2	18. 2	25. 3	34. 7

In this table the figures given for "exports" include both lime and cement, and are therefore incorrect. The error caused by this is, however, unimportant. These two products are hereafter to be recorded separately by the Treasury Department.

The above table shows that the imports have remained nearly stationary for the past six years, and that the production of the American factories has been more than tripled in the same time. The consumption of Portland cement has therefore increased by practically the whole amount of the increase in home production, more than 1,000,000 barrels, or about 30 per cent. It should be remembered, also, that the period since early in 1893 has been one of great business depression and comparative inactivity in railway construction, public improvements, and private building operations. In view of this fact, the increased demand for Portland cement, which has absorbed all the added domestic product without lessening the importations, is certainly remarkable, and points to a still greater demand for this useful product with the return of prosperous times. From present indications the year 1897 will show a further marked increase in the American production. Established factories, especially in the Pennsylvania region, are again greatly enlarging their plants. In the central part of the country two new companies, with reputed extensive capital and unlimited material, are to build works, but these will hardly be in operation before the spring of 1898. On the other hand, large enterprises requir-

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ing great quantities of Portland cement are being started at various points, and the building trade shows renewed activity. It is not likely, therefore, that the importation of cement will show any decrease during the present year, and it will probably be many years before our supply of Portland cement is wholly supplied by our own factories.

A strange state of affairs exists at present, however, in the cement market. The leading American manufacturers are competing so sharply among themselves that the best grades of American Portland are offered on large contracts at a price at least 50 cents per barrel lower than the leading imported brands. It is everywhere acknowledged that the best American cements are fully equal to the imported, and, in view of the immense demand, such competition appears quite unnecessary. Nevertheless, consumers are enjoying the benefit of this conflict, and are at present buying high-grade cements almost as cheaply as materials of the same quality are to be had in England or Germany.

THE PORTLAND CEMENT INDUSTRY IN THE VARIOUS STATES.

ARKANSAS.

The factory at White Cliffs, near Texarkana, is practically completed, and will be in operation early in 1897. The writer visited this locality soon after the close of the year, and inspected the materials and plant. The deposit of raw material consists of an immense bed of white, soft chalk, covering an area of 900 acres, and rising in cliffs to a height of over 200 feet above the Little River. The chalk is fairly uniform in composition, containing 88 to 90 per cent of carbonate of lime, 9 or 10 per cent of insoluble matter (clay), and less than 1 per cent of magnesia. It is in every way an excellent cement material, and the extent of the deposit is sufficient to supply an amount of cement equal to the whole present consumption of Portland cement in this country for more than a hundred years. The property of the company includes also 600 acres of fine-grained, yellow clay. The analysis of an average sample of these two materials resulted as follows:

Analyses of cement material from White Cliffs, Arkansas.

Chalk.	Per cent.	Clay.	Per cent.
Carbonate of lime	90.23	Silica	73.62
Carbonate of magnesia	1.15	Alumina, Iron oxide	19.30
Silica	5.33	Lime	
Alumina, Iron oxide	3.03	Magnesia	
Total	99.74		

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The plant of the White Cliffs Portland Cement Company is modeled closely after modern German factories. The materials are ground together by the dry process, molded into bricks, and burned in Aalborg continuous kilns. The present capacity of the works is 300 barrels per day.

MICHIGAN.

A factory is under construction near Bronson, Michigan, by the Monarch Portland Cement Company, to manufacture cement from the large deposit of marl which occurs at that point. At these works the rotary process of burning will be employed, as at Coplay, Phillipsburg, and Sandusky.

OHIO.

The factory of the Art Portland Cement Company, near Sandusky, referred to in the report for 1895, is not yet in operation. It was proposed by this company to manufacture a white Portland cement for ornamental purposes, but it appears doubtful whether this plan will be carried out.

A company of Pittsburg capitalists have purchased large tracts of marl land at Castalia, near Sandusky, and propose to erect works in the near future.

The project of establishing large works at Harper, mentioned in the last report, has not been carried out.

The factory at Middle Branch was destroyed by fire in March, 1897. It is understood that the works will be rebuilt.

MATERIALS.

Argillaceous limestone is still the chief cement material in this country, as shown by the following table:

Comparative product from limestone and marl.

	No.	Product.
		Barrels.
Factories using limestone	18	1,208,234
Factories using marl	8	334,789
Total	26	1,543,023

PROCESSES.

The Aalborg, or modified Shöfer, continuous kiln is coming rapidly into use in this country. It is employed at Glens Falls, New York, and at one of the largest factories at Coplay, Pennsylvania. At another of the large works at Coplay these kilns will be used in a projected extension of the plant. The Aalborg kiln has also been adopted at the new

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factory in Arkansas. The great advantage of this type of continuous kiln is its great economy of fuel. Only about 2 tons of soft coal per day are required for each kiln, with a daily production of 75 to 80 barrels of cement clinker. This is only about 12 per cent of the weight of clinker produced, and with coal at $2 per ton corresponds to a cost for fuel of only 5 cents for each barrel of cement produced.

The use of the rotary furnace is also rapidly increasing, as is shown by the following table:

Amount of Portland cement made in kilns of various kinds.

	1893.	1894.	1895.	1896.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*
Rotary furnace	149,000	242,176	400,821	632,370
Vertical kilns (continuous and intermittent)	441,653	556,581	589,503	910,653
Total	590,653	798,757	990,324	1,543,023
Per cent of total product burned in rotary furnace	25.2	30.3	40.5	41.0

One of the largest factories at Coplay, Pennsylvania, using the rotary furnace was increased by the erection of a second plant in 1896, and began operations in the new works in August. The total output of the two factories of this company is over 800 barrels per day, and further extensions are projected. It is probable, therefore, that the report for 1897 will show a still further increase in the relative product of the rotary furnace.

IMITATION PORTLAND CEMENTS.

Two of the chief companies engaged in the manufacture of common hydraulic cement are grinding the hard-burned clinkers separately, and putting the product on the market as Portland cement under several different names. This material shows no more than one-half the strength of true Portland. The presence of 15 per cent or more of magnesia is also a serious objection to these cements, as the most careful German work on the subject has shown that more than 4 per cent of magnesia causes cement to fall off in strength, while 8 per cent or over causes it to fall to pieces after long periods.

PROPOSED STANDARD SPECIFICATIONS FOR CEMENT TESTING.

The need of standard rules for testing cements has long been recognized by engineers, and the subject has been widely discussed in the columns of the engineering journals during the past year. The recom-

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ROCK CEMENT.

By URIAH CUMMINGS.

PRODUCTION AND PRICE.

There has been a slight increase in the production of rock cement in the United States during the year 1896 over that of 1895, the increase being confined mostly to Illinois and eastern New York.

In view of the continued depression in the general business of the country, and the fact that Portland cement has declined considerably, the advance in the prices of rock cement, although slight, is encouraging.

The following table shows the price of American rock cement in bulk at mills from 1891 to 1896, inclusive:

Price of American rock cement in bulk at mills, 1891 to 1896.

Year.	Per barrel.	Year.	Per barrel.
	Cents.		*Cents.*
1891	47.26	1894	48.07
1892	48.61	1895	50.32
1893	43.87	1896	50.80

The following table gives the amount and value of the rock cement produced in the United States during 1895 and 1896. The values are based on the selling prices of the cement per barrel in bulk at mills. Approximately 65 per cent of the product is sold in paper or cloth sacks and 35 per cent is sold in wood packages.

Product of rock cement in 1895 and 1896.

State.	1895.			1896.		
	Number of works.	Product.	Value.	Number of works.	Product.	Value.
		Barrels.			*Barrels.*	
Georgia	1	8,050	$6,038	1	12,700	$9,525
Illinois	2	491,012	171,854	2	544,326	217,731
Indiana and Kentucky	14	1,703,000	681,400	15	1,636,000	654,400
Kansas	2	140,000	56,000	2	125,567	50,226
Maryland and West Virginia	4	242,000	116,700	5	271,500	125,175
Minnesota	2	73,772	33,621	2	83,098	38,549
New Mexico	1	5,000	6,000	1	Closed.	

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Product of rock cement in 1895 and 1896—Continued.

State.	1895.			1896.		
	Number of works.	Product.	Value.	Number of works.	Product.	Value.
New York:		*Barrels.*			*Barrels.*	
Erie County	4	556,754	$269,089	4	550,851	$275,426
Onondaga County, Schoharie County	10	152,973	77,974	10	204,375	92,450
Ulster County	15	3,230,000	1,938,031	15	3,426,692	2,056,015
Ohio	3	38,060	22,836	3	28,565	17,139
Pennsylvania	5	600,895	300,447	6	608,000	304,000
Texas	1	10,000	17,000	1	12,000	18,000
Virginia	2	13,050	7,830	3	16,776	10,566
Wisconsin	1	476,511	190,604	1	450,000	180,000
Total	67	7,741,077	3,895,424	71	7,970,450	4,049,202

CONSUMPTION.

The use of cement is largely on the increase in this country, as may be seen by the following table, showing the number of pounds of American rock cement consumed per capita at the dates given:

Consumption, per capita, of cement in the United States.

Year.	Pounds per capita.
1850	6.46
1860	10.49
1870	12.77
1880	13.04
1890	33.93

The older States consume more cement per capita than do the younger States.

In the larger cities the brick and stone buildings are being laid in cement, whereas in former years quicklime was used for the purpose.

STANDARDS OF WEIGHT.

There are in this country three distinct standards of weight for a barrel of cement. The standard weight throughout the Eastern and Atlantic States is known as the "Eastern" weight for rock cement, while the "Western" weight is prevalent through the Middle and Western States. The Portland weight is the same throughout the country.

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Net weight of a barrel of cement in the United States.

Standard.	Pounds.
Eastern	300
Western	265
Portland	380
Sand	300

TESTS.

The report of the committee on a "uniform system for tests of cement" to the American Society of Civil Engineers states that "the proportions of cement, sand, and water should be carefully determined by weight." This practice of determining proportions by weight in the making of briquettes for testing purposes is quite rigidly adhered to, but whenever cement mortar is made for masonry work there is a wide departure from the rules observed in testing. In the mixing of cement mortar it is customary throughout the country to use an empty cement barrel for measuring the sand that is to be mixed with the cement. This manner of measuring is a convenient one, yet it results in a disparity of proportions when weights are considered, which militates against the rock cements and correspondingly favors the Portland cements.

It will be seen by the table that, with equal mixtures of cement and sand, by the barrel measure, the Eastern rock cement is carrying 26 per cent and the Western 43 per cent more sand, by weight, than is the Portland. So long as it remains the prevailing custom to mix cement and sand by measure rather than by weight it is not strange that people are deluded into a belief that Portland cement will carry 50 per cent more sand than will the rock cements. It is due to the unfortunate establishment of the different standards of weights per barrel that has led to many errors in judgment concerning the relative values of the two classes of cements.

There is a very large question involved in the matter of bulk as between the two classes. The volume of 100 pounds of rock cement is 25 per cent greater than is that of 100 pounds of Portland cement, and, assuming that both classes are ground equally fine, it is difficult to disprove that 100 pounds of rock cement will not cover over the surfaces of 25 per cent more sand than the 100 pounds of Portland cement.

Herein undoubtedly is to be found the solution of a problem which has puzzled the cement world since the foundation of the present system of cement testing—namely, that as the proportion of sand is increased, the difference in the relative strength of the two classes of cements decreases. This fact would seem to indicate that the rock cement, by having the greater volume, has a greater capacity for coating over the surfaces of the gang in mortar or concrete.

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It is a popular delusion concerning Portland cement that there is hardly a limit to its sand-carrying capacity, and oftentimes it is overloaded, producing a weak, dangerous mortar, which can in no manner compare, either in cost or quality, with a mortar made of rock cement and a lower admixture of sand. The ultimate strength of a neat Portland cement is reached in one year, and one-half of its strength is reached in seven days. The ultimate strength of a neat rock cement is reached in five years, and at seven days it has attained but one-eighth of its ultimate strength.

IMPORTS.

The following table shows the imports of cement, by ports, during the fiscal years ending June 30, 1894, 1895, and 1896:

Imports of cement, by ports, during the fiscal years ending June 30, 1894, 1895, and 1896.

Ports.	1894.		1895.		1896.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Atlantic Coast.						
Aroostook, Me	163,000	$853	977,225	$4,980	298,900	$1,541
Baltimore, Md	77,968,821	249,039	113,334,906	353,033	136,642,716	425,716
Bath, Me	8,400	54	.....	.....	.....	.....
Boston and Charlestown, Mass	62,072,160	198,653	68,952,320	216,392	103,363,854	329,284
Charleston, S. C	6,224,911	21,956	6,350,350	15,295	2,486,209	6,016
Georgetown, D. C	165,345	655	.....	.....	96,865	369
New Bedford, Mass	.....	.....	20,000	44	.....	.....
Newport News, Va	11,904,000	35,920	29,436,949	92,244	22,714,105	72,634
New York, N. Y	384,406,068	1,251,090	429,254,171	1,419,216	414,354,220	1,350,114
Passamaquoddy, Me	.....	.....	16,400	57	.....	.....
Philadelphia, Pa	111,829,516	348,662	106,658,722	336,788	100,788,476	308,573
Portland and Falmouth, Me	1,699,608	5,246	.....	.....	.....	.....
Richmond, Va	200,000	613	.....	.....	.....	.....
Savannah, Ga	9,881,156	27,008	16,651,072	48,075	17,271,973	44,378
Wilmington, N. C	.....	.....	.....	.....	.....	.....
Total	666,522,985	2,139,749	771,652,115	2,486,124	798,017,318	2,538,625
Gulf Coast.						
Galveston, Tex	19,207,393	58,681	23,703,800	62,879	22,820,243	73,053
Mobile, Ala	.....	.....	.....	.....	3,660,649	14,205
New Orleans, La	83,794,052	273,570	100,811,527	313,200	122,418,662	385,036
Pensacola, Fla	1,315,559	4,005	1,480,000	4,591	5,970,400	17,084
Saluria, Tex	.....	.....	3,800	11	.....	.....
Tampa, Fla	.....	.....	.....	.....	.....	.....
Total	104,317,004	336,256	125,999,127	389,681	154,869,954	489,378
Pacific Coast.						
Los Angeles, Cal	6,658,448	21,637	8,878,392	30,683	23,824,428	88,028
Oregon, Oreg	399,980	1,277	817,000	2,535	419,630	1,415
Puget Sound, Wash	21,706,002	66,665	6,156,340	12,892	11,253,968	36,194
San Diego, Cal	14,761,600	48,802	18,450,800	61,275	29,120,800	95,681
San Francisco, Cal	135,889,312	433,364	89,630,282	304,168	144,456,453	477,280
Willamette, Oreg	47,560,684	155,222	27,102,654	91,814	21,150,728	64,196
Total	226,976,026	726,967	151,035,468	503,387	230,226,007	762,794

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Imports of cement, by ports, during the fiscal years ending June 30, 1894, etc.—Cont'd.

Ports.	1894.		1895.		1896.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Lake.						
Buffalo Creek, N. Y	.....	.....	4,000	$46	380	$2
Cape Vincent, N. Y	76,450	$245	43,750	193	17,500	120
Champlain, N. Y	.....	.....	487,500	2,600	386,750	2,085
Chicago, Ill	998,026	3,289	6,415,582	20,311	6,940,820	22,922
Cuyahoga, Ohio	194,000	808	1,529,500	5,370	674,962	3,272
Detroit, Mich	313,300	1,420	1,018,750	4,515	2,223,625	9,861
Huron, Mich	2,700	20	.....	.....	.....	.....
Miami, Ohio	412,500	1,750	96,250	437	552,981	2,402
Oswegatchie, N. Y	3,605	27	333,005	1,457	698,375	3,243
Oswego, N. Y	74,000	400	232,050	1,044	56,250	290
Total	2,074,581	7,959	10,160,387	35,973	11,551,643	44,197
Interior.						
Vermont	5,600	26	.....	.....	37,500	165
Cincinnati, Ohio	.....	.....	.....	.....	.....	.....
Columbus, Ohio	.....	.....	.....	.....	400	15
Indianapolis, Ind	80,000	255	.....	.....	.....	.....
Kansas City, Mo	80,000	260	.....	.....	75,778	250
Louisville, Ky	200,000	618	.....	.....	66,138	293
Memphis, Tenn	.....	.....	200,000	639	.....	.....
St. Louis, Mo	14,877,677	52,997	824,496	3,133	993,915	4,039
Total	15,243,277	54,156	1,024,496	3,772	1,173,731	4,792
Grand total	1,015,133,873	3,265,087	1,059,871,593	3,409,937	1,195,838,653	3,839,756

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PRECIOUS STONES.

By George F. Kunz.

INTRODUCTION.

The most important events in connection with precious stones during 1896 are (1) the presentation of some interesting conclusions by Prof. William H. Hobbs, who attributes the origin of the Wisconsin diamonds to the Green Bay lobe, or the Pigeon River district immediately north of it; (2) the publication of the interesting results of investigations by the late Prof. H. Carvill Lewis on the genesis of the diamond, which brings forth much strong evidence of its origin from the distillation of hydrocarbons in carbonaceous shales that have been penetrated by peridotite or other volcanic intrusions;[1] (3) the finding in quantity at Yogo Gulch, Montana, of sapphires of as fine a blue as the best Ceylonese gems, although scarcely over 1 carat in size, and of three small diamonds from the same State; (4) the continued finding of the green, red, blue, and multicolored tourmalines, and a perfect crystal, 10 inches long, at Haddam Neck, Connecticut; (5) the finding of large crystallized beryls, many of them of gem value, in the feldspar quarries at Topsham, Maine; (6) the continued output of fine turquoise in the Los Cerrillos and Grant County mines of New Mexico; and (7) the visit to the United States of Prof. Henri Moisson, whose interesting lectures and experiments on the production of artificial diamonds were of the greatest scientific interest, although these gems are as yet commercially unavailable.

DIAMONDS.

An additional contribution to literature upon the occurrence of isolated crystals of diamonds in Wisconsin, by Prof. William H. Hobbs, of the University of Wisconsin, appears in an interesting article in the Neues Jahrbuch für Mineralogie, 1896, vol. 11, pp. 249–251, with map, describing four localities; and, in a letter to the writer, Professor Hobbs describes two additional localities. One stone of $6\frac{3}{8}$ carats was found at Saukville, Ozaukee County, 6 miles northwest of Milwaukee, and another of $2\frac{1}{16}$ carats at Burlington, Racine County, the latter found by Mrs. G. Pufahl, of that place. These two stones were examined by Professor Hobbs and the writer. The larger stone is a flattened,

[1] These results are published in the volume on the Genesis of the Diamond, edited by Professor Bonney, of London.

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distorted trisoctahedron; finely white in color, with two yellow stains; irregular, uneven surface, and with a deep octahedral impression on one side. It would perhaps cut to better advantage if it were cleaved, in which case it would probably produce two fine stones of over 1 carat each. The Burlington stone had a faint greenish color, which may be entirely exterior, as is the case with the diamond described from the Oregon locality. This crystal is an elongated twin, being tetrahedral in general form, and hence could be cut into a pear shape to better advantage than into a brilliant.

Professor Hobbs writes that the Saukville and the Burlington diamonds were found in the "Kettle moraine" of the Lake Michigan lobe, like the other Wisconsin diamonds referred to farther on. The Saukville stone is from the widened portion (interlobated) of the moraine between the Green Bay and the Lake Michigan lobes. The other is located on a cuspate portion of the moraine of the Lake Michigan lobe near the boundary of Illinois. These finds have considerable interest.

A diamond crystal was also found in 1886 by Mr. Louis Endlich, of Kohlsville, Washington County, Wisconsin. It was examined by Prof. William H. Hobbs, and found to be a rhombic dodecahedron of pale-yellow color, 20 millimeters in length and 13 millimeters in width, with an average thickness of 10 millimeters, and strongly resembling the stone found at Eagle, Wisconsin. The crystal is somewhat distorted. Its weight is 21 carats.

The diamonds found at Eagle, Oregon, and Kohlsville are of the same crystalline form, each having the faces of the dodecahedron showing vicinal planes of the hexakisoctahedron. The faces show also irregularities and depressed areas. The diamonds found at Eagle and Kohlsville are "Cape white," a very pale yellow; the one found at Oregon is almost white, with a faint greenish tint. In regard to their occurrence in Wisconsin, the interesting problem is readily solved on examining Professor Chamberlin's glacial map, where Eagle, Kohlsville, and Oregon are all seen to lie on the "Kettle moraine" of the later Glacial epoch. These diamonds were evidently transported from the north to the points at which they were found. If one studies from these points the ice movements as indicated by the traces of the glacier, one will readily see that these diamonds undoubtedly have a common origin, possibly in the northeastern part of the State, on the middle line of the Green Bay lobe, or perhaps in a still farther northeasterly direction. It is therefore of remarkable interest to find that along the State line, in the vicinity of the Menominee River, basic eruptive rocks are present in graphitic slates; and hence it is not improbable that the origin of the diamonds is of this character, as is the case in South Africa. The locality is one that has been little searched, and it is highly probable that diamonds may yet be found there. The diamonds of the Plum Creek district apparently differ in their source,

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although they were found only a few miles from the Kettle moraine, and may possibly have been washed out of the Menominee under the glacial action in this region; but they probably had their source in the region of the Pigeon River, where the geological conditions are identical with those observed on the Menominee.

There were recently for a time in the possession of Mr. H. Vreeslander, of New York City, three diamond crystals sent by Mr. A. F. White, of Butte, Montana, and claimed to have been found in that State. One was a trigonal trisoctahedron, $1\frac{3}{16}$ carat, with large oval markings over the entire crystal, which was of a faint yellow; one side of it was broken. The second was an octahedron of one-sixteenth carat, with rounded faces, an apparent twinning being visible on the edges; this was also a faint yellow in color. The third was an acute octahedron of one-thirty-second carat, with dulled faces, giving it a ground-glass effect, and showing a considerable growth on the octahedral faces, although the edges of the crystal were long and not so well developed. Some investigation is to be carried on at the locality.

The annual reports of the condition and production of the great South African diamond mines have been presented with extreme fullness. The leading points of general interest are summed up and included here, this being so important an element in the world's production of gems.

The following statement of the condition of the diamond-mining industry is gathered from the admirable report of Mr. Gardner F. Williams, manager of the De Beers Diamond Mining Company, Limited, and formerly of Oakland, California:

The two leading mines, the De Beers and the Kimberley, the only ones that are much worked at present, give the following statistics for the year ending June 30, 1896:

The output of "blue-ground" at the De Beers mine was 1,554,225 loads (16 cubic feet to a load); at the Kimberley mine 1,143,884 loads (together with 67,470 loads of "reef-rock" or waste); the total for both being 2,698,109 loads of blue-ground, as against 2,525,717 for the year before; an increase of 101,083 loads. The cost per load at the De Beers mine was 4s. 7.7d., as against 4s. 3.6d. the previous year; at the Kimberley mine 4s. 10.3d., as against 6s. 2.6d. the previous year. On June 30, 1895, there were in sight at the De Beers mine about 3,300,000 loads of blue-ground. As new workings have been carried down, the amount revealed between the 1,000 foot and 1,200-foot levels is estimated at 4,400,000 loads; giving a total of 7,700,000 loads. Deducting from this the output (as above) of over 1,500,000 loads, there remain fully 6,000,000 loads in sight; an amount equal to about four years' demand.

At the Kimberley mine at the close of last year some 1,800,000 loads were in sight above the 1,200-foot level; the carrying down of the "Prospect shaft" to 1,520 feet and the opening of intermediate levels

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every 40 feet have revealed about 3,300,000 loads more; making in all over 5,000,000. Deducting the output for the year of somewhat over 1,000,000 loads (as above), leaves about 4,000,000 loads now in sight; again about four years' supply at present rates of output.

At the De Beers mine the water removed amounted to an average of 3,877 gallons per hour, as against 5,231 the previous year; at the Kimberley, 7,894 gallons per hour, as against 9,882 before. A tunnel has been carried around this mine at the top of the melaphyr, to prevent surface water from getting down into the loose débris in the open mine; this has proved very successful, and no "mud-rushes" have occurred since.

The De Beers mine has not been deepened, the "rock-shaft" remaining at 1,233 feet; but a tunnel on the 1,200-foot level has been completed, and the main rock-chute from the levels above connects with it. This tunnel, 955 feet long, was driven to the northeastern side of the mine, in order to give better ventilation to that portion of the workings, and has had the desired effect. The Kimberley mine has reached the greatly increased depth of 1,585 feet on the "Prospect shaft" above mentioned, and levels have been opened in this deep portion every 40 feet.

The following table gives the amount of "blue-ground" brought up and placed for treatment:

Amount of "blue-ground" brought up and placed on the floors ready for treatment.

	De Beers.	Kimberley.	Total.
	Loads.	*Loads.*	*Loads.*
On June 30, 1895	1,974,127	725,106	2,699,233
Output for the year	1,554,225	1,143,884	2,698,109
Total	3,528,352	1,868,990	5,397,342
Washed and crushed during the year	1,565,631	1,031,395	2,597,026
Remaining June 30, 1896	1,962,721	837,595	2,800,316

A considerable amount of the material remaining on the floors is of the kind known as "hard blue," or "lumps," which does not readily disintegrate by exposure. Much of this, however, is now crushed by improved machinery.

The output from the De Beers mine has been materially reduced by scarcity of native labor and by interruption from "mud rushes" on certain of the levels, surface water getting access to the loose material and breaking into the workings.

The 2,597,000 loads of material washed and crushed during the year from the two mines yielded 2,363,000 carats of diamonds; so that the average yield has been 0.91 carat per load, as against 0.85 carat for the

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year previous. The total cost of mining and washing has averaged 7s. 0.1d. per load, as compared with 6s. 10.8d. the year before.

As diamonds are now valued at the general rate of about 30s. per carat, the proceeds, on the basis of 0.91 carat per load, would be about £1 7s., from which the cost of 7s. a load is to be deducted. The company, however, did not realize quite this amount, as they contracted with a syndicate to take the entire yield of the year at 27s. 6d. per carat. The net proceeds, therefore, as given in the report of Mr. Cecil Rhodes, are £1,900,000.

One very large diamond was obtained at the De Beers mine, on the 840-foot level, in June last. It was a pale-yellow octahedron of 503¼ carats, but somewhat flawed and cracked. In size this is the largest stone yet obtained from the mines of this district.

In his report Mr. Cecil Rhodes dwells on the financial history of the De Beers Consolidated Company since its formation in 1888. It then owed £5,000,000; its indebtedness now is £3,500,000. In the interval it has not only paid large dividends, but has bought £1,250,000 worth of consols, and has purchased the Wesselton, Gordon, Bulfontein, and Dutoitspan mines. These acquisitions, which comprise all the important mines immediately adjacent, and are now nearly complete, have been made with the profits alone, and not by any increase of capital. In the last year, out of the net profit of £1,900,000, the amount paid in dividends was £1,500,000, and the rest has been spent for expenses and the purchase of the new Gordon mine. The diamonds obtained were all taken by a syndicate at 27s. 6d. a carat, up to 200,000 carats a month. This syndicate has its branches and connections all over the world, and disposes of the diamonds at a profit. The same arrangement has been made with it to June 30, 1897, and an option extended to December 31.

A curious feature reported by a correspondent of the Jeweler's Circular, September 23, 1896, page 7, is the fact that great numbers of valuable diamonds are in the possession of native African chiefs, often far remote from the mines. These were accumulated in former years, when supervision was less thorough and the native laborers had large opportunities for theft. Many were sold to the "I. D. Bs." (illicit diamond buyers) on the spot, but many also were retained and taken home by the men on their return to their tribes; and these for the most part went into the hands of the negro chiefs. Indeed, it was often made a condition by a chief that anyone of his people who went to work in the mines should bring him back a diamond as a present; and this condition was enforced by severe punishment, or even death, in case of failure. As a consequence, many of the chiefs obtained numbers of fine stones, which they treasure more as charms or talismans than for their commercial value, of which they had little knowledge. Of late some enterprising parties have made long journeys into the uncivilized regions, with no little risk and hardship, to endeavor

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to procure some of these diamonds by barter. In some cases the chiefs refuse to sell at all; in others they demand impossible prices; but some have been obtained, chiefly for liquor, and especially for guns. One trader thus procured six diamonds of more than 200 carats each; and a small company has secured in four months diamonds worth £35,000 at the mines.

In the Bingara diamond field, according to the report for 1895 of the department of mines and agriculture of New South Wales, some work is going on steadily, and the new locality, Boggy Camp, has attracted a good deal of attention. Some 300 acres of diamantiferous "ground" had been taken up here, and several parties were actively operating. Only two of these had obtained important results up to the end of 1895, one having taken about 3,000 stones from the washings, and the other 1,100. The total value of these is about £400. They are not large, averaging about three to a carat, though a few have been found of greater size, up to 2 carats. For these rather small diamonds there is not very much demand, and as the deposits have been known and worked more or less for some years, it does not seem likely that they contain many large stones or can become important factors in the world's diamond supply. The stones are washed from a pebbly drift, overlain by basalt, and resting upon granite; the drift also yields some tin ore. There seems to be a large development in New South Wales of a condition similar to that of the "sublava" gravels of California, old river channels filled by igneous outflows, and yielding gold, platinum, and here diamonds, being described in various parts of the colonial report. Comparing the conditions with those of South Africa, the Government geologist, Professor Putnam, states that the area occupied by the diamond-bearing river drift is quite extensive, and he believes that the source of the diamonds will, in time, be traced to volcanic "pipes," as at Kimberley, but that the area is so largely covered by the basaltic flows that the pipes are concealed from observation.

To those interested in the use of the diamond for industrial purposes the following fact may be of interest:

In reference to bort, which is extensively used for slicing, engraving, and polishing, a case has recently come up in the New York custom-house from which it appears that this name, or that of diamond dust, is to some extent used commercially for a polishing powder composed of lime and silica. A New York firm imported some of this material under a name which was translated "polishing powder" in the invoice, and then objected to paying the 2 per cent duty upon it, on the ground that it should be admitted free, as diamond dust or bort. Analysis showed its composition, but the importer testified that it was commercially known as bort or diamond dust. The decision was, that even were this the case, the provision for free admission was intended only for the real bort, and should not cover other substances that might be merely so called—presumably for the purpose of evading the duty.

In the report of the department of mines and agriculture of New

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South Wales for 1895 is a valuable report upon diamond drills, their use, results, and cost. The department has a superintendent of diamond drills, Mr. W. H. J. Slee, under whose direction drills are rented and operated, and who presents and tabulates the year's work. In 1895 the entire depth bored was 299 feet, scarcely more than half that in the year previous. The total cost for boring was somewhat reduced, being $7.34 instead of $8.73 per foot. The amount of diamonds used, however, was very much greater, their value being 90 cents per foot, as against 18 cents per foot the year previous—a result due to great hardness in the rock bored. The average rate of boring was 9.34 inches per hour; most of it a 4-inch bore through porphyry, in the gold mines at Captains Flat.

A writer in the Engineering and Mining Journal gives a description of a simple outfit for a miner or prospector looking for diamonds in placer beds. After classifying the gold and diamond placers of Brazil and California under three groups, as (1) surface and ravine diggings (the "dry diggings" of the first African discoveries), (2) river beds, either at low water or exposed by artificial diversion (the "river diggings" of Africa), and (3) ancient river beds, covered by volcanic outflows or otherwise no longer occupied by streams, he recommends to the diamond seeker the following outfit: A light pick, a shovel, a "miner's wallet," or long bag for carrying the gravel, etc., to water (size 4 feet 8 inches long by a foot and a half across), and two screens or "riddles" with meshes of three-fourths and one-eighth inch, respectively, together with a tub for washing, easily made by cutting a barrel in half, or else a rubber bath tub, and a sheet of rubber cloth to sort the washed gravel upon. To examine it he should have a watchmaker's lens (two powers) and a hardness scale, made by fixing a chip of diamond, one of corundum, and one of quartz, with lapidary's cement, into the end of a piece of glass tubing or of a pencil from which the rubber has been removed. The lapidary's cement melts easily over a spirit lamp, may then be easily molded with the fingers, and becomes very hard and firm.

To examine for diamonds, the coarse riddle is fastened above the fine one, the gravel put into the upper one, and all immersed in the tub and washed and shaken. The coarse stones are retained in the upper riddle, and the sand and earth pass through both into the tub, leaving all the finer gravel in the lower riddle. This latter is detached from the other, and its contents are again washed and shaken, till the heavier portions have settled at the bottom; it is then quickly turned out on the rubber sorting cloth, which should be spread close by. The heavier stones will then be on the top, and may be examined with the lens and the hardness scale.

The writer of the article states that he has had much experience in the Brazilian placers, and believes that such simple directions will have value, as there are frequent inquiries from miners and prospectors, and very little definite information is to be found in published authorities.

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To the above-described outfit may be added a simple silver, iron, or bronze ring, with a natural octahedron of diamond brazed in it for a hardness test; also some sheets of emery paper, or paper coated with carborundum, so that when a stone is found that resembles a diamond, if it be rubbed for a few moments on the paper and any visible mark be made on it, one can be sure that it is not a diamond.

During 1896 a long trial was conducted in the United States circuit court to determine whether or not certain firms had violated the contract-labor laws by bringing in diamond cutters and polishers. It was decided in the negative. During this trial a large amount of valuable testimony bearing on the history of diamond cutting in the United States was taken, nearly everyone who had ever engaged in this industry being called upon to testify.

The remarkable discovery of Prof. Henri Moisson, of the Institute of France, alluded to in the last report (page 904), of a method for producing diamonds artificially by the rapid cooling of highly carbonized iron from fusion at very high temperatures, whereby the exterior is solidified, and the interior thus becomes subject to an enormous pressure, has not led to any commercial results, as the diamond crystals thus obtained are extremely minute. But it has great scientific interest and has been drawn into relation also with the occurrence of diamond carbon in meteorites. At the reception tendered him October 27, 1896, by the united scientific societies of New York, Professor Moisson performed his classic experiment of producing artificial diamonds by the method described in the last report. He was successful, and at the time stated that he had performed the experiment 300 times without failure, but that not more than one-half of a carat of diamond was produced by the 300 experiments.

Professor Rossel, of the University of Berne, has undertaken an inquiry as to the possible presence of diamond carbon in very hard steels, and in some extremely tough varieties of iron from the bottom of blast furnaces, where the pressure is very great. The result has proved the correctness of this suggestion, as Professor Rossel has obtained from such sources minute particles having octahedral crystallization and presenting all the physical properties of diamond. The largest of these do not exceed half a millimeter in diameter, but they suggest the possibility of more important results in the course of future experiment.[1]

Among various fraudulent schemes resorted to for the purpose of deceiving the public regarding diamonds, a notably ingenious one has been exposed during the past year. Certain parties operating in Philadelphia as a center, and claiming to have branches in New York and other cities, by large signs and extensive advertisements in the papers, announced extraordinary opportunities for procuring genuine diamonds at $1 each, and had a display window filled with the supposed gems in

[1] Journal Officiel Illustré de l'Exposition Nationale Suisse. 1896.

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showy settings. Every tenth stone was to be a real diamond; the rest were announced as "genuine white topaz, impossible to detect from diamond." Experts were "defied to distinguish them," etc. The Pennsylvania Retail Jewelers' Association, through its officers, undertook an investigation and laid the facts before the district attorney as a fraudulent lottery. The "white topaz diamond" proved to be cheap paste, and the settings to be 5-carat gold only. As to the one-tenth of true diamonds no evidence was obtained, and their existence was highly uncertain. Proceedings have also been begun against the same party for similar practices in Cleveland and Providence, the claims aggregating over $12,000. This system of deception has been set on foot in nearly every large city in the United States.

GENESIS OF THE DIAMOND.

There has recently been published a volume of small size, but of especial interest and importance, in regard to the origin of diamonds. This is none other than the posthumous issue of the full papers of the late Prof. H. Carvill Lewis, edited by his friend, Prof. T. G. Bonney, of London.[1] It will be remembered that Professor Lewis was the first to present a clear and definite theory of the origin of the South African diamonds, as resulting from the intrusion of igneous rocks into and through carbonaceous shales, and the crystallization of the carbon throughout the rock as it cooled, from hydrocarbons distilled from the shale that had been broken through. These views, now for the most part accepted, and subsequently confirmed by other and very interesting parallel discoveries, he presented in two papers read before the British Association for the Advancement of Science at its meetings held in 1886, at Birmingham, and in 1887, at Manchester. Before he was able, however, to prepare them for publication and carry them to the greater completeness that he desired, Professor Lewis succumbed to an attack of typhoid fever, which removed one of the most brilliant and capable of the rising scientists of this country. Agreeably to his expressed wishes, his material was intrusted to his friend and colaborer, Prof. George H. Williams, of Johns Hopkins University; but by a strange fatality, before the latter had time to arrange and edit these papers, he too fell a victim to the same disease in 1894. The work was then committed to Professor Bonney and is at last given to the scientific world.

The book consists of an introductory note by Mrs. Lewis; a preface by Professor Bonney; the two papers of Professor Lewis himself, with some later notes and references by the editor; a brief account of similar material from other localities, belonging to Professor Lewis, also by

[1] Papers and Notes on the Genesis and Matrix of the Diamond, by the late Henry Carvill Lewis, M. A., F. G. S., professor of mineralogy in the Academy of Natural Sciences, Philadelphia, professor of geology in Haverford College, U. S. A. Edited from his unpublished MSS. by Prof. T. G. Bonney, D. Sc., LL. D. F. R. S., etc. Longmans, Green & Co., London and Bombay, 1897. Pages xvi, 72. 2 plates.

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the editor; a closing note on some other manuscripts of Professor Lewis, and a full index. There are also two plates and a number of smaller illustrations, the latter from Professor Lewis's own drawings.

The first paper, "On a diamond-bearing peridotite and on the history of the diamond" (1886), is brief, dealing with the general character and occurrence of the diamantiferous rock at Kimberley and outlining Professor Lewis's theory.

The second paper, "The matrix of the diamond" (1887), is more extended, and goes into an exhaustive discussion and comparison of the various aspects, contents, and alterations of the rock, which he finds to be different from any previously described, and therefore proposes for it the name kimberlite. Its main character is that of a highly basic porphyritic peridotite, filled with olivine crystals and grains, more or less altered, and various other minerals, serpentine, tremolite, etc., with bronzite, rutile, perofskite, pyrope garnets, micaceous minerals, and other forms, and at times brecciated in structure, filled with fragments of carbonaceous shale brought up from below. The shales are of Triassic age, the "Karoo beds" of that region, and the intrusion of the peridotite in the great "pipes" or chimneys that constitute the mines is therefore proved to be of a later, though not exactly determined period.

The question has sometimes been raised whether the diamonds themselves may not have been carried up from a deeper source in rock below, instead of originating in the peridotite, and the occurrence of broken crystals has been cited in support of this view. Professor Lewis, however, disposes very completely of this idea in two ways: He refers to the well-known fact that each of the great mines or "pipes" yields diamonds that have, in some respects, a type or character peculiar to that one and different from the others; so that African experts, and even those who have never been there, can recognize from which mine any diamond has come. Further, as to the broken crystals, he shows that breakage not unfrequently occurs after the diamonds are removed from the rock, and points out that this is a result of strain in their formation, as indicated by microscopical and optical examination, and that such a condition is known to produce ruptures and explosions in other minerals. It may be added here, although Professor Lewis does not speak of it, that many crystals must be broken in the blasting of the rock, the shoveling and carting of the loosened material, and the various mechanical processes employed at the mines, and that pieces of such broken crystals would be separated and scattered to various parts of the dumping floors, never to be recognized as fragments of the same one when finally recovered perhaps at very different times.

The rock itself is a dark green compact material, resembling serpentine, and containing a large proportion of olivine in grains and crystals; several green minerals that, from the resemblance of their color, are not conspicuous from the ground mass (enstatite, chrome-diopside,

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smaragdite, and bastite); a mica, probably biotite, more conspicuous and quite abundant, and frequent grains of pyrope garnet, sometimes of gem quality and iniscalled "Cape rubies." Of smaller disseminated minerals are to be noted perofskite, quite frequent, and magnetite, chromite, ilmenite, and picotite, less so, though common. Rare and minute occurrences are apatite, epidote, orthite, tremolite, tourmaline, rutile, sphene, and leucoxene. As decomposition products there are serpentine and calcite, abundant, and zeolites, chalcedony, and talc, also cyanite (?). These, with the diamonds and the included fragments of carbonaceous shale, make up the contents of this remarkable rock.

Professor Lewis then goes into a detailed account of the mode of occurrence of these minerals, beginning with the most conspicuous species—the olivine—which is remarkable for its fine cleavage surfaces and very interesting in its alterations. These are chiefly (1) into serpentine, proceeding from without inward, and penetrating along crevices and fractures, also sometimes in the form of chrysotile, producing a velvety border or coating to the grain; (2) tremolite, more internal, the fibrous structure developing parallel to the vertical axis and domes of the olivine crystals; (3) when both these alterations are present and have gone so far as to obliterate most or all of the olivine, a talc-like substance intervenes between them, in which are developed minute needles of rutile, arranged parallel to the faces of the olivine crystal. The rock contains every stage of these changes, from pure bright unaltered olivine to those forms that have borders of serpentine or chrysotile, or incipient tremolite fibers within, to the complete alteration just described. The relation of all these to similar phenomena in other rocks and in meteorites is discussed with much fullness.

Professor Lewis then takes up the smaragdite, chrome-diopside, bastite, and enstatite (or bronzite, for it is just on the line between the two varieties). The two first named are, in some cases, fine enough in color and clearness to yield gems, and also sometimes the bronzite. All are colored by chromium. The diopside occasionally gives rise to calcite by alteration.

The mica is next considered. As all who are familiar with the rock are aware, it is the most prominent of the contained minerals to the eye. It is somewhat anomalous in character, being chemically a biotite, but optically nearer to phlogopite. It occurs in several distinct ways: (1) as included crystalline masses or plates, apparently an original ingredient of the rock; (2) surrounding grains of pyrope; (3) rarely as a result of the alteration of enstatite; and (4) as a metamorphic product from the included fragments of shale; and the first form has produced, by hydration, the vermiculite variety called vaalite, which occurs freely in the decomposed peridotite so largely known as the "blue ground."

After referring to the pyrope garnets, and suggesting that the various garnetiferous serpentines are doubtless derived from the decomposition of similar peridotites, as further indicated by their likewise

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containing olivine, bronzite, chrome-diopside, etc., the author mentions another variety of garnets as found in this rock, very small, very brilliant, very hard, colorless or greenish, and extremely difficult to distinguish from small diamonds. These he is inclined to refer to demantoid.

The remark is made that while perofskite is familiar in various nonfeldspathic igneous rocks, it has not been found in peridotite until Professor Williams recognized it in the peculiar rock from Syracuse, New York, and that later Professor Lewis identified it in the similar rock from Isoms Creek, Kentucky, where it had been previously regarded as anatase. These three rocks—those just named and the African—are the only known occurrences of what is here named kimberlite.

After going into some particulars as to the minor minerals found in this rock, Professor Lewis then takes up the base or ground mass and discusses it minutely. He terms it "a more or less homogeneous serpentinous mass," very difficult to study by reason of its decomposed condition, consisting now of a mixture of serpentine with calcite and some other products of alteration, the original structure being wholly lost.

Fragmental inclosures are frequent, "both of the adjoining shale and diabase, and also of more deeply seated granite, gneiss, eclogite, and other related rocks." Of these the shale predominates, sometimes making the rock a breccia. The shale itself is highly charged with carbon, so as to be quite combustible; but the included fragments are altered, having lost their carbon and become harder, sometimes even metamorphosed to a micaceous structure, as before referred to. In size they vary from large masses, in the upper part of the mines, called by the workers "floating-reef," to small fragments, diminishing in number and size in descending.

The author goes into a detailed petrographical and chemical discussion as to the original character of the rock, in which it is hardly possible to follow him in a review, and finding no known rock that presents identical characters, he proposes for it the name kimberlite. This he designates as "a porphyritic volcanic peridotite of basaltic structure," and notes three forms of its occurrence: (1) kimberlite proper, a typical porphyritic lava; (2) kimberlite breccia, the same rock broken and crushed by volcanic movements and crowded with included fragments of shale; (3) kimberlite tuff, the fragmental and tufaceous portion of the same rock. These varieties graduate into one another, and all occur together in the same neck or crater, the second, however, being most abundant and most productive of diamonds.

He treats of the origin of the brecciated structure, which has caused much discussion, some geologists regarding the whole rock as a sort of tufa or volcanic mud, while others hold that it is a true outpouring lava that has carried up fragments of the rocks broken through in its course, and has since been largely decomposed. Professor Lewis urges the latter theory strongly and supports it by many arguments, while the

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editor, Professor Bonney, evidently inclines to the other view, advocated by Prof. W. H. Huddlestone in 1885, and by some others. There is not space here to review Professor Lewis's several arguments for the true igneous character of kimberlite and against the tufaceous theory. The one to which Professor Bonney accords chief importance is the identity of the rock with that from Syracuse, New York, and Elliott County, Kentucky, where it occurs in actual dikes, such as are not found in tufas. The brecciated character which is so marked is referred by Professor Lewis to three causes, acting either separately or perhaps together. These are (1) rapid cooling and shrinkage; (2) "friction brecciation," from contact with the wall-rock, and (3) subsequent movements and explosions in the crater itself, below. He illustrates and parallels the first of these from meteorites, to some of which this rock bears marked resemblance both in structure and in contents, and the others from well-known occurrences in terrestrial volcanic rocks.

The third section of the volume is occupied with a detailed account, from specimens and notes of Professor Lewis, of the two other known occurrences of kimberlite, at Syracuse, New York, and Willard, Kentucky. The identity of these with the African rock, in almost all particulars, is remarkable, and as they form definite eruptive dikes Professor Lewis's views as to the latter are strongly confirmed.

It remains only to call attention to other and later facts which tend to bear out the views presented in this remarkable posthumous article.

The presence of a residual hydrocarbon in the rock of the African diamond mines was shown by an interesting and important observation of Sir Henry E. Roscoe,[1] which is alluded to by Professor Lewis in his second paper and has frequently been cited in discussions of the subject. He found that the "blue ground," on treatment with hot water, yielded an aromatic hydrocarbon, which he was able to separate by digesting the blue ground with ether and evaporating the solution. It then appeared as a crystalline aromatic solid, burning with a smoky flame (showing it rich in carbon), volatile, and melting at 50° C.

The bearing of this fact on Professor Lewis's theory is clear. He holds that the igneous rock, breaking through the highly carbonaceous Karoo shales (37.5 per cent of carbon,)[2] became charged with volatilized hydrocarbons distilled from the shale, and that in cooling these had crystallized, partly into diamonds and partly into the many carbonadoes, larger and smaller, which are distributed through the rock. Professor Roscoe's material strongly confirms this theory, which indeed he himself propounded.

Daubrée's discussion of the analogy of the occurrence of diamond in meteorites and in the South African kimberlite appeared in the Comptes Rendus, 1890, pp. 110–118.

On September 22, 1886, a meteorite fell at Novo Urei, in the province

[1] Proc. Lit. Philos. Soc. Manchester, Vol. XXIV. 1885, p. 5.

[2] J. E. Whitfield, analyst; see Gems and Precious Stones of North America, by G. F. Kunz, 1889, p. 33.

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of Pensa, Russia, which was found to contain about 1 per cent of diamond carbon in the form of gray particles.

In 1887 Mr. Fletcher[1] described the new mineral, cliftonite, a black substance with a hardness of 2.5 and a density of 2.12, occurring in cubes with faces of the dodecahedron or tetrahexahedron in the meteorite of Youndegin, West Australia. This suggested a graphitic alteration of diamond, a view taken by Brezina[2] regarding this new species and certain graphitic crystals of cubic type observed long before in the Arva meteorite and regarded as pseudomorphs after pyrite by Haidinger,[3] but later by Rose as after diamond.[4] Similar crystals were also known in the Sevier iron of Cocke County, Tennessee.

In 1891 the discovery of diamond, or at least of diamond carbon, in some quantity in the meteoric iron of Cañon Diablo, Arizona, was announced by the late Prof. A. E. Foote[5] and Dr. George A. Koenig. In July, 1892,[6] Dr. O. W. Huntington gave further experiments on the same material, confirming the determination of Professors Foote and Koenig; and in December of the same year similar results were published by Mr. M. C. Friedel.[7] A crucial test was then proposed by the author and carried out in the presence of Dr. Huntington at the World's Fair at Chicago, September 11, 1893, namely, the cutting of polished faces on pieces of diamond with some of the carbon powder from the cavities of the Cañon Diablo meteorite.[8]

In the meantime Prof. Henri Moisson, of Paris, had been making his now celebrated experiments on the artificial production of diamonds from the cooling, under extreme pressure, of highly carbonized iron fused in a specially constructed electric furnace.[9]

All these facts, taken together, form a remarkable series of confirmatory evidence for the views advocated by our late countryman in regard to the production of this most precious of gems, the origin of which has been so obscure a problem in mineralogy and geology. Another point of great scientific interest developed in the course of these investigations is the close similarity, both in composition and in structure, existing between some of these rarer igneous rocks of our globe and the extra-terrestrial visitants that come to us from space.

It is a matter for national pride that this remarkable investigation should have been made by an American scientist; and a deep debt of gratitude is due both to the English editor, Professor Bonney, for this labor of love alike to science and to a deceased friend, and to Mrs. Lewis, who has so carefully sought to preserve and to make public these papers of her brilliant and lamented husband.

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[1] Mineralogical Magazine, Vol. VII, p. 121.
[2] Ann. Mus. Wien, Vol. IV, 1889, p. 102.
[3] Poggendorff, Annalen, Vol. LXVII, 1846, p. 437.
[4] Beschr. Meteor., 1864, p. 40.
[5] Am. Jour. Sci., 3d series, Vol. XLII, 1891, pp. 413–417.
[6] Science, p. 15.
[7] Bull. Soc. Française de Minéralogie, No. 9, p. 258.
[8] Am. Jour. Sci., Dec., 1893, 3d series, Vol. XLVI, and Mineral Resources for 1893, pp. 683–685.
[9] Mineral Resources, 1895, pp. 903, 904.

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RUBY.

NORTH CAROLINA.

Concerning the discovery of true rubies in the Cowee Valley, in Macon County, North Carolina (first noticed in Mineral Resources for 1893, p. 693; more fully in that report for 1894, p. 599, and again last year, p. 905), it is of interest to state that this locality has lately been visited and examined by the eminent authority, Mr. C. Barrington Brown, whose joint article with Professor Judd[1] on the ruby mines of Burma was reviewed in this report for last year.[2] The results of this investigation are to be presented to the Royal Society of London in a similar article by the same two eminent authorities, and it is hoped that it may be published in time to embody the main features of it in the next issue of this report.

At present all that can be stated as to Mr. Brown's conclusions is that the manner of occurrence of the rubies here is claimed to be new to science, and to have important bearings upon the genesis of the Burmese gems.

Prospecting has been extended for over 3 miles up and down the Cowee Valley, and the "bottom" and "hillside" gravels have been shown to be ruby-bearing throughout. At one point near the head of the valley the gems have been found in situ, and prospecting is in progress to determine the nature and extent of this occurrence.

Associated with the rubies are found various minerals, notably some very beautiful almandine garnets, which yield cut gems of remarkable brilliancy and color. There are also found gray, blue, and magenta corundum, and small quantities of gold, sperrylite (platinum arsenide), monazite, zircon, and rutile.

The best ruby crystal thus far obtained here weighs about 6½ carats, and is claimed to be of fine quality. It has not yet been cut, however, and its gem value can not definitely be determined. It is believed by those engaged in developing this locality that a veritable ruby-bearing district, similar to that of Burma, has at last been discovered in North Carolina, but under conditions unexpected and novel in character.

BURMA.

In a paper recently presented before the Institution of Mining and Metallurgy of London, Mr. T. Trafford Wynne has given very full accounts of the history and methods of mining in the ruby district of Burma, in the Mogok Valley. Much of his description, though with some little variation of detail, is substantially identical with that given in the report of Messrs. Brown and Judd, referred to above. He describes the three native methods in much the same way: The "Twinlones," or

[1] Philos. Trans. Royal Soc. London, Vol. CLXXXVII, 1896, pp. 152–228.
[2] Seventeenth Ann. Rept. U. S. Geol. Survey. Part III (Mineral Resources), 1896, pp. 905–906.

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"Twins," pits dug in alluvial deposits down to the gem gravel, for which he uses the native name *Byon;* the "Hmyaws" (hmyaudwins of Brown and Judd), a sort of hydraulic mining of the hill wash, or alluvium along the hillsides; and the "Loos" or "Loo-twins," i. e., cave mines, where the gems are gathered from fissures and cavities in the limestone rock. The chief points in which Mr. Wynne's account varies from the other are in the statement that the alluvium has been subjected to a sort of natural riffling process, by ridges of rock crossing the valleys, over which the lighter and finer material has been carried, while the coarser and heavier, containing the gems, has been retained above them; and in his account of the Hmyaw-twins, or "Water-mines," wherein he states that the cutting down of the banks is done by hand and the water allowed to fall from as great a height as possible upon loosened masses of clay and gravel, carrying the disintegrated material into boarded channels, where it is stirred with hoes, etc., and the heavy "Byon" caught in a box at the lower end, and the light mud washed away. The "Byon" is then picked over by hand.

He adds that this form of mining is chiefly in the hands of the headmen of the villages, as there is considerable expense to be met in making ditches and bamboo flumes, etc., before profits can be realized.

Mr. Wynne then goes on to give later accounts of the introduction of European methods. The English company that now holds the mining rights from the Government made various attempts with little result for some time, but finally established a successful experiment in working at the lower end of the Tagoungnandine Valley. Here there was available a 100-foot head of water power. This was employed to drive a 4-foot Pelton wheel pump at the mining pit. As it was found to work successfully, the same method is being extended into the main valley of the Mogok. Another process is also employed at one point—that of tunneling through the rock barrier that obstructs the drainage of the valley and causes it to hold so much water in the soil. The tunnel was 10 by 10 feet and 500 feet long, and drained the valley to a depth of 40 feet; a washing plant was erected there, driven by water power. The total cost of excavating, hauling, washing, and sorting for a load of 15 cubic feet is a little over half a rupee. This method, of course, is available only in the smaller valleys, where the rock barrier is narrow.

This same paper and various other recent references mention the discovery of a ruby district at a point known as Nanyaseik, some 60 miles northwest of Mogoung, where fine gems are reported to occur through a considerable area. No very definite accounts of this region are yet attainable, but some parties connected with the Burma ruby mines have visited it and report that it is likely to prove a serious rival to Mogok.

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SAPPHIRE.

MONTANA.

The existence of sapphire in the State of Montana has been known for some years past, and has attracted considerable attention. Several localities are now known, and several distinct modes of occurrence. They were first found in transported gravels along the bars of the upper Missouri; then they have been found in the earthy product of decomposed dikes, and lastly farther down in the unaltered igneous rock itself, the succession thus presenting a close parallel to the history of the diamond workings in South Africa.

The first published description of the Montana sapphires was by the late Dr. J. Lawrence Smith.[1] He said:

> These pebbles are found on the Missouri River near its source, about 61 miles above Benton. They are obtained from bars on the river, of which there are some four or five within a few miles of each other. Considerable gold is found on these bars, it having been brought down the river and lodged there, and the bars are now being worked for gold. The corundum is scattered through the gravel (which is about 5 feet deep) upon the rock bed. Occasionally it is found in the gravel and upon the rock bed in the gulches, from 40 to 50 feet below the surface, but it is very rare in such localities.

A fuller account of the conditions and yield was given by the author in his volume on Gems and Precious Stones of North America, published in 1890 (pp. 48–49). He subsequently visited the locality and examined it carefully, publishing the results in the appendix to the same work (pp. 340–342).

In 1891 the first serious attention began to be paid to the mining of sapphires in this district. The bars consist of an auriferous glacial gravel, and in working them for gold, sapphires were obtained as a by product. By 1890 companies began to be formed and claims taken up and examined with a view to sapphire mining. The region extends for some 6 miles along the Missouri River, the central point being Spokane Bar, 12 miles east of Helena. Other names, such as Emerald Bar, Ruby Bar, French Bar, Eldorado Bar, etc., were given to different points of the area. The gravel rests on a slaty bed rock and contains a variety of minerals besides gold and sapphires—small crystals of white topaz; garnets in rounded grains, often of rich color and miscalled rubies; cyanite; stream tin; chalcedony; limonite pseudomorphs after pyrite nodules, etc. At Ruby Bar two facts of great significance were encountered bearing on the age of the gravel and the source of the gems. The writer saw and measured a mastodon tusk 3 feet long, embedded in the sapphire layer of the gravel; and a dike was found cutting the slaty bed rock beneath, in which were crystals of sapphire, pyrope, and sanidin. All these facts were described by the writer,[2] together with an

[1] Am. Jour. Sci., Sept., 1873, 3d series, Vol. VI, p. 185.
[2] Mineralogical Magazine, London, Vol. IX, 1891, p. 396.

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account of the rock, by Mr. H. A. Miers,[1] who characterized it as a "vesicular mica-augite-andesite," abounding in brown mica and porphyritic crystals of augite, with a ground mass of feldspar microlites and brown glassy interstitial matter, with magnetite.

Two years before, indeed (in 1889), the writer had seen some specimens of a trachytic rock, inclosing well-defined crystals of sapphire similar to those of Eldorado Bar, from a dike somewhat farther up the river. These facts, which were referred to in Gems and Precious Stones of North America (p. 49), and the appendix (p. 341), sufficiently showed the source of the gems as coming from the erosion of dikes of igneous rock.

More recently sapphires have been found throughout a considerable district lying some 75 to 100 miles east of the Missouri bars, the principal point being Yogo Gulch, on the Yogo Fork of Judith River, near its headwaters, in Fergus County, Montana, on the eastern slope of the Little Belt Mountains. The nearest town is Utica, 15 miles to the northwest, in the same county. The sapphires occur over a somewhat extended area, which is being explored and laid out in claims. They are embedded in a yellow earthy material, from which they may be washed out by sluicing, as for gold, the heavy crystals gathering at the bottom. Mr. S. S. Hobson, of Great Falls, Montana, the original discoverer of the gems at Yogo Gulch, states that there are at that point two dikes containing sapphires, which have been traced for a distance of 7,500 to 8,000 feet in an east-west course, about 800 feet apart. One of these is 75 feet wide, and consists of "yellow earth" (i. e., is completely decomposed). It has been found that what was supposed to be the end of the "vein" is really a 50-foot fault, and that the vein can be traced very much farther. In working down to a greater depth the unaltered igneous rock has been reached. These Yogo Gulch sapphires have been referred to by the writer in the Sixteenth and Seventeenth Annual Reports of the United States Geological Survey.

Other localities are also coming to light in the same State. One of these is at Rock Creek, Granite County, 30 miles from Phillipsburg, where the gems are reported of good blue color, with other tints, and some pale rubies; another is on Cottonwood Creek, 18 miles from Deer Lodge, the stones being of varied colors—red, pink, yellow, and occasionally blue; the third has been recently announced in Choteau County.

As regards the gems themselves, marked differences appear in those from the two principal Montana regions. All are of small size, but the crystallization differs markedly. Those from the Missouri gravels are characterized by the presence of the prismatic faces, with the basal plane, and rarely any of the rhombohedral modifications, the prevailing forms being hexagonal, either prismatic or so short as to be tabular.

A beautiful example of this type is figured in Gems and Precious Stones of North America, colored Pl. I, Fig. C. The specimens from the minor localities have generally a similar type of form. The Yogo Gulch

[1] Loc. cit.

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crystals, on the other hand, are largely rhombohedral, with the basal plane more or less present, but the prismatic and pyramidal faces hardly at all. The rhombohedral *X*, which is prominent in these crystrals, as shown in figures and descriptions by Mr. J. H. Pratt,[1] has the remarkable interest of being new to this species. Other very noticeable features, which the writer was the first to observe and point out, are the striations on the basal plane parallel to its intersections with the rhombohedron, and sometimes rising into steps as the oscillation becomes a replacement, as well shown in Mr. Pratt's figures, and the singular depressions on the basal plane in other crystals, their sides being formed by faces of the inverse rhombohedron, sometimes meeting in a point and at other times truncated and floored by a basal plane.

We have here two distinct types of crystallization in the same mineral from the same State, and produced apparently under similar conditions in igneous rocks. It will be extremely interesting to learn by further exploitation and study whether these two types bear any fixed or definite relation to the particular variety of eruptive rock in which they occur. The accounts thus far given of the rocks examined seem to suggest such a possibility.

A petrographical description of the Yogo Gulch rock will be given by Prof. L. V. Pirsson, of Yale University, in the American Journal of Science.

He regards the rock as a dark basic lamprophyre, consisting mainly of biotite and pyroxene, having its closest affinities with the monchiquite group, of which he considers it a basic unaltered type. It is much richer in the ferromagnesian components, while lacking the feldspars of the minette group, though it has some relations with them and with the "shonkinites," before described, from this region.[2]

Professor Pirsson regards this occurrence as an important addition to our knowledge concerning pyrogenetic corundums. He holds that the clear-cut forms of the crystals, and also their general distribution, prove them to have been crystallized out of the magma as definitely as the well-formed phenocrysts of feldspar in a porphyry disclose their origin. Their form and occurrence, moreover, agree with the important experiments and conclusions of Lagorio,[3] viz, that corundums originating in an igneous rock form flat hexagonal tables with low rhombohedra, and also correspond to the experiments of Morozcewicz,[4] which showed that molten glass of a basic character dissolves alumina in considerable quantity, and that on cooling crystals of corundum and spinel separate out.

As to the value of the Montana sapphires in jewelry, it is hardly possible yet to predict how far they may be really important. Much beautiful material has already been obtained, but little of high value.

[1] A paper to appear in Am. Jour. Sci. for September, 1897.
[2] Am. Jour. Sci., 3d series, Vol. L, 1895, p. 467.
[3] Zeitsch. für Krystallographie, Vol. XXIV, 1895, p. 281.
[4] Ibid.

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Those from the Missouri bars had a wide range of color—light blue, blue-green, green, and pink—of great delicacy and brilliancy, but not the deep shades of blue and red, that are in demand for fine jewelry. As semiprecious or "fancy" stones, however, they have value.

The Judith River region is more promising, the colors varying from light blue to quite dark blue, including some of the true "cornflower" tint so much prized in the sapphires of Ceylon. Others incline to amethystine and almost ruby shades. Some of them are "peacock blue" and some dichroic, showing a deeper tint in one direction than in another; and some of the "cornflower" gems are equal to any of the Ceylonese, which they strongly resemble, more than they do those of Cashmere. Several thousand carats were taken out in 1895 from a preliminary washing of 100 loads of the "earth." Of these, 200 carats were of gem quality, and yielded, when cut, 60 carats of fine stones, worth from $2 to $15 a carat. All, however, are small, none having yet been obtained of more than 1½ carats in weight.

Mr. T. E. Crutcher, of Helena, Montana, reports that sapphires have been found in some abundance and of good size and quality in the northeastern part of Choteau County, and that a number of claims have been located. The character of the stones found is similar to that of the sapphires from the bars of the Missouri.

Small ruby corundums are reported by Mr. H. H. Rusby, of Gallinas Spring, New Mexico, to have been found in San Miguel County, but no particulars are given as to their quality or mode of occurrence. A single specimen of ruby corundum is mentioned by Mr. E. C. Blackney, of Custer, South Dakota, as having been found near that place. The occurrence of crystals of ruby-red corundum in hornblende slates in the Lower Gem mines, Towns County, Georgia, is reported by Mr. Fererето S. Ropes, of Franklin, North Carolina.

BURMA.

Over the signature of F. C. Gates, revenue secretary, there were published at Rangoon, Burma, on November 4, 1895, the printed rules concerning the mining for rubies and other precious stones in the Upper Burma ruby district. These are given to the various workers, and treat of the cutting of stones, the buying, selling, and transportation of them, and supplementary rules and lists. Gems are worked for in the north, south, east, and west of the Sangyin region, and during the last five years the work has been carried on more especially in the Mandalay district, which covers about 500 acres.

Dr. Max Bauer, of the University of Marburg, in Hesse, presents an admirable paper on the occurrence of ruby in Burma in the Separat-Abdruck aus dem Neuen Jahrbuch für Mineralogie, Geologie, und Palaeontologie, Jahrg. 1896, vol. 11, pp. 197–238, with one plate. This article exhaustively describes the occurrence of ruby, spinel, and the associated minerals in that country.

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BERYL AND EMERALD.

During the past year many fine crystals of beryl of gem value have been found at Topsham, Maine, one a crystal 12 inches long and 2 inches in diameter.

Dr. A. Bibbins, of Baltimore, Maryland, reports transparent beryl found at H. H. Wright's quarry, Hampden, Baltimore County, occurring in pegmatite, with hornblende, associated with almandine garnets. Occasionally one would pass for a gem.

Mr. J. L. Rorison, Bakersville, North Carolina, has found some very good specimens of emerald crystals, quite dark in color on the outer edge, with white or very light interiors, thus resembling the crystals found at Arendal in Norway. Work was carried only to a depth of 6 feet, and nothing of gem value was found, but the specimens were interesting in their resemblance to those from the Norwegian locality.

TOPAZ.

Mr. G. F. Moore, of Roseberry, Boise County, Idaho, who has for some years worked gold-gravel mines about 100 miles north of Boise, has found in the gravel a large waterworn crystal of topaz identical in habit with those from the Alabaschka locality in the Urals. The crystal is of a greenish color, weighs 1,110 carats, and measures 50 millimeters in length and 46 millimeters at its greatest breadth. Associated with it are amethyst crystals, all found on the bed rock. This is the first discovery of topaz reported from Idaho, and the occurrence in the gravel suggests that a locality exists from which this specimen was transported and where perhaps finer material may be found.

An interesting article on topaz and other western minerals by Maynard Bixby appeared in the Mineral Collector for October, 1896, Vol. III, pp. 113–114, with plate. Mr. Bixby calls attention to the remarkable groups of opaque topaz from Thomas Mountain Utah. These are larger than similar transparent crystals, and are definitely terminated, and it is believed that their opacity is due to the occurrence in them of kaolinite crystals. Another locality is described 35 miles southwest from Simpson Springs, Utah, where the largest fine transparent topaz is obtained. The colorless crystals are obtained on the surface, and, as previously noted in this report, fine colored ones are obtained in the matrix at some depth, the colorless variety being evidently originally wine-colored specimens that have been decolorized by exposure to light. Wine-colored topaz crystals have always been known to be sensitive to light, whether they be from the Ural, Japan, New Zealand, Utah, or Mexico. Mr. Bixby also notes a new locality for topaz somewhere near Livingston, Montana, these being of good size and resembling those from Crystal Peak, Colorado.

Topaz has been found in some quantities near Oban, New South Wales; but no particulars have as yet been received, and no important sales reported.

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TOURMALINE.

Dr. A. C. Hamlin, of Bangor, Maine, reports the finding of a tourmaline 7½ inches long by 3 inches wide at Mount Mica, Paris, Maine. It was presented to the Garland-Hamlin collection of tourmalines in the mineralogical cabinet of Harvard University.

Mr. A. C. Bates published an interesting article in the Mineral Collector for July, 1896, and describes the tourmaline at Haddam Neck, Connecticut. At this locality a tourmaline crystal has lately been obtained nearly 10 inches in length and an inch in diameter, partially transparent, and of a very rich green color; it is now in the collection of Mr. Clarence S. Bement, of Philadelphia. Many other choice and remarkable specimens have been procured at this locality during the year.

D. C. Morgan & Co., of Waynesville, North Carolina, report crystals of transparent green tourmaline from the vicinity of that place.

CHRYSOLITE.

Mr. W. A. H. Schreiber, Webster, North Carolina, reports olivine (chrysolite, peridot) in granular masses, of a very bright yellow-green color and susceptible of a fine, high polish, from Jackson County, North Carolina. This would be of some interest as an ornamental stone if obtained in any amount.

GARNET.

In California, according to Mr. Braverman, of Visalia, several varieties of garnet occur in Tulare County. He reports essonite (cinnamon garnet) at Three Rivers, pyrope (specimens only, but these to the value of $50) on Rattlesnake Creek, and topazolite near the chrysoprase locality, 12 miles northeast of Visalia. Almandine garnet is reported from South Dakota, on Elephant Gulch, Custer County, as abundant, by Mr. Blackney, of Custer.

QUARTZ.

The crystals of quartz with fluid inclusions from Herkimer County, New York, often contain curiously formed masses of bitumen, moving bubbles of gas, etc. During the past year one of the most interesting of these was found. In a group of three crystals was a cavity in which was a tiny amber-colored spider-shaped inclusion, having small projections of a lustrous black hydrocarbon, evidently of a bituminous nature, the form of the group being exactly that of a spider, which moved freely in the fluid as the crystal was turned.

The extent to which tourist mineral-buying is encouraged is shown in the estimate that 15,000 pounds of crystals of quartz were obtained from Montgomery, Salina, and Garland counties, Arkansas, and sold in the city of Hot Springs for the sum of $5,000, during the year 1896.

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Mr. P. McGill, of Cheyenne, Wyoming, states that quartz (rock crystal) is found in considerable quantity about 18 miles west of that place, in Cheyenne Pass. Mr. T. C. Hopkins, State College, Pennsylvania, reports the finding of some very brilliant crystals of quartz, singly and doubly terminated, 2 miles north of White Haven, Luzerne County, Pennsylvania, in seams of red quartzite of the Mauch Chunk red-shale formation. The crystals were quite as clear as those from Herkimer County, New York, and measured from one-half inch in diameter down to microscopic size. Beautiful clusters of small quartz in crystals are announced as occurring at Autauga, Alabama, by Prof. E. A. Smith, of the university of that State. Rock crystal has been found in three localities in Tulare County, California—Drum Valley, Three Rivers, and Yokohol—as reported by Mr. Braverman, of Visalia.

Dr. Bibbins, of Baltimore, reports a crystal of smoky quartz from Harford County, Maryland, 8 inches in length and 3½ inches in diameter, and also the finding of pebbles of smoky quartz in the Potomac gravel derived from the waste of the area of rocks from which crystals are obtained. This fact, of course, indicates the occurrence of the mineral in some quantity. Crystals of 40 pounds each in weight are reported by Mr. R. M. Chatham from the vicinity of Elkin, Surrey County, North Carolina. Large crystals of smoky quartz, 4 to 5 inches in diameter, are obtained at Bandy Creek, Lemhi County, Idaho, as stated by Mr. Cary Wright. The specimens are in the collection of Mr. J. M. Parfets, of Salmon, Idaho. Smoky quartz is mentioned as plentiful by Mr. Blackney, of Custer, South Dakota, but without particulars as to locality. It is also reported in Guadaloupe County, New Mexico, on the Pecos River, by Mr. H. H. Rusby, of Gallinas Spring.

Rose quartz occurs in enormous quantities in the granite region of the Black Hills, according to Mr. Blackney, of Custer, South Dakota; gold quartz is also abundant. It is often rich in color, and has been used to some extent as an ornamental stone. Specimens were brought from there by Dr. Jenney in his first trip to the Black Hills.

Dr. Willis E. Everette, of Tacoma, Washington, has found in that State some very interesting crystals of hyaline quartz, in which there has been a partial alteration, and which, when cut, give peculiar internal reflections.

Rutilated quartz in good specimens is reported from near Glenville, Jackson County, North Carolina, by Mr. Fererето S. Ropes, of Franklin.

AMETHYST.

Rutilated amethyst crystals from Box Creek, in the Black Hills of South Dakota, are reported by Mr. A. C. Blackney, of Custer. Mr. G. L. Chase, of Colorado Springs, Colorado, reports some beautiful crystals of amethyst from the southern portion of Goochland County, Virginia. Another amethyst locality in the same State is given by

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Mr. J. Benjamin Dillon, of Livingston, Nelson County, who announces fine crystals of it near that place.

The return to fashion of the amethyst has done much to encourage the opening of the old locality for the small but dark-purple specimens of this mineral occurring in the Auvergne district, in France, where this industry is now receiving some attention. Many interesting facts have been gathered and recorded by M. Demarty, of Clermont-Ferrand, where the mines are now located. In the Auvergne there are found, in addition to these, ruby, sapphire and zircon (hyacinth variety), beryl (emerald), topaz, resinite opal, agate, jasper, perlite, turquoise, quincite, retinite, spinel, olivine, garnet, and other species of precious and ornamental minerals.

To obtain a grant in France to exploit precious stones it is necessary to be the proprietor of the land. Some 40 hectares are embraced in the amethyst mines (placer), but much of this area is not exploitable, as the amethyst is rarely found limpid and transparent. The mines are situated about 40 kilometers from Clermont, at three principal points, viz, the Ravine, the Fountain, and La Sablonnière (the sand pit). The stone of the vein at the Ravine is about 2.5 meters in thickness. It is not available for jewelry, as it is nearly all opaque and traversed by white zones, but the effect is very agreeable, and it is used for fancy objects, such as jewel boxes, stamp boxes, cane heads, button and glove hooks, etc. The stone is sold in blocks in the rough at $30 for 220 pounds. The working is done in trenches down to 8 meters in depth. In a part of this vein the rock is seamed with agate and chalcedonic opal of a milky blue.

The Fountain is the most important vein, and was exploited about 150 years ago by the Spaniards. A trench has been opened 390 feet in length to a maximum depth of 8.5 meters. The vein is composed of four or five small ones which branch off, then join and unite into one or two more important small veins. The aspect is very irregular, and the thickness varies from 0.01 to 0.9 meter. When the small veins come together they form pockets, where the handsomest stones and the finest crystals are found. The vein does not follow a straight line, but an irregular one, and is strongly inclined. Sometimes the finest stones are at the surface; sometimes it is necessary to search for them at a depth of 20 meters, so that a shaft of 3 by 2.5 meters has been sunk to that level. This shaft is divided, one part being for ladders and one for the lift which brings up the material. The water is taken out by the aid of a suction and flowing pump. Powder is never used, although the gangue (granulite) is often very hard, because powder shatters the rock too much and also blackens it. The stone extracted from the mine is sorted by hand so as to separate the barren portions; and the whole is washed in running water by two women. Then it is carted to a room for rough hewing and trimming, where a woman, by means of a machine, breaks the stone into pieces of variable size, making

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Creek and Fox Creek, 45 miles southwest; and jasper bloodstone (heliotrope) in large quantities from the Chugwater, 50 miles northwest from Cheyenne.

Moss agate has been found at Soldiers' Delight, Baltimore County, Maryland, by Miss Eleanor Goucher, daughter of the president of the Woman's College of Baltimore.

The name enhydros, or hydrolite, is given to certain chalcedonic concretions containing a fluid, usually water. These are in fact agates in an incomplete or interrupted stage of formation. Prof. Henry A. Ward, of Rochester, New York, has lately found some remarkable examples of them in Afghan Border, India, quite as fine as those from Uruguay.

The name "cyclops" has been given to a peculiar occurrence of red and white chalcedony in concentric layers, specimens of which, sent from Chihuahua, Mexico, have been cut and polished and placed upon the market as a new semiprecious stone. The specimens for the most part are small nodules, averaging perhaps half an inch across, and are more or less hemispherical. The center consists of a little nodule of red chalcedony, and this is overlain and surrounded by clear or translucent colorless chalcedony. When the convex surface is polished en cabochon the red center shows very strikingly, producing an eye-like effect; and the stones make attractive rings, scarf pins, and the like. They were first sent to Mr. E. J. Smith, of Chicago, who proposed for them the name "cyclops."

OPAL.

Opal mining is assuming considerable importance in New South Wales, especially in the Wilcannia district. The locality, occurrence, and prospects are treated of in the annual report of the department of mines and agriculture, New South Wales, issued in 1895. The chief point is the small mining town of White Cliffs, 62 miles from Wilcannia and 16 miles from the nearest railway station. About 300 men are steadily employed in opal mining at this place. The rock is Cretaceous, and carries seams or veins of common opal, in which occur patches of fine gem material. These are claimed to improve in quality and frequency with increasing depth. The opal seams appear to run somewhat in layers, one of the shafts showing three distinct levels at 10, 20, and 30 feet. Work has been carried down to 50 feet, which is much deeper than any previous level. At that depth there is no sign of change in the opaliferous rock, and therefore the extent to which the gems may occur is still unknown. Some of the material is unsurpassed in quality, though it varies much, the price ranging from $2.50 to $10.50 per ounce, with an average of perhaps $5 at the mines for the fine material. One stone, obtained in 1895, brought $500, and two "patches" were found that yielded $6,000 and $15,000, respectively. In some cases the opal replaces fossil wood and shells. Estimates of the total yield are difficult, owing to the loose and careless manner in

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which the miners keep their accounts, but enough could be traced to show that the opals sold at the mines had yielded at least $30,000 in 1895, and probably much more, and in three years fully $135,000. The total output since the field began to be worked may reach $500,000. A large area of neighboring country is still unexplored as to the occurrence of opal, and Mr. W. H. J. Slee, chief inspector of mines, is disposed to think that there may be a wide extension of the gem-bearing district. Years ago he obtained specimens of opal, occurring with gypsum, from Milparinka, a point 160 miles from White Cliffs, and he now believes that it may be found at many points between those places and Wilcannia and the Queensland border. Should this prove to be the case, it will be highly interesting to trace the relation of these opal fields to those already exploited in Queensland, described in the report for last year.

A remarkable opal was brought to the United States in 1896 from Australia, which is of interesting origin. It was originally a section of an opalized tree, no trace of the beautiful color being visible except at the broken ends. This, by careful cutting, afforded an opal of 271 carats, in many respects the largest fine opal in the United States, and although of a vegetable origin the cellular structure has been replaced so that not a trace of the original woody structure is visible.

Dr. Bibbins, of Baltimore, reports a brown and milky opal, with hyalite, from Bare Hills, Maryland, found by Dr. A. C. Spencer.

Mr. Warren M. Foote, of Philadelphia, Pennsylvania, reports opalized wood in magnificent compact masses up to 1 foot in diameter, susceptible of a high polish and showing the replacement in detail of wood cells, fiber, and structure by a lustrous brown and yellow semiopal, from Clover Creek, Lincoln County, Idaho.

TURQUOISE.

The British consul at Meshed has treated exhaustively of the ancient turquoise mines of Persia in an article in the London Times. The great source of the world's supply of turquoise has long been the locality in Khorassan, in northern Persia. Anciently it was obtained in Arabia, and recently the New World has become prominent, Arizona and New Mexico yielding largely. The Persian mines are constantly worked, however, though in a rude oriental fashion; but they are rarely visited, and hence considerable interest attaches to this account from Meshed, the nearest important commercial town.

Nishapur, the name usually given to the locality, is situated about 400 miles due east from Teheran. The mines are a few miles from Nishapur, at an elevation of some 6,000 feet above sea level. Ascending gradually through low hills, with villages where the miners live, the visitor comes to an east-west ridge, with the turquoise mines lying along its southern face for a distance of about half a mile. Only one, known as the Reish mine, is at present actively worked. There is little

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or no system employed, as the mine is leased with a precarious tenure, and the holders may be thrown out at any time by a higher bidder; their only effort, therefore, is to get as much as possible out of it with the least present cost.

The entrance is a cave-like excavation near the top of the ridge, about 12 yards across, with a vertical shaft of 15 feet in diameter going down some 80 or 90 feet. At the top of this shaft two men recline with their backs against the cave wall, and turn with their feet a wooden wheel, which brings up a sheepskin bag, holding perhaps a peck of débris. This is taken out, emptied, and replaced by a third man, and then sent down by a "run" of the wheel to a point about halfway down the shaft, where two more men, on a ledge, are similarly engaged. At the mouth of the cave a number of men are seated together, breaking up the pieces of rock with small hammers. Whenever a good-sized piece of turquoise is found, it is laid to one side to be sent to Meshed. The finer débris is sifted and picked over by a large number of boys.

The bags come up rapidly and contain much turquoise of various grades. The mine produces large amounts, but a good deal of it is inferior—some greenish, some liable to fade, and some affected with whitish spots. Really fine stones are rare; but the Orientals use the defective material as well, for they all esteem it, and the poorest, if possible, must have some kind of a turquoise, if only a greenish or faded one, set in a tin ring. All the work thus far done, however, reaches very little into the hill; and from the abundance of the gem wherever the rock is opened there must be a great deal of fine material not yet approached. Even before the hill is reached the surface is seen to be strewn with fragments of turquoise in various stages of alteration, from green and flawed pieces to a chalky yellowish mass entirely changed in appearance. On entering the cave one sees that the rock walls are seamed with blue and green streaks of turquoise. But much that looks well when first obtained is liable to fade or turn green. In some cases white specks appear, which gradually enlarge until they destroy the value and beauty of the stone; and at Meshed, where the product is taken to be cut and exported, no one will purchase a turquoise until he has had it in his possession for some days. After cutting at Meshed, they are at once exported, their price rising as much as tenfold at that place, where it is hard to buy fine, perfect stones now, though in former years they could be had there at quite moderate rates. Turquoises are cheaper now in Constantinople, Tiflis, and even in India, than they are in Meshed.

Turquoise has been discovered in Australia at a locality named Mount Lorigan, in New South Wales. Indications are favorable, and considerable work has been done, but no important results are as yet reported.

M. Carnot, in the Bulletin of the Mineralogical Society of France, vol. xviii, 1895, pp. 119–123, gives an analysis of the turquoise from the

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Burro Mountains, Arizona, and compares it with an analysis made of the Persian turquoise, as follows:

Analyses of turquoise.

	Phosphoric acid (P_2O_5).	Alumina (Al_2O_3).	Copper oxide (CuO).	Ferrous oxide (FeO).	Lime (CaO).	Water (H_2O).	Quartz or clay.	MnO, MgO, F.
Burro Mountains	*Per cent.* 28.29	*Per cent.* 34.32	*Per cent.* 7.41	*Per cent.* 0.91	*Per cent.* 7.93	*Per cent.* 18.24	*Pr. ct.* 2.73	Trace.
Persia	29.43	42.17	5.10	4.50	.....	18.59	.21	Trace.

These results show the Arizona material to differ chiefly in the presence of calcium oxide and the absence of most of the iron. M. Carnot also emphasizes the fact that all the iron in both is in the protoxide state; whereas in the standard analyses heretofore given it has been regarded as mainly sesquioxide. Turquoise analyses present considerable variation; but M. Carnot deduces, as a formula to which they may all be fairly referred—

$$P_2O_5(Al_2O_3,Cu_3,Fe_3,Ca_3)O_3+Al_2O_3+5H_2O.$$

JADEITE.

Prof. Max Bauer, in the Jahrbuch für Mineralogie, 1896, vol. i, p. 85, announces the discovery, based upon specimens of jadeite from an unknown locality in Thibet, that this mineral is a component of a rock consisting of plagioclase, nephelite, and jadeite, the last sometimes preponderating to the exclusion of the other two. He remarks that if the jadeite here is, as usual, a member of the group of crystalline schists, we have in that case the first occurrence of nephelite in other than eruptive rocks.

Prof. L. V. Pirrson, in the American Journal of Science, fourth series, vol. 1, 1896, p. 401, says:

> It appears to us, however, that this interesting occurrence of nephelite may prove to be of great importance in explaining the origin of jadeite, whose significance in the crystalline schists has never been understood, and it may also furnish one explanation why, among all the varieties of metamorphosed igneous rocks occurring among the crystalline schists, those containing nephelite have not been found.

WARDITE.

This is a new mineral that may possess some interest as a semi-precious stone. It was described by Mr. J. M. Davison in the American Journal of Science for August, 1896. It occurs in coatings and concentric layered masses, with an oölitic or spherulitic structure, encrusting cavities in the massive variscite from Utah. Its color is light green, or bluish green; luster, vitreous; hardness, about 5—greater than variscite; and specific gravity, 2.77. In composition it is

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a hydrous phosphate of alumina, with 6 per cent of soda, a little magnesia and iron, and a trace of copper protoxide. The formula derived comes very close to turquoise; but the presence of the soda and the comparative absence of copper are marked distinctions. It seems to form a third member of a group in which peganite and turquoise precede it—phosphates of alumina in which the water increases regularly. The species was named in honor of Prof. Henry A. Ward, of Rochester, New York.

SMITHSONITE.

Golden-yellow carbonate of zinc, locally known as "Turkey fat," occurs in beautiful mammillary masses in the Morning Star mine, Yellville, Arkansas. The coloring matter of this is undoubtedly greenockite (sulphide of cadmium). These, when cut and polished, form very pleasing ornamental stones. The coloring is richer than in any of the smithsonite found at the ancient zinc mines of Laurium, in Greece, which have been worked for two thousand years. Some fine examples of this mineral are now in the cabinet of the United States National Museum and in the Field Columbian Museum at Chicago. These were found by Mr. W. A. Chapman, of Yellville, Arkansas, and were cut by Prof. F. W. Clarke, of the United States Geological Survey.

AMBER.

A remarkable article on the fossilized woods of the United States, by Prof. F. H. Knowlton, of the United States Geological Survey appeared in Science for April 17, 1897, new series, Vol. III, p. 582. He treats largely of the occurrence and geology of the amber deposits of Cape Sable, Maryland; of those near Canyon Diablo, Arizona; in the vicinity of the Black Hills, South Dakota; at Trenton and Camden, New Jersey; and in Chesapeake and Delaware counties, Maryland. He also traces the amber in the Magothy River district, Maryland, to a tree, the cell structure of which he has studied, and which he has named, for the present, *Cupressinoxylon bibbinsi*.

A paper of much interest, on amber, appeared during the past year in the form of an address delivered at the Ipswich meeting of the British Association for the Advancement of Science, by Dr. Conwentz, curator of the Provincial Natural History Museum at Dantzic, and perhaps the greatest living authority upon amber. This address, although dealing generally with the amber of the Baltic and of northern Europe, had special reference to that found on the east coast of England. After distinguishing the three species of fossil resin associated under the name of amber—the soft varities termed *gedanite* and *glessite*, and the harder *succinite*, or amber proper—Dr. Conwentz presents the facts, gathered at many points, as to the occasional occurrence of succinite on the British coast, and fixes its limits. It is found more or less in Norfolk and Suffolk, extending southward to Essex and northward to

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Yorkshire, chiefly cast up on the shore or brought in by fishermen's nets. Quite a little local industry exists at some points in cutting and polishing it into charms and ornaments. These are also now imported from Prussia, and sold to visitors sometimes as local material; but Dr. Conwentz is satisfied that most of it is truly English. The interesting deduction is made that the prehistoric amber articles found in graves, etc., in England, dating back even to the stone age, are probably of native material, and not derived from the Continent, as has been generally supposed. They are not abundant; and the amber known to be now obtained along the British coast would account for all the ancient objects without the necessity of inferring a foreign source.

As to the general occurrence of amber, the source is a bed of clay and green sand, in which it occurs with fossil wood, etc., partly in Smaland and partly under the Baltic, and from which it is washed out and cast up on the shores not only of Prussia, but of Denmark, southern Finland, and several of the Baltic islands. Then it is found at points on the coast of Holland and England, indicating a wide extension of the Smaland bed, to some extent at least under the present German Ocean. The age of this bed is Lower Oligocene, and the age of the amber itself and of the trees that produced it is thus carried back to the later Eocene. Dr. Conwentz discusses the nature of the associated wood, and finds no difference in its microscopic structure from that of modern pines, so that the separate genus Pinites is not warranted, and the amber pine should be known as *Pinus succinifera*. Probably, however, other coniferous trees shared in the production, especially of the associated glessite and gedanite, and leaves and flowers of several such species are preserved in pieces of amber. In addition, many traces of other groups of plants are similarly inclosed, some of which are of great interest, as indicating the presence in northern Europe of a number of genera and families related to the present flora of Asia and North America, and showing a warm temperate climate. This conclusion is not new, but the facts as presented in Dr. Conwentz's paper are of great geological interest in confirming it.

USE OF GEMS.

The use of jewels for ecclesiastical purposes is growing more frequent. The most remarkable article of the kind in this country was presented during the past year to Trinity Church, New York, by Prof. Thomas Egleston, founder of the School of Mines, Columbia University, who has for many years been a vestryman of that church. A peculiar interest attaches to this object in several ways. It is in itself a collection of elegant stones, many of them of rare varieties, obtained during years of travel with exceptional opportunities. Professor Egleston collected them and gave them to his wife, who died in 1895; and they have now, with their settings, been made into this very beautiful and striking

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memorial gift—a jeweled communion chalice in memory of Mrs. Augusta McVickar Egleston, the design being Professor Egleston's.

The chalice is 9 inches high and half that width. It rises from a cup embossed with fleur-de-lis crosses, set with rich purple Ural amethysts and Indian carbuncles. The highly ornamented stem that supports this has three blue sapphires, two yellow diamonds, and a ruby-red Nevada garnet set into it, while the top of the base bears six Ceylonese chrysoberyls and a green tourmaline from Maine. Below, the sides of the base form six vertical panels; three of these bear repoussé designs in gold—of the Crucifixion, the Adoration, and the Baptism of Christ, respectively—separated by three floriated panels, two of passion flowers and one of a jeweled cross. All these are set with beautiful gems; the passion flowers in one of the panels have an emerald for the center of each, in the other a sapphire; the cross consists of five stones, the one at the intersection being a yellow sapphire; the left arm, a red zircon; the right, a moldavite (the rare green volcanic glass of Moravia); above is a green sapphire ("Oriental emerald"), and below a green zircon and an andalusite. At the top of the panel is a star ruby (asteria), and at the bottom a Brazilian topaz. At the foot of the cross are two garnets, one from Nevada, ruby-red, the other a green demantoid ("Uralian emerald") from the Ural Mountains; around it, in the four spaces, are four rubellites.

This description may give an idea of the richness and rarity of the gems in this unique object. All the panels and the foot of the chalice are similarly inlaid, the latter with six Ceylonese moonstones alternating with Siriam carbuncles, and between these twelve green garnets. In all there are 180 stones, and the list of species includes amethyst, andalusite, chlorastrolite, chrysoberyl, diamond, emerald, garnet, moldavite, moonstone, peridot, ruby, sapphire, tourmaline, topaz, and zircon, and many of these in rare shades of color.

Among the most novel aspects of fashion in reference to diamonds, mention may be made of two points: the interest taken in colored diamonds, and the engraving of initials, monograms, etc., on the faces of table diamonds. In regard to the former, the increasing abundance of white stones is leading to a demand for the much rarer colored ones among those who purchase objects of elegant luxury without regard to cost. The remarkable Egleston memorial chalice, just described, has among its rich jewel decorations a number of colored diamonds. The De Beers Company has in its office at Kimberley a case containing perhaps a dozen diamonds of peculiar elegance and value, several of which are colored. Some are deep blue, and one of considerable size is a flawless stone of deep rose color, believed to be the finest pink diamond known. It can not be purchased.

The engraving of diamonds, though by no means new, is coming into vogue somewhat again; and work of the kind is announced as done by some jewelers in this country, for the first time. Mary Queen of Scots

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is said to have possessed a large diamond engraved with her coat of arms, which is now owned by a private collector in England. A fine specimen is also in the Tiffany collection at the Field Columbian Museum at Chicago. This is a large stone on which is carved a likeness of William II of Holland. The work is said to have occupied the artist, Devrees, for five years. At the late Antwerp Exposition was shown a finger ring and a cross, each cut out of a single piece of diamond. The process is conducted by means of a very small revolving drill, similar in its action to the dentist's drill, making 3,000 to 10,000 revolutions per minute. It is manipulated with the fingers, like a pencil, the operator dipping the tip from time to time into a mixture of oil and diamond dust. Of course, the work is extremely slow, and requires the utmost patience and skill. It necessarily spoils the brilliancy of the stone, by interfering with the reflection and refraction of light that give the diamond its chief beauty, and must be regarded rather as a tour de force than as a branch of really ornamental art.

At no time in the past decade has there been such a large demand as there is at present for the colored precious stones of all varieties, including emeralds, rubies, and sapphires, fine examples of which have commanded prices never before equaled. The lesser gems, such as topaz, a Spanish variety of quartz, amethyst, and many others, have been used for purse tops, cardcases, and even ornaments for silver-mounted cut glass, etc., so that the demand has nearly equaled the supply; and not only jewelers but silversmiths have been using the colored gems in great quantities.

The prolific occurrence of beautiful opal in Queensland and New South Wales, and the great ingenuity displayed in the jeweler's art, have led to a number of peculiar forms of cutting. First, in the form of round beads that are drilled, producing the effect of pearls with an iridescent play of colors; frequently there is strung between the beads a rondelle-cut diamond, emerald, amethyst, or topaz, the rondelle being a flat bead with faceted edges. Another form of cutting is one in which the opal bead is cut in two, forming hemispheres, and between the two halves there is set a diamond, emerald, topaz, or rock-crystal rondelle, the whole forming a perfect bead, the brilliant-cut transparent gem of whatever color, in the center, furnishing a wonderfully pleasing effect to this otherwise crystallized rainbow.

GEM LITERATURE.

An interesting article on precious stones has appeared in the volume issued by T. K. Brunner, secretary of the State Board of Agriculture, Raleigh, North Carolina, entitled North Carolina and its Resources, 1896, pp. 107–113, the article being illustrated with colored plates of nine specimens and numerous illustrations of North Carolina gem minerals. The report is very clear, and as it contains a full description of the minerals of the State, it can not fail to be a valuable aid to geologists and naturalists, as well as to investors.

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Prof. F. W. Rudler, of the Royal School of Mines, London, has prepared a new edition of the Handbook to the Museum of Practical Geology, Jermyn street, London, which has been issued in 8vo, viii, 167 pp., and is sold by the museum only. This is the guide and descriptive catalogue of one of the most comprehensive and admirably displayed museums in Europe. There are many references to precious stones (pp. 101–119), and in the museum itself there are beautiful and characteristic, and often unique, examples. The collection, being so central in the world's greatest metropolis, does much to create a taste for precious stones and to serve as a reference collection to all who visit it from all quarters of the globe.

In the report of the United States National Museum for 1894, pp. 633–750, an admirable article appears on the study of primitive methods of drilling, by Mr. J. D. McGuire. In this report Mr. McGuire treats exhaustively of the primitive methods of chipping, drilling, and engraving, from the earliest times to our own day, giving various forms of aboriginal drills from ancient Egypt to the present, and throwing much light on the subject of prehistoric and savage stone cutting.

In the Alphabetical Dictionary of Names of Minerals; Their History and Etymology, by Prof. Albert H. Chester, New York, 1896, 8vo, 320 pp., Wiley and Son, there are given about 5,000 names of minerals and gems, with the references to the original authorities. This is a great convenience as a check list to all interested in minerals and precious stones.

Artificial minerals are scarcely within the province of this report. Carborundum is a mineral that has never existed in nature, but for an abrasive its only peer is the diamond. It has been formed in large quantities in magnificent crystals, which, although not transparent, are highly polished, and as a crystallized brilliant product are quite equal in elegance to any mineral found. These are now made on an immense scale by the Carborundum Company at their works at Niagara Falls, the motive power of which is electricity generated by Niagara water power.

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PRODUCTION IN THE UNITED STATES.

Production of precious stones in the United States in 1896.

Diamond	None.
Sapphire	$10,000
Ruby	1,000
Topaz	200
Beryl (aquamarine, etc.)	700
Emerald	None.
Phenacite	None.
Tourmaline	3,000
Peridot	500
Quartz, crystal	7,000
Smoky quartz	2,500
Rose quartz	500
Amethyst	500
Prase	100
Gold quartz	10,000
Rutilated quartz	500
Dumortierite in quartz	50
Agate	1,000
Moss agate	1,000
Chrysoprase	600
Silicified wood	4,000
Opal	200
Garnet (almandite)	500
Garnet (pyrope)	2,000
Topazolite	100
Amazon stone	1,000
Oligoclase	500
Moonstone	250
Turquoise	40,000
Utahlite (compact variscite)	500
Chlorastrolite	500
Thomsonite	500
Prehnite	100
Diopside	200
Epidote	250
Pyrite	1,000
Rutile	100
Anthracite	2,000
Catlinite (pipestone)	3,000
Fossil coral	1,000
Arrow points	1,000
Total	97,850

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ABRASIVE MATERIALS.

By Edward W. Parker.

BUHRSTONES.

PRODUCTION.

The value of buhrstones and millstones produced in the United States from domestic quarries in 1896 was $22,567, exactly $25 more than the value of the product in 1895. The industry compared with what it was when the first volumes of Mineral Resources were published is now very small, and there is no probability that it will regain its former importance. It has given way to modern invention. The roller process for the manufacture of flour has entirely supplanted the use of buhr in all large mills, and the use of stones is now confined to paint, cement, bone, and phosphate mills, and mills for grinding the coarser cereals. Some idea of the decline of the industry is shown by a comparison of the statistics of production and importations in the past fourteen years covered by these reports. In 1882 the value of the domestic product was estimated at $200,000. In 1895 and 1896 the value of the output was only 11.3 per cent of this amount. The average value for the past six years has been $19,273, less than 10 per cent of the output in 1882. The imports have shown a similar but not quite so great a falling off. In 1882 the value of imported buhr, rough and manufactured, was $104,034. In 1895 the imports were valued at $20,316, less than one-fifth of the 1882 imports; and in 1896 the imports were $26,965, about 25 per cent of the imports in 1882. Combining the domestic product with the imports, a total value in 1882 is shown of $304,034. In 1895 the combined value of domestic and imported material was $42,858, about 14 per cent of the value in 1882, while in 1896 the combined value was 16 per cent, amounting to $49,532. There will always be a limited demand for the domestic millstones, and for a small amount of imported buhr, and it is probable that the production and imports will continue to average about the same as for the past six years.

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Although classed as buhrstone, the domestic material is entirely distinct from any of the buhrs which are imported from France, Belgium, and Germany. The French buhr is considered the best. Both it and the Belgian buhr consist of small particles of silica mixed with calcareous material, and are hard and porous. The German buhr is said to be of basaltic lava. The domestic stone is a quartz conglomerate. All of the foreign stone is quarried in small pieces, which are shipped in the rough state at cheap freight rates to this country, where they are dressed to conformable shapes, fitted together, and bound into solid wheels. The domestic stone is found in large bowlders, which are worked down to millstones of the required size, the chief advantage for these being in the fact that they are in one piece. It occurs in several localities along the eastern slope of the Alleghany Mountains, notably in Ulster County, New York, where it is called Esopus stone; in Lancaster County, Pennsylvania, where it goes by the name of Cocalico stone, and in Montgomery County, Virginia, it is quarried as Brush Mountain stone. It has also been quarried in Moore County, North Carolina, under the name of North Carolina grit, but no product has been reported from that locality for several years. The product in 1895 was from New York, Pennsylvania, and Virginia.

In the following table is exhibited the value of the millstones produced in the United States since 1880:

Value of buhrstones produced in the United States from 1880 to 1896.

Year.	Value.	Year.	Value.
1880	$200,000	1889	$35,155
1881	150,000	1890	23,720
1882	200,000	1891	16,587
1883	150,000	1892	23,417
1884	150,000	1893	16,639
1885	100,000	1894	13,887
1886	140,000	1895	22,542
1887	100,000	1896	22,567
1888	81,000		

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IMPORTS.

Value of buhrstones and millstones imported into the United States from 1868 to 1896.

Year ended—	Rough.	Made into millstones.	Total.
June 30, 1868	$74,224	.....	$74,224
1869	57,942	$2,419	60,361
1870	58,601	2,297	60,898
1871	35,406	3,698	39,104
1872	69,062	5,967	75,029
1873	60,463	8,115	68,578
1874	36,540	43,170	79,710
1875	48,068	66,991	115,059
1876	37,759	46,328	84,087
1877	60,857	23,068	83,925
1878	87,679	1,928	89,607
1879	101,484	5,088	106,572
1880	120,441	4,631	125,072
1881	100,417	3,495	103,912
1882	103,287	747	104,034
1883	73,413	272	73,685
1884	45,837	263	46,100
1885	35,022	455	35,477
Dec. 31, 1886	29,273	662	29,935
1887	23,816	191	24,007
1888	36,523	705	37,228
1889	40.432	452	40,884
1890	32,892	1,103	33,995
1891	23,997	42	24,039
1892	33,657	529	34,186
1893	29,532	729	30,261
1894	.....	.....	[a] 18,087
1895	.....	.....	20,316
1896	.....	.....	26,965

[a] Not separately classified after 1893.

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GRINDSTONES.

OCCURRENCE.

Grindstones of domestic manufacture are obtained from the sandstone deposits which extend along the shores of Lake Erie for some distance east and west of Cleveland, Ohio, and as far inland as Marietta, and on Lake Huron above Detroit, Michigan. In Mineral Resources for 1886 the methods of manufacture and use are given in detail, together with a tabular statement of the several varieties, foreign or domestic, that occur, with their special uses. Five varieties are produced in the United States—four in Ohio and one in Michigan. The four in Ohio are: (1) Berea, fine sharp grit, used specially for sharpening edge tools; (2) Amherst, soft loose grit, for edge tools and saws; (3) Independence, coarse sharp grit, for grinding springs and files and for dry grinding of castings; (4) Massillon, also coarse sharp grit, for large edge tools, springs, files, and dry castings. The Huron (Michigan) stone has a fine sharp grit, and is used for sharpening edge tools when a very fine edge is required.

PRODUCTION.

The production of grindstones in 1896 shows a wholesome recovery from the depression of the two previous years, amounting in value to $326,826 against $205,768 in 1895, a gain of $121,058, or about 59 per cent. Compared with 1894, there was an increase in 1896 of $103,612. The industry is now practically controlled by three or four large firms in Ohio, which have the strength necessary to maintain prices.

In the following table is shown the value of grindstones produced in the United States since 1880:

Value of grindstones produced in the United States, 1880 to 1896.

Year.	Value.	Year.	Value.
1880	$500,000	1889	$439,587
1881	500,000	1890	450,000
1882	700,000	1891	476,113
1883	600,000	1892	272,244
1884	570,000	1893	338,787
1885	500,000	1894	223,214
1886	250,000	1895	205,768
1887	224,400	1896	326,826
1888	281,800		

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IMPORTS.

The amount and value of grindstones imported into the United States since 1868 are as follows:

Grindstones imported and entered for consumption in the United States, 1868 to 1896, inclusive.

Year ended—	Finished.		Unfinished or rough.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Long tons.		*Long tons.*		
June 30, 1868	.....	$25,640	.....	$35,215	$60,855
1869	.....	15,878	.....	99,715	115,593
1870	.....	29,161	.....	96,444	125,605
1871	385	43,781	3,957.15	60,935	104,716
1872	1,202	13,453	10,774.80	100,494	113,947
1873	1,437	17,033	8,376.84	94,900	111,933
1874	1,443	18,485	7,721.44	87,525	106,010
1875	1,373	17,642	7,656.17	90,172	107,814
1876	1,681	20,262	6,079.34	69,927	90,189
1877	1,245	18,546	4,979.75	58,575	77,121
1878	1,463	21,688	3,669.41	46,441	68,129
1879	1,603	24,904	4,584.16	52,343	77,247
1880	1,573	24,375	4,578.59	51,899	76,274
1881	2,064	30,288	5,044.71	56,840	87,128
1882	1,705	30,286	5,945.61	66,939	97,225
1883	1,755	28,055	6,945.63	77,797	105,852
1884	.....	.....	.....	.....	[a] 86,286
1885	.....	.....	.....	.....	50,579
Dec. 31, 1886	.....	.....	.....	.....	39,149
1887	.....	.....	.....	.....	50,312
1888	.....	.....	.....	.....	51,755
1889	.....	.....	.....	.....	57,720
1890	.....	.....	.....	.....	45,115
1891	.....	.....	.....	.....	21,028
1892	.....	.....	.....	.....	61,052
1893	.....	.....	.....	.....	59,569
1894	.....	.....	.....	.....	52,688
1895	.....	.....	.....	.....	54,276
1896	.....	.....	.....	.....	66,195

[a] Since 1884 classed as finished or unfinished.

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CANADIAN PRODUCTION.

The Geological Survey of Canada gives the following statement of the production of grindstones in the Dominion since 1886:

Production of grindstones in Canada since 1886

Calendar year.	Tons.	Value.
1886	4,000	$46,545
1887	5,292	64,008
1888	5,764	51,129
1889	3,404	30,863
1890	4,884	42,340
1891	4,479	42,587
1892	5,283	51,187
1893	4,600	38,379
1894	3,757	32,717
1895	3,475	31,932

OILSTONES AND WHETSTONES.

PRODUCTION.

While the value of oilstones and whetstones produced in the United States in 1895 was the largest on record, the reports for 1896 indicate a value less than in any year since 1890. The total value of the product in 1896 (including oilstones, whetstones, or water hones, scythestones, kitchen and shoemakers rubstones) was $127,098 against $155,881 the preceding year. The rough material from which they are made is obtained from various localities in the United States. The higher grades of oilstones are made from two grades of novaculite quarried in the vicinity of Hot Springs, Arkansas, and known, respectively, as "Arkansas" and "Washita" stone. Fine-grained sandstone, called "Hindostan" or "Orange" stone, from Orange County, Indiana; Lake Superior stone, quarried in Cuyahoga County, Ohio, and a similar material known as Labrador stone, from Cortland County, New York, and chocolate stone from Lisbon, New Hampshire, are used for whetstones. Scythestones and rubstones are made from Indian Pond and Lamoille stone, quarried in Grafton County, New Hampshire, and Orleans County, Vermont, from Berea grit (which also furnishes grindstones), and from some of the Indiana sandstone.

The production of oilstones, etc., in the United States has for several years been practically controlled by one concern, the Pike Manufacturing Company, of Pike Station, New Hampshire. This company owns quarries at French Lick, Georgia, Orangeville and Paoli, Indiana; Haverhill, Piermont, Orford, and Lisbon, New Hampshire; Truxton, New

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York; Westmore and Brownington, Vermont, and besides having its own quarries and 1,000 acres of quarry land in Garland County, Arkansas, this company has contracted with all the individual quarrymen for their entire output for a number of years. During 1896 the Pike Company erected a mill at Hot Springs, Arkansas, for cutting and finishing the novaculite quarried in that vicinity, and discontinued the manufacture of Labrador stone from Cortland County, New York.

Under existing circumstances the first uniform selling value that can be placed upon the product is for the finished articles, which for the past six years has been as follows:

Value of oilstones, whetstones, etc., produced in the United States since 1891.

Year.	Value.
1891	$150,000
1892	146,730
1893	135,173
1894	136,873
1895	155,881
1896	127,098

From 1880 to 1890, inclusive, the product and value of the rough stone has been published in these reports, exception being made in the case of the output for 1890, when the value for the unfinished product was given for the novaculite of Arkansas, and in all other cases the value of the finished stones is quoted. The annual production from 1880 to 1890 was as follows:

Product of oilstones and whetstones from 1880 to 1890.

Year.	Pounds.	Value.
1880	420,000	$8,000
1881	500,000	8,580
1882	600,000	10,000
1883	600,000	10,000
1884	800,000	12,000
1885	1,000,000	15,000
1886	1,160,000	15,000
1887	1,200,000	16,000
1888	1,500,000	18,000
1889	5,982,000	32,980
1890	.....	69,909

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The reports of production by the Pike Manufacturing Company have been furnished this office annually since 1892, with permission to publish. They may be taken as indicative of the condition of the industry, and are shown in the following table. These figures are not claimed to be exact, but are estimated, though sufficiently approximate for all practical purposes. In making its report for 1896, the company states that it still controls the class of goods manufactured by it, and is able to maintain a uniform quality in the finished material, and in this way is securing the confidence of European buyers, and foreign demand is increasing. For the past three years home consumption has been much curtailed on account of the depressed conditions, but during that time export business has improved.

Production of oilstones, etc., by the Pike Manufacturing Company since 1892.

Kind.	1892.		1893.		1894.	
	Output.	Value.	Output.	Value.	Output.	Value.
Washita stone.pounds..	400,000	$60,000	300,000	$45,000	300,000	$45,000
Arkansas stone...do....	20,000	12,000	12,000	12,000	15,000	15,000
Labrador stone...do....	500	50	200	20	100	10
Hindostan stone .do....	300,000	15,000	250,000	13,000	300,000	15,000
Sandstone .....do....	100,000	2,000	100,000	2,000	100,000	2,200
Chocolate stone ..do....	20,000	2,000	20,000	2,000	25,000	2,500
Scythestones ....gross..	16,000	50,000	13,000	40,000	15,000	45,000
Total value.....	.....	141,050	.....	114,020	.....	124,710

Kind.	1895.		1896.	
	Output.	Value.	Output.	Value.
Washita stone.....pounds..	250,000	$40,000	240,000	$50,000
Arkansas stone.....do....	15,000	20,000		
Hindostan stone.....do....	300,000	12,000	275,000	10,000
Sandstone .....do....	100,000	2,000	100,000	2,000
Chocolate stone.....do....	10,000	1,000	10,000	1,000
Scythestones .....gross..	15,000	47,750	15,000	35,000
Total value.....	.....	122,750	.....	98,000

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IMPORTS.

The following table shows the total value of all kinds of hones and whetstones imported since 1880:

Imports of hones and whetstones since 1880.

Year ended—	Value.	Year ended—	Value.
June 30, 1880	$14,185	Dec. 31, 1889	$27,400
1881	16,631	1890	37,454
1882	27,882	1891	35,344
1883	30,178	1892	33,420
1884	26,513	1893	25,301
1885	21,434	1894	26,671
Dec. 31, 1886	21,141	1895	32,439
1887	24,093	1896	50,588
1888	30,676		

CORUNDUM AND EMERY.

PRODUCTION.

There was very little change either in amount or value of the product in 1896 compared with 1895. The aggregate output of corundum and emery in 1896 was 2,120 short tons, an increase of 18 tons over that of 1895. The value increased from $106,256 to $113,246, an increase of $6,990. The average production during the past eight years has been 1,958 short tons. The product both in 1895 and 1896 was slightly in excess of this figure. There was a decrease of nearly 300 tons in the amount of emery mined in Westchester County, New York, and shipped from Peekskill, the deficit in this product being made up by increased production in Massachusetts and North Carolina. Efforts are being made by producers to secure a protective tariff of 1½ cents per pound on emery imports, claiming that this amount of protection is necessary in order to properly develop the corundum deposits of North Carolina, South Carolina, and Georgia.

Aside from this and a reported method of converting emery into corundum by an electrolytic process, there were no developments or changes of note since the preceding report. The converting method mentioned, but which has not been verified, consists of mixing emery with lumps of coal and reducing by an alternating arc current.

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The producers of both emery and corundum are averse to giving publicity to their business, and in order to maintain the confidential nature of the statistics the production of the two minerals is stated together in the following table:

Annual product of corundum and emery since 1881.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1881	500	$80,000	1889	2,245	$105,567
1882	500	80,000	1890	1,970	89,395
1883	550	100,000	1891	2,247	90,230
1884	600	108,000	1892	1,771	181,300
1885	600	108,000	1893	1,713	142,325
1886	645	116,190	1894	1,495	95,936
1887	600	108,000	1895	2,102	106,256
1888	589	91,620	1896	2,120	113,246

IMPORTS.

The corundum used in the United States is exclusively of domestic production. Emery is imported from Turkey and the island of Naxos, one of the Cyclades group in the Grecian Archipelago.

The following table shows the imports of emery from 1867 to 1896:

Emery imported into the United States from 1867 to 1896, inclusive.

Year ended—	Grains.		Ore or rock.		Pulverized or ground.		Other manufactures.	Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Value.	
June 30—	*Pounds.*		*Long tons.*		*Pounds.*			
1867	.....	.....	428	$14,373	924,431	$38,131	.....	$52,504
1868	.....	.....	85	4,531	834,286	33,549	.....	38,080
1869	.....	.....	964	35,205	924,161	42,711	.....	77,916
1870	.....	.....	742	25,335	644,080	29,531	.....	54,866
1871	.....	.....	615	15,870	613,624	28,941	.....	44,811
1872	.....	.....	1,641	41,321	804,977	36,103	.....	77,424
1873	610,117	$29,706	755	26,065	343,828	15,041	$107	70,919
1874	331,580	16,216	1,281	43,886	69,890	2,167	97	62,366
1875	487,725	23,345	961	31,972	85,853	2,990	20	58,327
1876	385,246	18,999	1,395	40,027	77,382	2,533	94	61,653
1877	343,697	16,615	852	21,964	96,351	3,603	.....	42,182
1878	334,291	16,359	1,475	38,454	65,068	1,754	34	56,601
1879	496,633	24,456	2,478	58,065	133,556	4,985	.....	87,506
1880	411,340	20,066	3,400	76,481	223,855	9,202	145	105,894

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Emery imported into the United States from 1867 to 1896, inclusive—Continued.

Year ended—	Grains.		Ore or rock.		Pulverized or ground.		Other manufactures.	Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Value.	
June 30—	*Pounds.*		*Long tons.*		*Pounds.*			
1881...	454,790	$22,101	2,884	$67,781	177,174	$7,497	$53	$97,432
1882...	520,214	25,314	2,765	69,432	117,008	3,708	241	98,695
1883...	474,105	22,767	2,447	59,282	93,010	3,172	269	85,490
1884...	143,267	5,802	4,145	121,719	513,161	21,181	188	148,890
1885...	228,329	9,886	2,445	55,368	194,314	8,789	757	74,800
Dec. 31—								
1886...	161,297	6,910	3,782	88,925	365,947	24,952	851	121,638
1887...	367,239	14,290	2,078	45,033	a144,380	6,796	2,090	68,209
1888...	430,397	16,216	5,175	93,287	.....	.....	8,743	118,246
1889...	503,347	18,937	5,234	88,727	.....	.....	111,302	218,966
1890...	534,968	20,382	3,867	97,939	.....	.....	5,046	123,367
1891...	90,658	3,729	2,530	67,573	.....	.....	.....	71,302
1892...	566,448	22,586	5,280	95,625	.....	.....	2,412	120,623
1893...	516,953	20,073	5,066	103,875	.....	.....	3,819	127,767
1894...	597,713	18,645	2,804	51,487	.....	.....	1,841	71,973
1895...	678,761	25,066	6,803	80,386	.....	.....	27,586	133,038
1896...	755,693	28,493	6,389	119,738	.....	.....	.....	148,231

a To June 30, only; since, classed with grains.

INFUSORIAL EARTH.

OCCURRENCE.

Deposits of infusorial earth are found in several States on the eastern slope of the Alleghany Mountains, and in two of the Pacific Coast States, Nevada and California. It has not been reported in any of the States lying between the Appalachian and Rocky Mountain systems. Among the Eastern States it has been mined in Connecticut, New Hampshire, New Jersey, Maryland, and Virginia.

PRODUCTION.

During 1896, the amount of infusorial earth mined in the United States was 2,796 short tons, valued at $16,042, against 4,954 short tons, valued at $20,514, for the previous year. The mining of infusorial earth is a very irregular business, so irregular that except in the two New England States it can hardly be called an industry. For several years mining was carried on quite steadily at Popes Creek and Dunkirk in Maryland, but operations at the former place have been abandoned. Work was suspended at Dunkirk in 1894, but resumed in 1895, with an output of 3,000 tons, and for a while in 1896, when 700 tons were shipped.

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Until 1896, mining in Nevada was spasmodic. The owners of the deposits near Virginia City mine enough raw earth in one year to supply their demands for three or four years. This material is made into polishing powders. Another deposit was opened near Carson City and the owners expect to work the mine steadily. The earth from this deposit is mixed with asbestos for making boiler and steam-pipe coverings. It is claimed to be 92 per cent pure silica and requires no preparation before marketing.

The Napa County, California, mines are still idle, but a small amount (65 tons) was mined in Santa Barbara County. The New Jersey mines were not producing in 1896. The irregularity of the industry may be seen in the following table. In 1880, a product of 1,833 tons, valued at $45,660, was obtained. The next year with a product of 1,000 tons, the value fell to $10,000; the same amount was valued at $8,000 in 1882, and fell to $5,000 in 1883, remaining at $5 per ton until 1888, the product varying from 1,000 to 3,000 tons per year. The census of 1889 reported a production of 3,466 tons, worth $23,372. The following year, with a decrease of 934 tons in amount, the value rose to $50,240, the largest ever reported. The value fell to $21,988 in 1891, increased to $43,655 in 1892, fell to $22,582 in 1893, and again to $11,718 in 1894. The large values reported in 1890 and 1892 were due, not to any advance in prices, but to the more advanced stage of manufacture when the material was first marketed.

The amount and value of the product of infusorial earth for the years they have been obtained since 1880 are shown in the following table:

Production of infusorial earth from 1880 to 1896.

Year.	Short tons.	Value.	Year.	Short tons.	Value.
1880	1,833	$45,660	1889	3,466	$23,372
1881	1,000	10,000	1890	2,532	50,240
1882	1,000	8,000	1891		21,988
1883	1,000	5,000	1892		43,655
1884	1,000	5,000	1893		22,582
1885	1,000	5,000	1894	2,584	11,718
1886	1,200	6,000	1895	4,954	20,514
1887	3,000	15,000	1896	2,796	16,042
1888	1,500	7,500			

GARNET.

The occurrence of the variety of garnet used for abrasive purposes was treated briefly in this report for 1895. There have been no new developments either in the mining or manufacturing of this material, and the only feature of interest was the decreased production. The

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statistics of garnet production, excluding the gem varieties, were not collected by this office until 1894, when an output of 2,401 short tons, worth $90,660, was reported. The following year (1895) the product increased to 3,325 short tons, with a comparatively smaller increase in value to $95,050. The product in 1896 was 2,686 short tons, 285 tons more than in 1894, but having a value more than $20,000 less than in the former year.

Production of abrasive garnet for three years.

Year.	Short tons.	Value.
1894	2,401	$90,660
1895	3,325	95,050
1896	2,686	68,877

QUARTZ CRYSTAL.

Connecticut is credited with the entire product of quartz used for wood finishing. In 1894 this amounted to 6,024 short tons, valued at $18,054. The following year the product was 9,000 tons, worth $27,000, and in 1896 it was 6,000 tons, worth $18,000. Quartz for this purpose must be very pure and white. It is reduced to an impalpable powder, mixed with oil as in ordinary pigments, and applied to the smooth fresh surface of the wood. The oil penetrates the pores, carrying the fine grains of quartz with it. The quartz fills up the pores of the wood, which is then susceptible of taking a high polish.

TRIPOLI.

Virginia produced 1,000 short tons of tripoli in 1896, and Georgia added a small output of 15 tons. Newton County, Missouri, produced 1,800 tons of the porous siliceous rock quarried near Carthage, and which, for want of better nomenclature, is included with the tripoli product. In 1894 and 1895 the producers of this material reported the value of their various manufactured articles in making their returns to the Survey. For prudential reasons the value of their manufactured product in 1896 was withheld, and only the value of the crude rock is given. This would make a seemingly large decrease in value and is not published separately. The value of the combined product of Georgia, Missouri, and Virginia in 1896 was $15,580.

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PHOSPHATE ROCK.

PRODUCTION.

The total production remained nearly constant, as shown in the following tables, and the condition of the industry showed little variation from the depression of 1895; nor is any great improvement in price anticipated until the product is reduced in quantity. In Florida the chief feature of interest was that river mining and land-pebble mining changed places on account of the great effort of the river-pebble producers to market a large product.

The greatest item of interest was the extension of the Tennessee field by the discoveries at Mount Pleasant, to which reference will be made on another page.

Product of phosphate rock from 1891 to 1896.

State.	1891.		1892.		1893.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Florida:	*Long tons.*		*Long tons.*		*Long tons.*	
Hard rock	57,982	.....	[a] 155,908	$859,276	215,685	$1,117,732
Soft rock			6,710	32,418	13,675	64,626
Land pebble			21,905	111,271	86,624	359,127
River pebble	54,500	.....	[b] 102,820	415,453	122,820	437,571
Total	112,482	$703,013	287,343	1,418,418	438,804	1,979,056
South Carolina:						
Land rock	344,978	2,187,160	243,653	1,236,447	308,435	1,408,785
River rock	130,528	760,978	150,575	641,262	194,129	748,229
Total	475,506	2,948,138	394,228	1,877,709	502,564	2,157,014
Grand total	587,988	3,651,151	681,571	3,296,127	941,368	4,136,070

[a] Includes 52,708 tons of land rock carried over in stock from 1891.
[b] Includes 12,120 tons of river pebble carried over in stock from 1891.

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Product of phosphate rock from 1891 to 1896—Continued.

State.	1894.		1895.		1896.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Florida:	*Long tons.*		*Long tons.*		*Long tons.*	
Hard rock.....	326,461	$979,383	307,098	$1,302,096	296,811	$1,067,525
Soft rock	.....	.....	6,916	32,000	400	2,300
Land pebble...	98,885	296,655	181,011	593,716	97,936	176,972
River pebble...	102,307	390,775	73,036	185,090	190,052	300,556
Total	527,653	1,666,813	568,061	2,112,902	495,199	1,547,353
South Carolina:						
Land rock.....	307,305	1,252,768	270,560	898,787	267,072	792,457
River rock.....	142,803	492,808	161,415	512,245	135,351	389,192
Total	450,108	1,745,576	431,975	1,411,032	402,423	1,181,649
Tennessee	19,188	67,158	38,515	82,160	26,157	57,370
North Carolina	.....	.....	.....	.....	7,000	17,000
Grand total..	996,949	3,479,547	1,038,551	3,606,094	930,779	2,803,372

SOUTH CAROLINA.

In the following tables will be found statements of the shipments of South Carolina phosphate rock since 1874 and the product of the State from 1867 to 1896:

Detailed statement of total foreign and coastwise shipments and local consumption of South Carolina rock since June 1, 1874.

[Long tons.]

Period.	Shipments and consumption.	Beaufort.	Charleston.	Total.	Total for each year.
June 1, 1874, to May 31, 1875..	Foreign ports...	44,617	25,929	70,546	122,790
	Domestic ports .	7,000	25,560	32,560	
	Consumed	.....	19,684	19,684	
June 1, 1875, to May 31, 1876..	Foreign port....	50,384	25,431	75,815	132,896
	Domestic ports .	9,400	28,831	38,231	
	Consumed	.....	18,850	18,850	
June 1, 1876, to May 31, 1877..	Foreign ports...	73,923	28,844	102,767	163,220
	Domestic ports .	6,285	40,768	47,053	
	Consumed	.....	13,400	13,400	
June 1, 1877, to May 31, 1878..	Foreign ports...	100,619	21,123	121,742	208,323
	Domestic ports .	8,217	60,729	68,946	
	Consumed	.....	17,635	17,635	
June 1, 1878, to May 31, 1879..	Foreign ports...	97,799	21,767	119,566	199,365
	Domestic ports .	8,618	52,281	60,899	
	Consumed	.....	18,900	18,900	
June 1, 1879, to May 31, 1880..	Foreign ports...	47,157	14,218	61,375	190,763
	Domestic ports .	13,346	94,002	107,348	
	Consumed	.....	22,040	22,040	

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Detailed statement of total foreign and coastwise shipments and local consumption of South Carolina rock since June 1, 1874—Continued.

[Long tons.]

Period.	Shipments and consumption.	Beaufort.	Charleston.	Total.	Total for each year.
June 1, 1880, to May 31, 1881..	Foreign ports...	62,200	8,568	70,768	266,734
	Domestic ports .	65,895	91,929	157,824	
	Consumed	.....	38,142	38,142	
June 1, 1881, to May 31, 1882..	Foreign ports...	89,581	22,905	112,486	332,077
	Domestic ports..	65,340	111,314	176,654	
	Consumed	.....	42,937	42,937	
June 1, 1882, to May 31, 1883..	Foreign ports...	94,789	28,251	123,040	378,380
	Domestic ports..	62,175	150,545	212,720	
	Consumed	.....	42,620	42,620	
June 1, 1883, to May 31, 1884..	Foreign ports...	132,114	20,539	152,653	431,779
	Domestic ports..	41,040	181,363	222,403	
	Consumed	5,800	50,923	56,723	
June 1, 1884, to May 31, 1885..	Foreign ports...	111,075	11,495	122,570	395,403
	Domestic ports..	44,130	161,700	205,833	
	Consumed	12,000	55,000	67,000	
June 1, 1885, to Dec. 31, 1885..	Foreign ports...	105,761	8,581	114,342	277,789
	Domestic ports..	16,321	112,126	128,447	
	Consumed	5,000	30,000	35,000	
Jan. 1, 1886, to Dec. 31, 1886..	Foreign ports...	153,443	5,926	159,369	430,549
	Domestic ports..	14,622	187,558	202,180	
	Consumed	9,000	60,000	69,000	
Jan. 1, 1887, to Dec. 31, 1887..	Foreign ports...	189,995	9,740	199,735	480,558
	Domestic ports..	15,905	181,918	197,823	
	Consumed	13,000	70,000	83,000	
Jan. 1, 1888, to Dec. 31, 1888..	Foreign ports...	124,474	3,611	128,085	448,567
	Domestic ports..	20,404	212,078	232,482	
	Consumed	13,000	75,000	88,000	
Jan. 1, 1889, to Dec. 31, 1889..	Foreign ports...	137,102	5,900	143,002	541,645
	Domestic ports..	60,000	248,643	308,643	
	Consumed	15,000	75,000	90,000	
Jan. 1, 1890, to Dec. 31, 1890..	Foreign ports...	72,241	55,000	127,241	463,998
	Domestic ports..	15,000	213,757	228,757	
	Consumed	13,000	85,000	98,000	
Jan. 1, 1891, to Dec. 31, 1891...	Foreign ports...	94,528	4,655	99,183	475,516
	Domestic ports .	22,000	252,083	274,083	
	Consumed	14,000	88,250	102,250	
Jan. 1, 1892, to Dec. 31, 1892...	Foreign ports...	105,150	5,052	110,202	394,227
	Domestic ports .	30,425	148,600	179,025	
	Consumed	15,000	90,000	105,000	
Jan. 1, 1893, to Dec. 31, 1893...	Foreign ports...	156,257	175	156,432	502,564
	Domestic ports .	22,872	160,942	183,814	
	Consumed	15,000	147,318	162,318	
Jan. 1, 1894, to Dec. 31, 1894...	Foreign ports...	114,155	12,417	126,572	450,108
	Domestic ports .	21,000	154,853	175,853	
	Consumed	12,683	135,000	147,683	
Jan. 1, 1895, to Dec. 31, 1895...	Foreign ports...	114,430	10,090	124,520	431,975
	Domestic ports .	9,500	155,855	165,355	
	Consumed	12,100	130,000	142,100	
Jan. 1, 1896, to Dec. 31, 1896...	Foreign ports...	113,351	12,000	125,351	402,423
	Domestic ports .	12,000	130,072	142,072	
	Consumed	10,000	125,000	135,000	

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Phosphate rock (washed product) mined by the land and river mining companies of South Carolina since 1867.

Year ending—	Land companies.	River companies.	Total.
	Long tons.	*Long tons.*	*Long tons.*
May 31, 1867	6	.....	6
1868	12,262	.....	12,262
1869	31,958	.....	31,958
1870	63,252	1,989	65,241
1871	56,533	17,655	74,188
1872	36,258	22,502	58,760
1873	33,426	45,777	79,203
1874	51,624	57,716	109,340
1875	54,821	67,969	122,790
1876	50,566	81,912	132,478
1877	36,431	126,569	163,000
1878	112,622	97,700	210,322
1879	100,779	98,586	199,365
1880	125,601	65,162	190,763
1881	142,193	124,541	266,734
1882	191,305	140,772	332,077
1883	219,202	159,178	378,380
1884	250,297	181,482	431,779
1885	225,913	169,490	395,403
Dec. 31, 1885 (from June 1)	149,400	128,389	277,789
1886 (calendar year)	253,484	177,065	430,549
1887	261,658	218,900	480,558
1888	290,689	157,878	448,567
1889	329,543	212,102	541,645
1890	353,757	110,241	463,998
1891	344,978	130,538	475,516
1892	243,652	150,575	394,227
1893	308,425	194,129	502,564
1894	307,305	142,803	450,108
1895	270,560	161,415	431,975
1896	267,072	135,351	402,423

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FLORIDA.

The following table shows accurately the destination of all shipments of Florida hard-rock phosphate in 1896:

Shipments of Florida hard-rock phosphate in 1896, by ports.

Port.	Savannah.	Brunswick.	Fernandina.	Port Tampa.	Total.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Aarhuus	1,405	.....	.....	.....	1,405
Aberdeen	.....	.....	1,038	.....	1,038
Antwerp	3,309	2,075	5,136	.....	10,520
Barbados	.....	.....	500	.....	500
Birkenhead	.....	.....	2,442	.....	2,442
Bremen	7,098	.....	.....	.....	7,098
Danzig	.....	.....	2,215	.....	2,215
Dortrecht	.....	.....	.....	3,293	3,293
Dublin	.....	.....	513	.....	513
Galatz	.....	2,494	.....	.....	2,494
Gerstemunde	.....	.....	3,967	.....	3,967
Genoa	18,107	.....	4,930	.....	23,037
Ghent	.....	1,693	3,779	7,115	12,587
Gothenburg	.....	.....	.....	4,093	4,093
Hamburg	36,428	8,019	19,622	5,910	69,979
Harbourg	.....	.....	5,300	5,488	10,788
Hull	.....	1,100	.....	.....	1,100
Kastrup	6,377	.....	.....	.....	6,377
Landskrona	.....	.....	.....	8,441	8,441
Leghorn	1,096	.....	.....	.....	1,096
Liverpool	.....	8,107	1,980	.....	10,087
London	2,156	.....	.....	6,382	8,538
Memel	.....	.....	2,981	.....	2,981
Port de Bone	.....	.....	.....	1,455	1,455
Reval	1,812	.....	.....	.....	1,812
Riga	1,607	.....	.....	.....	1,607
Rotterdam	4,397	9,685	23,870	2,996	40,948
St. S. du R.	3,207	.....	2,321	.....	5,528
Stettin	6,620	7,390	29,346	15,185	58,541
Venice	4,720	.....	.....	5,552	10,272
Total	98,339	40,563	109,940	65,910	314,752

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Monthly shipments of Florida hard-rock phosphates in 1896.

Month.	Savannah.	Brunswick.	Fernandina.	Port Tampa.	Total.
January	2,106	2,075	7,144	4,701	16,026
February	4,370	2,808	7,421	2,254	16,853
March	8,518	3,039	20,721	2,982	35,260
April	6,006	4,598	16,241	9,712	36,557
May	12,250	3,421	19,508	10,685	45,864
June	4,430	2,168	3,961	5,950	16,509
July	2,156	6,906	6,240	.....	15,302
August	4,567	2,472	10,920	2,525	20,484
September	13,563	1,000	4,619	4,042	23,224
October	10,758	4,852	6,577	6,078	28,265
November	15,832	4,168	4,676	11,400	36,076
December	13,783	3,056	1,912	5,581	24,332
Total	98,339	40,563	109,940	65,910	314,752

TENNESSEE.

The event of principal interest in phosphate mining during the year was the discovery and rapid development of high-grade phosphate rock in Maury County, Tennessee. This is an important addition to the phosphates in Hickman and Perry counties, which were described in the last report, and which have since been described at greater length by Dr. C. W. Hayes in a paper entitled "The Tennessee phosphates," published in Part II of the Seventeenth Annual Report of the Survey.

The following description of the Maury County phosphate is extracted from a paper by Mr. J. B. Killebrew:

MAURY COUNTY, TENNESSEE.

In December, 1895, the Hon. S. Q. Weatherly, of Lewis County, in passing by the farm of Scott Jennings, near Mount Pleasant, Maury County, observed in the deep cuts along the road a thinly laminated rock that to him suggested zinc ore. Actuated more by curiosity than with the expectation of making any valuable discovery, he took a piece of this thin rock, broke it so as to see the structure, and recognized, as he thought, the granulated appearance of the phosphate rock of Hickman County. Impressed with this similarity in general appearance, he took the specimen to Mr. H. I. Arnold, who was interested in the phosphate industry in the latter county. Mr. Arnold sent the samples to Mr. Lucius P. Brown, a well-known chemist of Nashville. Mr. Brown's analysis, submitted within ten days, showed that the rock contained over 75 per cent of bone phosphate. The softness and porosity of the rock and the abundance of its outcrops, together with the nearness of the stratum to the surface and the proximity of the deposit to the railroad, at once declared the great value of the beds. Mining was begun within the town limits of Mount Pleasant January 16, 1896, and the greatest excitement at once sprang up in all the region surrounding that place. Nearly every farmer within 10 miles of the little town began to look for

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phosphate rock on his farm. Thousands of excavations were made, though in many places the outcrop sufficiently indicated the presence of the phosphate in workable quantity. Stock companies were rapidly organized, and development began in every portion of the phosphate-bearing region.

At present there are numerous companies and firms at work, the principal ones being: The Blue Grass Phosphate Company; the Columbian Phosphate Company; the Tennessee Phosphate Company; the Mount Pleasant Phosphate Company; Cajet & Co., successors to Meadors & Co.; Carpenter & Co.; Ligon & Shaw, lessees; Phosphat Générale de Floride, operated by Riche and associates; Barrett & Co.; C. D. Hardin & Co.; R. L. Goodloe.

There are also a few individuals who mine small quantities of phosphate rock on their farms or town lots and sell to local dealers or speculators.

The monthly shipments of rock, which began in July, 1896, up to June 30, 1897, as furnished by Milton H. Smith, the president of the Louisville and Nashville Railroad, are as follows:

Phosphate shipments from Maury County, Tennessee.

Month and year.	Long tons.
July, 1896	350
August, 1896	2,582
September, 1896	2,566
October, 1896	2,240
November, 1896	4,809
December, 1896	6,831
January, 1897	7,374
February, 1897	6,806
March, 1897	6,724
April, 1897	8,265
May, 1897	9,966
June, 1897	5,522
Total	64,035

The total mined for the year ending June 30 was 64,928 long tons.

The area containing the phosphate of lime in workable quantities in the vicinity of Mount Pleasant is embraced within 15 square miles, about one-third of which, it is estimated, contains valuable beds where the phosphate may be easily and cheaply mined. In many places the surface of the country lies below the deposits, and in others the beds are covered by high hills. The mining now is confined to those places where the beds of phosphate lie near the surface and where the overburden does not exceed 2 or 3 feet of earth. No mining is done by tunneling, nor is any explosive necessary to loosen the deposits.

In mining, the mass is thrown down by picks and the spall fork is used to segregate all fragments of a greater diameter than 2 inches. The smaller fragments are not considered desirable without being washed, because so much aluminous matter, in the form of clay, adheres to them as to increase the percentage of noxious ingredients above the limitallowed and to decrease the phosphate of lime below the limit of 75 per cent, upon which basis all contracts are made. This is a guaranty that it shall contain 34.4 per cent of phosphoric acid.

From the best information obtainable and after examining a number of mines and

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making a conservative estimate, it is believed that the workable phosphate within easy reach of Mount Pleasant is contained within 3,000 acres. It has an average thickness of 4 feet, making due allowance for the interference of "chimneys." Taking an average of 3,000 tons to the acre, it will be seen that the total quantity now in sight is 9,000,000 tons. It is yet too early to estimate with absolute precision the cost of mining this phosphate. It depends largely on the amount of stripping to be done and the thickness of the seam. Taking all estimates and consolidating them, the cost of mining and putting upon the cars is not far from 70 cents per ton. The average number of tons mined per man per day varies from 1½ to 3 tons. This, however, does not include the cost of stripping.

The average analysis of many carloads of the phosphate shipped to fertilizer works is as follows:

Analysis of Maury County phosphate.

	Per cent.
Moisture	1.50
Sand	2.25
Phosphate of lime	78.75
Peroxide of iron and alumina	2.25
Carbonate of lime	4.00

This would give a percentage of 36.1 phosphoric acid. All sales, as has been stated, are made on a guaranty of 75 per cent of phosphate lime. The royalty paid to the owners of land for mining privileges varies from 10 cents to 40 cents per ton.

The phosphates are usually roasted, so as to expel the moisture, and crushed before being put on board the cars.

The prices received at present vary from $1.20 to $1.60 per ton f.o.b. cars at Mount Pleasant. This would seem to be an extremely low price, and scarcely justifies any extensive outlay for mining. It is believed, however, that as the small individual miners dispose of their holdings, so that the phosphate will not be forced on the market and sold for what it will bring, the prices will reach a healthy and remunerative basis. For many years the South Carolina phosphate sold for $4 per ton, of which $1 was paid to the State for royalty.

Recent investigations have disclosed deposits of this Lower Silurian phosphates in Marshall County, near the line of the Nashville, Chattanooga and St. Louis Railway.

Dr. J. M. Safford, in describing this phosphate in the American Geologist for October, 1896, showed that the layers are evidently a residuum left after the natural leaching of certain highly phosphatic limestones. Some of the rock has also been formed by replacement of limestone by phosphate of lime. Dr. Safford thus describes the age of the deposits:

The limestones yielding the phosphate are undoubtedly of Trenton age. Among the divisions of the Nashville rocks of this age we have the following:

(1) *The Orthis bed.*—This represents a horizon easily recognized throughout the Silurian basin of middle Tennessee. The bed is about 60 feet thick. It gets its name from the fact that some of its layers are almost wholly made up of the shells of *Orthis testudinaria.*

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(2) Next above the Orthis bed is the Capitol limestone, a granular, current-formed, and hence laminar limestone, showing cross stratification. It gets its name from the fact that it supplied the rock for the building of the capitol at Nashville. Its grains are the fragments of comminuted shells, corals, etc., the whole once a drifted calcareous sand. Hence its laminar structure and cross stratification. Average thickness may be placed at about 60 feet.

(3) The *Dove limestone*, a series 10 to 12 feet thick, of mostly a compact, dove colored limestone.

(4) Upon the Dove lies another division, 28 feet thick, recently designated the *Ward limestone*. Parts of this are much like the Capitol, laminated and showing current action.

All of these are more or less phosphatic, but it is the Capitol division or horizon which is the great source of the phosphate. Parts of this limestone show upon analysis from 15 to 25 per cent of phosphate, the dark lines marking the lamination of the rock being especially rich. Throughout middle Tennessee, wherever the limestone has been subjected to the proper leaching conditions, residual fragments of phosphate may be found, the pieces often looking like sandstone or like porous chert. About Mount Pleasant the original limestone appears to have been especially rich in phosphate, though other localities may be discovered as good.

The Orthis bed lies under the masses of the leached-out phosphate, and its outcrops, rich in Orthis shells, are a guide to them.

The Ward division, the fourth of the series above, also yields locally noteworthy quantities of phosphate, as does also the upper part of the Orthis bed.

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IMPORTS.

The following table shows the imports of fertilizers of all kinds into the United States from 1868 to 1896:

Fertilizers imported and entered for consumption in the United States, 1868 to 1896.

Year ending—	Guano.		Crude phosphates and other substances used for fertilizing purposes.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Long tons.		*Long tons.*		
June 30, 1868	99,668	$1,336,761	.....	$88,864	$1,425,625
1869	13,480	217,004	.....	61,529	278,533
1870	47,747	1,414,872	.....	90,817	1,505,689
1871	94,344	3,313,914	.....	105,703	3,419,617
1872	15,279	423,322	.....	83,342	506,664
1873	6,755	167,711	.....	218,110	385,821
1874	10,767	261,085	.....	243,467	504,552
1875	23,925	539,808	.....	212,118	751,926
1876	19,384	710,135	.....	164,849	874,984
1877	25,580	873,459	.....	195,875	1,069,334
1878	23,122	849,607	.....	285,089	1,134,696
1879	17,704	634,546	.....	223,283	857,829
1880	8,619	108,733	.....	317,068	425,801
1881	23,452	399,552	.....	918,835	1,318,387
1882	46,699	854,463	133,956	1,437,442	2,291,905
1883	25,187	537,080	96,586	798,116	1,335,196
1884	28,090	588,033	35,119	406,233	994,266
1885	20,934	393,039	40,068	611,284	1,004,323
Dec. 31, 1886	13,520	306,584	82,608	1,179,724	1,486,308
1887	10,195	252,265	53,100	644,301	896,566
1888	7,381	125,112	36,405	329,013	454,125
1889	15,991	313,956	35,661	403,205	717,161
1890	4,642	59,580	31,191	252,787	312,367
1891	11,937	199,044	29,743	214,671	413,715
1892	3,073	46,014	92,476	666,061	712,075
1893	5,856	97,889	106,549	718,871	816,760
1894	5,757	105,991	126,820	904,247	1,010,238
1895	4,270	51,642	80,088	450,379	502,021
1896	6,532	79,815	113,955	639,858	719,673

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SULPHUR AND PYRITES.

By EDWARD W. PARKER.

SULPHUR.

PRODUCTION.

The production of sulphur in the United States during 1896 was 5,260 short tons, valued at $87,200. While this output was a gain of nearly 50 per cent over the combined product during the preceding three years (1893, 1894, and 1895), it is, when considered with the consumption, of comparative insignificance. It has, however, an importance in the promises of future production. The increased output in 1896 was due to the operation of the Frasch process of mining sulphur from the extensive deposits in Calcasieu Parish, Louisiana. About 80 per cent of the total product in 1896 was from these beds. The projectors of the enterprise have met with some obstacles and delays natural in the development of a hitherto untried method, but have succeeded sufficiently to feel encouragement for the future, and look to a largely increased production in 1897. The only other producing region in the United States at present is at Black Rock, Beaver County, Utah. Since 1880, the deposits at this place have been worked regularly, except in 1888, 1889, and 1890, when they were in litigation. The Utah sulphur deposits are large and yield an excellent quality of sulphur, but owing to the expense attached to railroad transportation the market is restricted to a comparatively local demand. The Louisiana sulphur is more favorably located. A short haul by rail places the product at New Orleans, where water transportation is available, by sea to New York and other ports, and by river to interior points.

During the past year considerable attention has been directed toward the sulphur deposits in western Texas, mention of which was made in Mineral Resources for 1895. Since that report was written the region has been more thoroughly prospected with encouraging results, and a company capitalized at $500,000, has been organized to develop it. It is estimated that the sulphur from this region can be placed free on board vessels in the Gulf of Mexico at $10 per ton.

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The following table shows the product of sulphur in the United States since 1880:

Sulphur product of the United States since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	600	$21,000	1889	450	$7,850
1881	600	21,000	1890	.....	.....
1882	600	21,000	1891	1,200	39,600
1883	1,000	27,000	1892	2,688	80,640
1884	500	12,000	1893	1,200	42,000
1885	715	17,875	1894	500	20,000
1886	2,500	75,000	1895	1,800	42,000
1887	3,000	100,000	1896	5,260	87,200
1888	.....	.....			

DOMESTIC CONSUMPTION.

In discussing the production, importations, and consumption of sulphur, the use of iron pyrites in the manufacture of sulphuric acid must be considered. During the past decade iron pyrites has become a formidable rival to sulphur, but it is for the past six years only that reliable statistics are available. Previous to 1884 pyrites was included with other sulphur ores in the reports of imports published by the Treasury Department. From 1887 to 1891 iron pyrites was included with other iron ores. From 1884 to 1887 and since 1891 iron pyrites containing not more than 3.5 per cent of copper has been reported separately. In 1887 the pyrites imported into the United States amounted to only 16,578 long tons, and the domestic product was only 52,000 long tons. Four years later (1891), when the imports were next reported, they amounted to 100,648 long tons and the domestic product more than doubled. Assuming that the pyrites, imported and domestic, contained an average of 45 per cent of sulphur, it is seen that 93,233 long tons of sulphur was displaced by pyrites, of which 45,292 long tons was from imported ores. In the same year it is shown that the imports of crude sulphur amounted to 116,971 long tons, against 162,674 long tons in 1890, a decrease of 45,703 long tons, substantially the same as the increase in sulphur contained in imported pyrites. The imports of sulphur decreased again about 16,000 long tons in 1892, while the sulphur contents of imported pyrites increased about 23,000 long tons. In 1893 there was an increase of 4,600 long tons in the imports of sulphur, an increase of over 19,000 long tons in the sulphur contents of imported pyrites, and a decrease of over 15,000 long tons in the sulphur contents of domestic pyrites. Previous to this, since 1887, there had

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been a constant increase in the production of iron pyrites. In 1894 is seen an increase of nearly 20,000 long tons in the imports of sulphur, and of 13,573 long tons of sulphur in domestic pyrites, and a decrease of 13,119 long tons in sulphur contained in foreign pyrites. Paradoxically, these fluctuations have been nearly constant; but when we consider the totals we find a persistent and almost regular increase in the consumption of sulphur from 211,275 long tons in 1891 to 284,908 long tons in 1896. Comparatively, the domestic product of sulphur has been so small that it has been disregarded in the discussion, but is shown in the following table:

Estimated consumption of sulphur in the United States from 1891 to 1896.

	1891.	1892.	1893.	1894.	1895.	1896.
Sulphur:	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Domestic	1,071	2,400	1,071	446	1,607	4,696
Imported (*a*)	116,971	100,938	105,539	125,241	121,286	138,168
Sulphur contents of pyrites: (*b*)						
Domestic	47,941	49,405	34,100	47,673	44,697	51,968
Imported	45,292	68,561	87,715	74,596	85,796	90,076
Total domestic consumption	211,275	221,304	228,425	247,956	253,386	284,908

a Crude sulphur only; does not include flowers of sulphur, refined sulphur, or sulphur lac.
b Based on average sulphur contents of 45 per cent.

In the foregoing table the domestic production of sulphur has been reduced from short tons to long tons for the sake of uniformity.

REVIEW OF THE INDUSTRY.

During 1896 the spirit of combination took hold of the sulphur industry in the form of a syndicate organized to control the supply and prices of Sicilian sulphur and the sulphur obtained from alkali waste. While the plan was at first looked upon by outside parties as impossible of successful operation owing to the conflicting interests involved, the record of the year showed that the syndicate had been able in the face of adverse conditions to advance the price about 60 per cent between March and October. In 1895 and the early part of 1896 prices for Sicilian sulphur reached the lowest figure ever known, the average at shipping ports being $10.62 per ton, against $12.06 in 1894, $13.86 in 1893, and $18.37 in 1892. The abnormally low prices in 1895, due to the competition among producers rather than overproduction for several years, developed the fact that the consumption of sulphur was not increased by cheapness of the raw material. Under such circumstances it was easily reasoned that consumption would not fall off

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because of higher prices, and higher prices could only be obtained by a combination of interests. In Mineral Resources for 1895 the formation of a syndicate for the purpose of controlling the industry was mentioned. Since then the "trust" has become an accomplished fact. The principal parties at interest are Baron Oppenheimer, a Parisian banker; Commander Florio, of the Florio Steamship Company, Palermo, Sicily, and Mr. H. M. Chance, the inventor of the Chance process for recovering sulphur from alkali waste, Birmingham, England.[1]

The syndicate is under contract to pay to producers $15.94 per ton for best unmixed seconds, with an advance of 1 per cent in price for every 3 per cent reduction of output ordered, based on an annual production of 340,000 tons. The price to be paid by the syndicate is thus seen to be an advance of exactly 50 per cent over the average price received at Sicilian shipping ports in 1895. In one very important respect the judgment of the syndicate, for a while at least, was proven. With the advance in prices the demand not only did not fall off, but was actually increased. This was particularly true in regard to the United States market, notwithstanding an increase of over 3,000 long tons of domestic sulphur, of nearly 27,000 tons in the product of domestic pyrites, and of 9,733 tons of imported pyrites. The increase in the quantity shipped to America was caused by the large demand from sulphite pulp and paper manufacturers. Mr. Alfred S. Malcomson, a large importer of Sicilian sulphur at New York, is authority for the prediction that the record of the present year (1897) will show a material decrease in the imports of brimstone, basing his prediction on the fact that several of the large consumers of Sicilian brimstone are changing their plants from brimstone to pyrites burners. The effect of these changes has been shown at the time of writing this report (May 1, 1897) in the decline of sulphur prices, and indicates that the high prices in September, October, and November, 1896, were too excessive for even the syndicate to maintain. In the face of existing conditions, the ability of the syndicate to keep the price from falling any lower is evidence of its strength.

[1] Report of Louis H. Brühl, United States consul, Catania.

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PRICES.

Mr. Malcomson has furnished the Survey with the following statement of the prices of Sicilian sulphur, ex steamer New York, for each month during 1896 and up to May, 1897:

Spot prices for Sicilian sulphur, per long ton, ex steamer at New York.

Date.	Best unmixed seconds.	Best thirds.
1896.		
January	$15.50	$15.00
February	15.50	15.00
March	15.00	14.50
April	15.50	14.87½
May	$15.50 @ 16.00	15.00
June	19.00	18.50
July	19.50	19.00
August	20.00 @ 21.00	19.50
September	22.50 @ 23.00	22.00
October	24.00 @ 25.00	23.50
November	22.00	21.50
December	21.00	20.50
1897.		
January	20.00 @ 20.50	19.75
February	19.75	19.25
March	20.00	19.25
April	19.25 @ 19.50	18.75
May	19.25 @ 19.50	18.50

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IMPORTS.

Sulphur imported and entered for consumption in the United States, 1867 to 1896.

Year ended—	Crude.		Flowers of sulphur.		Refined.		All other. (a)	Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Value.	
	Long tons.		*Long tons.*		*Long tons.*			
June 30, 1867	24,544	$620,373	110	$5,509	251	$10,915	.....	$636,797
1868	18,151	446,547	16	948	65	2,721	.....	450,216
1869	23,590	678,642	97	4,576	645	27,149	.....	710,367
1870	27,380	819,408	76	3,927	157	6,528	$1,269	831,132
1871	36,131	1,212,448	66	3,514	92	4,328	754	1,221,044
1872	25,380	764,798	36	1,822	57	2,492	.....	769,112
1873	45,533	1,301,000	55	2,924	36	1,497	.....	1,305,421
1874	40,990	1,260,491	51	2,694	57	2,403	.....	1,265,588
1875	39,683	1,259,472	18	891	.....	.....	.....	1,260,363
1876	46,435	1,475,250	41	2,114	44	1,927	.....	1,479,291
1877	42,963	1,242,888	116	5,873	1,171	36,962	.....	1,285,723
1878	48,102	1,179,769	159	7,628	150	5,935	.....	1,193,332
1879	70,370	1,575,533	138	6,509	69	2,392	.....	1,584,434
1880	87,837	2,024,121	124	5,516	158	5,262	.....	2,034,899
1881	105,097	2,713,485	98	4,226	71	2,555	.....	2,720,266
1882	97,504	2,627,402	159	6,926	59	2,196	.....	2,636,524
1883	94,540	2,288,946	79	3,262	115	4,487	.....	2,296,695
1884	105,112	2,242,697	178	7,869	126	4,765	.....	2,255,331
1885	96,839	1,941,943	121	5,351	114	4,060	.....	1,951,354
1886	117,538	2,237,989	213	8,739	116	3,877	.....	2,250,605
1887	96,882	1,688,360	279	9,980	84	2,383	.....	1,700,723
Dec. 31, 1888	98,252	1,581,583	128	4,202	27	734	.....	1,586,519
1889	135,933	2,068,208	15	1,954	10	299	.....	2,070,461
1890	162,674	2,762,953	12	1,718	103	3,060	.....	2,767,731
1891	116,971	2,675,192	206	6,782	10	1,997	.....	2,683,971
1892	100,938	2,189,481	158	5,439	26	4,106	.....	2,199,026
1893	105,539	1,903,198	241	5,746	43	1,017	.....	1,909,961
1894	125,241	1,703,265	173	4,145	45	1,207	.....	1,708,617
1895	121,286	1,546,481	581	12,888	229	4,379	50,006	1,613,754
1896	138,168	1,967,454	665	13,266	447	8,226	183,683	2,172,629

a Includes sulphur lac and other grades not otherwise provided for, but not pyrites.

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Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1876 to 1896.

Countries whence exported and customs districts through which imported.	1876.		1877.		1878.		1879.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRIES.	*Long tons.*		*Long tons.*		*Long tons.*		*Long tons.*	
Dutch West Indies and Guiana	1,515	$15,427	.....	.....	.....	.....	.....	.....
England	30	1,211	425	$14,631	(?)	$16	2	$335
Scotland	24	910	472	13,231	160	3,961	806	19,287
Gibraltar	.....	.....	290	7,789	.....	.....	.....	.....
Quebec, Ontario, Manitoba, etc	.....	.....	.....	.....	12	264	.....	.....
Italy	46,941	1,439,839	41,819	1,194,000	47,494	1,161,367	64,420	1,453,138
Japan	456	16,291	437	13,137	256	7,548	224	4,528
Portugal	.....	.....	.....	.....	.....	.....	467	10,410
Total	48,966	1,473,678	43,443	1,242,788	47,922	1,173,156	65,919	1,487,698
DISTRICTS.								
Baltimore, Md	5,157	157,828	3,882	105,175	5,455	138,202	6,969	157,243
Barnstable, Mass	.....	.....	.....	.....	.....	.....	600	13,780
Boston and Charlestown, Mass	5,031	154,883	3,931	101,215	5,795	131,945	7,841	173,506
Charleston, S. C	.....	.....	.....	.....	526	12,267	605	13,812
Delaware, Del	450	13,500	.....	.....	.....	.....	890	21,907
Huron, Mich	.....	.....	.....	.....	12	264	.....	.....
Newark, N. J	.....	.....	1,071	31,802	462	13,240	443	10,175
New Orleans, La	172	5,705	150	4,750	.....	.....	100	2,087
New York, N. Y	24,524	721,092	21,867	654,997	28,240	690,989	36,543	827,193
Philadelphia, Pa	12,549	385,671	9,216	256,224	6,657	167,222	11,704	263,467
Providence, R. I	600	18,232	1,739	45,487	519	11,479	.....	.....
San Francisco, Cal	483	17,367	862	27,768	256	7,548	224	4,528
Savannah, Ga	.....	.....	725	15,370	.....	.....	.....	.....
Total	48,966	1,473,678	43,443	1,242,788	47,922	1,173,156	65,919	1,487,698

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Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1876 to 1896—Continued.

Countries whence exported and customs districts through which imported.	1880.		1881.		1882.		1883.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRIES.	*Long tons.*		*Long tons.*		*Long tons.*		*Long tons.*	
England	1	$22	.....	.....	.....	.....	13	$379
Scotland	1,604	36,444	1,668	$43,311	755	$20,294	3	88
France	988	23,580	.....	.....	526	13,770	34	858
French West Indies	.....	.....	.....	.....	2	8	.....	.....
Greece	.....	.....	.....	.....	500	13,927	.....	.....
Italy	80,301	1,862,712	102,771	2,645,293	92,944	2,504,862	92,861	2,248,870
Japan	282	4,744	691	16,253	2,980	66,356	1,038	23,714
San Domingo	.....	.....	.....	.....	240	7,875	.....	.....
Spain	.....	.....	308	8,637	.....	.....	500	12,856
Spanish possessions in Africa and adjacent islands	.....	.....	.....	.....	9	310	87	2,030
Total	83,236	1,927,502	105,438	2,713,494	97,956	2,627,402	94,536	2,288,795
DISTRICTS.								
Baltimore, Md	13,827	313,342	16,477	430,917	13,781	364,384	11,977	286,438
Beaufort, S. C	.....	.....	.....	.....	540	13,889	.....	.....
Boston and Charlestown, Mass	8,207	183,486	8,860	226,801	7,467	194,317	7,756	173,569
Charleston, S. C	1,061	25,398	3,065	78,741	6,025	161,281	4,051	106,235
Middletown, Conn	.....	.....	.....	.....	9	310	.....	.....
New Orleans, La	280	7,121	100	2,646	230	6,516	428	10,378
New York, N. Y	46,657	1,083,784	57,608	1,453,082	46,531	1,260,222	45,385	1,110,313
Philadelphia, Pa	10,679	254,892	17,987	477,547	14,839	408,611	22,772	549,095
Providence, R. I	1,255	31,155	650	17,507	1,244	33,036	535	13,830
Richmond, Va	.....	.....	.....	.....	660	17,760	.....	.....
San Francisco, Cal	1,270	28,324	691	16,253	6,054	151,234	1,072	24,572
Savannah, Ga	.....	.....	.....	.....	586	15,842	560	14,365
Total	83,236	1,927,502	105,438	2,713,494	97,956	2,627,402	94,536	2,288,795

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Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1876 to 1896—Continued.

Countries whence exported and customs districts through which imported.	1884. (a)		1885.		1886.		1887.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRIES.	*Long tons.*		*Long tons.*		*Long tons.*		*Long tons.*	
Belgium	.....	.....	190	$4,766	60	$1,718	.....	.....
Danish West Indies	.....	.....	.....	.....	.....	.....	861	$5,250
England	.....	.....	606	15,084	81	2,535	162	4,437
France	.....	.....	.....	.....	.....	.....	290	6,951
Quebec, Ontario, Manitoba, and the Northwest Territory	.....	.....	.....	.....	.....	9	.....	.....
Italy	.....	.....	94,370	1,894,858	112,283	2,166,565	89,924	1,588,146
Japan	.....	.....	1,541	25,683	4,972	66,505	6,146	83,576
Spain	.....	.....	134	1,552	.....	.....	.....	.....
Total	105,143	$2,242,678	96,841	1,941,943	117,396	2,237,332	97,383	1,688,360
DISTRICTS.								
Baltimore, Md	15,037	303,226	14,505	285,006	19,307	364,958	12,547	225,669
Barnstable, Mass	650	16,163	480	11,040	1,617	35,385	1,152	22,816
Beaufort, S. C	600	13,259	610	12,847	.....	.....	.....	.....
Boston and Charlestown, Mass	5,294	112,152	5,125	99,712	3,681	69,898	4,850	85,575
Champlain, N. Y	.....	.....	.....	.....	.....	9	.....	.....
Charleston, S. C	6,125	132,570	8,525	169,564	13,350	265,265	12,420	220,598
New Orleans, La	.....	.....	102	2,282	250	5,102	.....	.....
New York, N. Y	52,478	1,135,725	45,537	909,123	58,758	1,115,519	46,711	792,114
Philadelphia, Pa	18,786	401,568	18,696	381,010	15,568	300,749	15,267	269,216
Providence, R. I	651	15,517	1,840	37,422	1,265	25,930	600	11,291
San Francisco, Cal	5,522	112,598	1,421	33,937	3,600	54,517	3,176	50,521
All other customs districts	.....	.....	.....	.....	.....	.....	660	10,560
Total	105,143	2,242,678	96,841	1,941,943	117,396	2,237,332	97,383	1,688,360

a Sources not reported.

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Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1876 to 1896—Continued.

Countries whence exported and customs districts through which imported.	1888.		1889.		1890.		1891.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRIES.	*Long tons.*		*Long tons.*		*Long tons.*		*Long tons.*	
Belgium	83	$1,993	180	$4,086	182	$3,995	267	$6,576
Danish West Indies	.....	.....	.....	.....	550	9,076	.....	.....
England	310	7,200	305	8,337	4,898	101,100	5,613	127,976
Scotland	.....	.....	.....	.....	20	467	.....	.....
Italy	92,528	1,499,720	123,260	1,935,368	115,240	1,800,585	101,660	2,140,516
Japan	6,332	72,729	6,441	77,853	21,031	221,316	12,763	168,073
Other countries	.....	.....	.....	.....	.....	.....	501	8,372
Total	99,253	1,581,582	130,191	2,025,644	141,921	2,136,559	120,804	2,451,513
DISTRICTS.								
Baltimore, Md	11,989	182,769	15,791	234,693	21,198	322,018	9,339	247,324
Beaufort, S. C	500	9,000	600	9,213	.....	.....	1,300	26,951
Boston and Charlestown, Mass	3,760	62,298	6,446	104,257	7,410	135,044	6,381	136,402
Charleston, S. C	12,005	199,048	23,377	364,859	15,752	255,106	28,281	557,384
Mobile, Ala	.....	.....	.....	.....	.....	.....	750	14,863
New Orleans, La	200	3,845	.....	.....	200	3,397	1,300	30,474
New York, N. Y	50,486	816,286	60,922	959,872	66,359	983,754	44,027	910,075
Pensacola, Fla	.....	.....	.....	.....	.....	.....	1,399	23,206
Philadelphia, Pa	10,519	173,699	13,288	202,357	13,919	210,576	10,842	216,763
Providence, R. I	1,310	21,012	570	8,581	1,240	19,160	.....	.....
San Francisco, Cal	6,352	78,732	4,539	57,925	8,223	87,391	8,819	115,637
Savannah, Ga	.....	.....	2,345	44,244	5,560	86,826	5,245	99,717
Willamette, Oreg	.....	.....	.....	.....	.....	.....	288	11,852
Wilmington, N. C	1,532	25,893	1,753	28,443	2,040	32,800	2,832	60,843
All other customs districts	600	9,000	560	11,200	20	287	1	22
Total	99,253	1,581,582	130,191	2,025,644	141,921	2,136,559	120,804	2,451,513

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Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1876 to 1896—Continued.

Countries whence exported and customs districts through which imported.	1892.		1893.		1894.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COUNTRIES.	*Long tons.*		*Long tons.*		*Long tons.*	
England	6,522	$162,616	8,777	$196,149	12,435	$228,300
Scotland	.....	.....	1,452	27,288	.....	.....
France	1	23	.....	.....	.....	.....
Quebec, Ontario, etc	1	49	8	269	.....	.....
Italy	90,668	2,147,942	103,146	1,958,303	68,854	1,031,690
Spain	.....	.....	.....	.....	899	15,343
Japan	12,227	213,776	8,307	133,455	4,777	62,567
Total	109,419	2,524,406	121,690	2,305,464	86,965	1,337,900
DISTRICTS.						
Baltimore, Md	9,981	263,293	13,759	271,949	9,854	132,272
Beaufort, S. C	.....	.....	.....	.....	.....	.....
Boston and Charlestown, Mass	9,086	221,033	11,001	224,624	12,649	227,976
Charleston, S. C	14,651	364,593	10,885	209,246	10,560	163,358
Mobile, Ala	.....	.....	.....	.....	774	12,740
New Orleans, La	2,118	47,165	2,441	43,970	2,407	34,184
New York, N. Y	52,647	1,191,169	57,474	1,085,289	35,319	548,742
Norfolk and Portsmouth, Va	.....	.....	.....	.....	.....	.....
Philadelphia, Pa	9,380	211,570	12,625	241,293	5,149	73,980
Portland, Me	2,000	42,460	.....	.....	.....	.....
Providence, R. I	.....	.....	.....	.....	700	9,063
San Francisco, Cal	7,256	127,797	7,766	125,507	4,424	59,790
Savannah, Ga	.....	.....	4,650	86,562	2,712	42,439
Willamette, Oreg	398	6,866	541	7,948	559	6,647
Wilmington, N. C	1,900	48,388	540	8,807	1,858	26,709
Vermont	.....	.....	8	209	.....	.....
All other customs districts	2	72	.....	.....	.....	.....
Total	109,419	2,524,406	121,690	2,305,464	86,965	1,337,900

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Statement, by countries and by customs districts, showing the imports into the United States of crude sulphur or brimstone each fiscal year from 1876 to 1896—Continued.

Countries whence exported and customs districts through which imported.	1895.		1896.	
	Quantity.	Value.	Quantity.	Value.
COUNTRIES.	*Long tons.*		*Long tons.*	
England	17,332	$272,807	15,640	$248,498
Italy	96,162	1,296,989	125,850	1,586,551
Japan	14,241	130,988	8,997	95,244
Total	127,735	1,700,784	150,487	1,930,293
DISTRICTS.				
Baltimore, Md	10,706	150,129	13,759	169,666
Beaufort, S. C	800	11,669	660	8,250
Boston and Charlestown, Mass	19,683	301,749	19,564	304,374
Charleston, S. C	11,576	143,915	9,730	118,885
Mobile, Ala	880	13,027	.....	.....
New Orleans, La	1,260	17,179	2,139	28,711
New York, N. Y	55,484	702,998	74,281	914,504
Norfolk and Portsmouth, Va	700	8,368	2,400	31,970
Philadelphia, Pa	8,216	110,841	9,085	122,195
Portland, Me	.....	.....	1,600	21,435
Providence, R. I	1,604	21,779	580	7,276
Puget Sound, Wash	.....	.....	458	5,710
San Francisco, Cal	6,356	64,758	6,370	66,934
Savannah, Ga	8,965	135,816	7,764	102,905
Willamette, Oreg	885	9,423	47	720
Wilmington, N. C	620	9,133	2,050	26,758
Total	127,735	1,700,784	150,487	1,930,293

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Total exports of sulphur from Sicily since 1883—Continued.

Country.	1890.	1891.	1892.	1893.	1894.	1895.	1896.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United States	106,656	97,520	84,450	83,901	105,773	99,227	124,923
France	71,790	56,168	73,176	89,736	56,932	69,696	76,739
Italy	40,231	42,212	38,711	54,486	49,895	49,349	54,009
United Kingdom	26,213	23,408	24,853	27,453	22,165	24,043	21,913
Greece and Turkey	18,103	11,414	*a*14,845	*a*13,840	*a*16,870	*a*16,195	*a*18,556
Portugal	16,695	11,439	13,490	14,545	8,670	14,562	12,001
Russia	17,158	11,930	14,178	19,730	17,977	17,962	18,752
Germany	15,703	10,629	14,326	16,259	16,437	15,472	15,680
Austria	8,746	10,575	9,096	10,169	11,494	12,170	13,799
Turkey	4,231	3,000	(*a*)	(*a*)	(*a*)	(*a*)	(*a*)
Spain	5,679	3,845	7,382	3,499	3,445	5,753	5,910
Belgium	7,279	5,089	5,133	4,358	5,644	6,410	7,527
Holland	.....	.....	2,183	2,957	2,365	3,335	3,834
Sweden	3,314	2,252	4,561	6,579	7,887	5,730	14,540
Australia	.....	.....	1,200	.....	.....	.....	.....
Denmark	400	300	(*b*)	(*b*)	(*b*)	(*b*)	(*b*)
Other countries	2,565	3,542	3,152	1,680	3,376	7,732	8,562
Total	344,763	293,323	310,736	349,192	328,930	347,636	396,745

a Exports to Greece and Turkey combined after 1892. *b* Included in exports to Sweden.

PORTS IN THE UNITED STATES RECEIVING SICILIAN SULPHUR.

The ports in the United States to which such shipments were made, together with the amount shipped to each since 1883, and the quality of the shipments since 1886, are shown in the following tables:

Ports in the United States receiving Sicilian sulphur and the amount received by each.

Port.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
New York	41,238	46,460	50,814	49,952	45,979	60,706	55,939
Charleston	5,425	7,706	12,416	10,556	14,324	22,496	12,399
Philadelphia	23,123	19,234	12,153	15,662	11,764	11,793	14,334
Baltimore	16,175	13,986	16,435	15,680	10,306	17,330	15,316
Boston	5,864	4,723	4,200	3,800	3,300	6,300	4,950
Wilmington, N. C.	.....	.....	.....	.....	1,020	2,355	2,040
Savannah	.....	.....	.....	.....	.....	3,545	3,240
Port Royal	600	610	680	660	1,000	600	.....
Providence	650	1,140	1,370	1,180	630	1,250	590
Sundries	670	.....	.....	.....	600	480	.....
San Francisco	1,884	500	.....	.....	296	.....	.....
New Orleans	350	100	250	.....	200	250	200
Woods Hole	650	470	1,060	1,100	.....	1,160	.....
Total	96,629	94,929	99,378	98,590	89,419	128,265	109,008

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EXPORTS OF SICILIAN SULPHUR.

The figures in the following tables, showing exports of sulphur from Sicily, the countries to which exported, and the ports through which the imports into the United States were received, have been furnished by Mr. A. S. Malcomson, of New York:

Total exports of sulphur from Sicily since 1883.

Country.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
United States	96,629	94,929	99,378	98,590	89,419	128,265	109,008
France	63,602	65,098	58,264	54,280	56,222	52,083	67,340
Italy	66,810	56,292	49,415	48,658	48,997	47,664	43,522
United Kingdom	41,788	40,760	33,402	30,236	30,007	35,634	39,203
Greece	10,494	7,033	13,664	19,697	18,370	5,809	10,158
Portugal	15,298	11,018	17,760	30,943	16,587	15,851	16,799
Russia	10,413	12,831	13,420	10,570	13,441	22,043	17,678
Germany	7,232	6,622	6,103	8,689	9,700	12,402	15,401
Austria	4,915	6,037	5,965	5,800	6,702	8,942	8,984
Turkey	3,043	1,285	3,077	4,598	6,238	1,457	2,231
Spain	5,242	3,920	2,243	5,890	5,873	3,433	6,586
Belgium	7,660	6,793	9,516	6,580	5,318	6,951	7,752
Holland	1,256	696	1,237	2,999	1,747	2,793	2,424
Sweden	1,010	744	328	1,916	1,169	3,004	3,899
South America	.....	.....	.....	.....	710	95	23
Australia	.....	.....	.....	.....	600	885	.....
Denmark	.....	.....	810	.....	202	464	443
Total	335,392	314,058	314,582	329,446	311,302	347,775	351,451

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Quality of Sicilian sulphur received at the different ports, etc.—Continued.

Port.	1890.		1891.		1892.		1893.	
	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
New York	20,801	16,589	29,358	19,665	34,390	14,700	29,146	14,250
Charleston	20,873	6,690	17,196	4,450	4,010	500	11,665	1,860
Philadelphia	1,000	10,094	450	6,406	3,600	6,800	1,900	6,260
Baltimore	5,930	10,770	4,510	6,855	900	11,455	2,050	7,900
Boston	200	2,300	1,300	650	1,825	1,500	500	.....
Savannah	2,750	3,170	850	700	600	570	3,450	1,880
Wilmington, N. C.	1,309	.....	1,900	700	.....	.....	.....	1,140
New Orleans	.....	.....	.....	.....	.....	.....	1,900	.....
Other ports	1,540	2,640	1,200	1,330	4,000	.....	.....	.....
Total	54,403	52,253	56,764	40,756	49,325	35,525	50,611	33,290

Port.	1894.		1895.		1896.	
	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.	Best unmixed seconds.	Best thirds.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
New York	33,150	13,725	35,888	19,975	50,557	17,796
Charleston	3,273	12,023	700	8,450	2,330	5,370
Philadelphia	350	5,050	1,200	7,150	500	5,500
Baltimore	600	14,700	1,100	8,620	3,650	10,500
Boston	1,017	3,300	2,350	2,600	4,600	700
Savannah	5,695	4,100	3,784	800	8,370	1,025
Wilmington, N. C.	.....	1,890	.....	650	1,260	1,400
New Orleans	2,400	.....	1,700	.....	2,100	.....
Other ports	800	3,700	1,880	2,380	7,975	1,290
Total	47,285	58,488	48,602	50,625	81,342	43,581

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PYRITES.

PRODUCTION.

The output of iron pyrites for use in the manufacture of sulphuric acid in 1896 was the largest ever obtained, amounting to 115,483 long tons, against 99,549 long tons in 1895, an increase of 15,934 long tons, or more than 15 per cent. The largest production in any previous year was in 1892, when 109,788 long tons were mined. The increase in 1896 was in the face of an increased output of sulphur from American mines, abnormally large importations of brimstone, and an increase of 9,733 long tons of iron pyrites from foreign sources. The conditions affecting the pyrites industry are closely allied to those affecting the production, prices, and consumption of sulphur. They have been considered in the foregoing report on the latter subject and need not be treated here. It may be stated here, however, that during the past few years pyrites has largely superseded the use of sulphur for acid making. During 1896 the rapid and almost revolutionary advance in the price of Sicilian sulphur has stimulated the production of pyrites and caused the changing of a number of furnaces from sulphur burners to pyrites burners. It is claimed that acid made from pyrites may be used for purposes representing 95 per cent of the total consumption, and that with brimstone at $15 acid from pyrites can be produced more cheaply It is probable that its use would have been still larger at the present time but for the expense and trouble of making the necessary changes in the furnaces.

The increasing use of pyrites is not confined to the United States. England, Germany, and France are now large consumers. Spain is one of the most important sources of supply for the European market, and furnishes a large percentage of the pyrites imported into the United States. France produced in 1895 248,934 long tons of pyrites, valued at $617,021, and averaged about 245,000 tons in the five years from 1891 to 1895, inclusive.

The *Revista Minera de Espana* reports the amount of pyrites exported from Spain (the principal source of this ore) in 1895 to have been 480,255 long tons. Four years before, in 1891, the exports were 279,161 long tons. In 1892 they were 435,906 long tons; in 1893, 393,453 long tons, and in 1894, 511,769 long tons.

The reports of production in and exports of pyrites from Spain show unreconcilable figures. As the export statistics are probably obtained from the customs house, they are considered more reliable, and are presented in the table on the next page, together with the amount produced in the United States, Canada, and France. These cover practically all of the pyrites output of the world. In connection with this table is given an estimate of the amount of sulphur displaced in the markets of the world by the use of iron pyrites.

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World's product of iron pyrites and amount of sulphur displaced. (*a*)

Countries.	1891.	1892.	1893.	1894.	1895.	1896.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Spain (*b*)	279,161	435,906	393,453	511,769	480,255	.....
France	243,030	226,304	227,288	278,452	248,934	.....
United States	106,536	109,788	75,777	105,940	99,549	115,483
Canada	60,474	53,372	52,270	36,185	30,534	.....
Total	689,211	825,370	748,788	932,346	859,272	.....
Sulphur displaced	310,145	371,416	336,955	419,556	386,672	.....

a Based on estimated 45 per cent of sulphur contents. *b* Exports only.

The amount and value of pyrites mined for sulphur contents in the United States since 1882 have been as follows:

Production of pyrites in the United States from 1882 to 1896.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Long tons.			*Long tons.*	
1882	12,000	$72,000	1890	99,854	$273,745
1883	25,000	137,500	1891	106,536	338,880
1884	35,000	175,000	1892	109,788	305,191
1885	49,000	220,500	1893	75,777	256,552
1886	55,000	220,000	1894	105,940	363,134
1887	52,000	210,000	1895	99,549	322,845
1888	54,331	167,658	1896	115,483	320,163
1889	93,705	202,119			

IMPORTS.

The following table shows the imports of pyrites containing not more than 3.5 per cent of copper from 1884 to 1896:

Imports of pyrites containing not more than 3.5 per cent of copper from 1884 to 1896. (*a*)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Long tons.			*Long tons.*	
1884	16,710	$50,632	1892	152,359	$587,980
1885	6,078	18,577	1893	194,934	721,699
1886	1,605	9,771	1894	163,546	590,905
1887	16,578	49,661	1895	190,435	673,812
1891	100,648	392,141	1896	200,168	648,396

a Previous to 1884 classed among sulphur ores; 1887 to 1891 classed among other iron ores; since 1891 includes iron pyrites containing 25 per cent and more of sulphur.

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CONSUMPTION.

As the imports of iron pyrites for use in the manufacture of sulphuric acid were not stated separately by the Bureau of Statistics of the Treasury Department prior to 1891, a comparison with the preceding years can not be made. The following table shows the amount of pyrites mined and imported for the past five years, and as no exports are reported by the Treasury Department, these figures may be accepted as representing the domestic consumption. The table also shows the estimated amount of sulphur displaced each year on a basis of 45 per cent of sulphur contents.

Amount of pyrites consumed in the United States, and estimated sulphur displaced, from 1891 to 1896.

Source.	1891.	1892.	1893.	1894.	1895.	1896.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
Domestic product.....	106,536	109,788	75,777	105,940	99,549	126,384
Imports.....	100,648	152,359	194,934	163,546	190,435	200,168
Domestic consumption.....	207,184	262,147	270,711	269,486	289,984	326,552
Sulphur displaced estimated on basis of 45 per cent contents.	93,233	117,966	121,815	121,269	130,493	146,948

OCCURRENCES IN THE UNITED STATES.

There are four localities in the United States where pyrites for acid making is produced, namely, in Franklin County, Massachusetts; Louisa and Prince William counties, Virginia, and in Gaston County, North Carolina. The mineral is found in nearly every one of the United States, but either low percentage of sulphur or the smallness or inaccessibility of the deposits has restricted the production to the four localities mentioned. In the report for 1895 mention was made of the pyrites deposits in Arkansas. Since that report was published a company has been organized for the development of the property, and it is stated that before the close of 1897 the ore will be upon the market.

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GYPSUM.

By Edward W. Parker.

OCCURRENCE.

Large deposits of gypsum are found in many of the United States. East of the Mississippi River the principal localities are in New York, where it occurs in beds of great thickness and extent in a line of counties extending westward from Oneida to Niagara; in Ohio, near the city of Sandusky; in Michigan, on the Grand River, near Grand Rapids, and at Alabaster Point, Iosco County, and in Bay County; in Virginia, along the north fork of the Holston River, and in Smyth and Washington counties. Gypsum is also reported in Alabama and Louisiana, but the deposits are not worked at the present time. West of the Mississippi River and east of the Rocky Mountains extensive gypsum deposits are found in Iowa, Kansas, Arkansas, Texas, Oklahoma, and the Indian Territory. Operations are carried on in Webster County, Iowa; Barber, Saline, Marion, Marshall, and Dickinson counties, Kansas; at Quanah, Texas, and at Okarche, Oklahoma.

The Rocky Mountain States producing gypsum are Colorado, Montana, Utah, South Dakota, and Wyoming, and deposits are reported in Idaho and New Mexico. Extensive stratified deposits of gypsum occur in the Santa Rita range of mountains in Pima County, southern Arizona. They were discovered by Prof. William P. Blake, in February, 1896, when examining the copper ore deposits of that region. Professor Blake is of the opinion that the gypsum has a wide geographical distribution, but the place in which it was noted by him is in the low hills toward the northern end of the Santa Rita range, about 20 miles northeast of Tucson, and 15 miles, or possibly less, from the line of the Southern Pacific Railway. The strata stand at a high angle, nearly on edge. Some of the layers are exceedingly tough and compact, others are covered upon the outcrop by a thick accumulation of a white, ashes-like substance, mostly lime sulphate. The thickness of the series is estimated at over 200 feet. These strata of gypsum are regarded by Professor Blake as a part of a great series of sandstone shales and quartzites above the lower Carboniferous limestone, and referable, probably, to the Coal Measure period. These deposits have not yet been explored or opened. The high rates of freight to a suitable market will probably prevent the profitable utilization of this material, at least for sometime to come.

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Some work has been done on another deposit of gypsum in the Sierritas, about 18 miles south of Tucson. The material was shipped to Tucson and calcined into plaster of paris for plastering the Roman Catholic cathedral in that city, but diligent inquiry has failed to obtain definite information of any commercial product in 1896.

Among the Pacific States California has been the only producer of gypsum in commercial quantity, though an extensive deposit, upon which some work has been done, is reported in eastern Oregon. The Oregon deposit is located in the high bluffs extending along both sides of the Snake River into western Idaho. It is about six or seven miles from Huntington, in Baker County, and a mill having a capacity of 50 tons of calcined plaster per day has been erected at Huntington, and 1,800 tons of rock were quarried in 1896, but none of this was marketed before the close of the year and is not included in the product.

The States on the eastern slope of the Rocky Mountains are particularly rich in valuable gypsum deposits, of quality suitable for high-grade plaster of paris. Over 43 per cent of the total product of gypsum in 1896 was obtained from Iowa, Kansas, Indian Territory, South Dakota, and Texas, and more than 95 per cent of this product was calcined. The writer had an opportunity recently of visiting one of these deposits near the town of Quanah, in the northwestern part of Texas. This deposit is an exceedingly interesting one. It is located on both sides of South Groesbeck Creek, 5 miles west of Quanah. The Fort Worth and Denver Railroad crosses the deposit, affording ample transportation facilities. The gypsum rock lies about 12 feet below the surface, the overburden consisting of a similar material in a disintegrated condition, known as "gypsite" or "dirt." Part of this dirt is gray in color, but most of it is almost snow-white. It is all used, there being practically no waste. The "dirt" is mined by scrapers drawn by mules, the gray and white materials being mixed before charging into the calcining kettles or tanks. Care is taken to secure about the same mixture for each charge. The calcined product of the "dirt" is of an attractive shade of gray color, and is used entirely for wall plaster. It is of excellent quality so far as color and durability are concerned, and sells at a higher price than the plaster made from the gypsum rock, which is of brilliant white, and is used for the white coating over plastered walls, and the usual purposes of plaster of paris in the arts. A finer grade of the white plaster is used by dentists for making plaster casts. This gypsum deposit has been developed by the erection of a large mill, fitted with the most modern appliances for economical work, such as conveyors, crushing mills, screens, etc., and the amount of hand labor necessary is reduced to a minimum. The mill is erected directly on the deposit, and the crude "dirt" and rock are obtained a few feet from the door of the mill. The property upon which the deposit is exposed covers several acres, though the beds probably extend under ground for a number of miles in all directions, as artesian water from wells

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within a radius of 5 miles is highly impregnated with gypsum, similar to that of the creek crossing the deposit. The water is commonly known as "gyp" water in the neighborhood. It is not fit for drinking purposes for men, but horses and cattle seem to thrive on it.

On the western slope of the Alleghany Mountains the two States producing gypsum are Ohio and Michigan. These two States alone produced 40 per cent of the gypsum product in 1896. Nearly the entire output is calcined, only the otherwise wasted material being ground for land plaster.[1] On the eastern slope of the Alleghanies, New York, and Virginia are the only producers. New York's product is used principally for land plaster; no calcined plaster was reported from this State in 1896. Out of 5,955 tons of gypsum produced in Virginia in 1896, 1,200 tons, slightly more than 20 per cent, was calcined; all of the rest was sold for land plaster.

PRODUCTION.

The gypsum product of the United States in 1896 amounted to 224,254 short tons, against 265,503 short tons in 1895, a decrease of 41,249 short tons, or 15.5 per cent. The percentage of decrease in the amount produced was small compared with the decline in value. In 1895 the total value of gypsum produced (reckoning the value in the condition in which the material was first marketed) was $797,447, an average of $3 per ton. The total value of the product of 1896 was $573,344, an average of $2.55 per ton. The actual decrease in value was $224,103. Considering separately the conditions in which the product was marketed, it is seen that the principal decrease in value was in the calcined plaster. During 1895, 203,800 tons of crude rock were calcined, yielding 150,801 tons of calcined plaster, worth $4.47 per ton on an average. In 1896, 179,598 tons of crude rock produced 137,405 tons of plaster of paris, which sold for a little less than $3.60 per ton. The sales of land plaster in 1895 were 35,079 short tons, averaging $2.40 per ton. Land plaster sales in 1896 were 27,354 short tons, averaging $2.18 per ton. Crude gypsum sold in 1895 amounted to 26,624 short tons, at an average of $1.42 per ton; in 1896, 17,302 short tons were sold at an average price of $1.10 per ton. Thus it will be seen that there was a general decrease not only in product, but also in the average price.

Considering the product in the two years, by States, it will be observed that but five States show an increase in product, and with the exception of Texas the increases are unimportant. Colorado increased her output from 1,371 to 1,600 tons; Michigan from 66,519 to 67,634 tons; Ohio from 21,662 to 22,364 tons; Virginia from 5,800 to 5,955 tons; and Texas from 10,750 to 16,022 tons. California's product decreased from 5,158 to 1,452 tons; Iowa's output decreased from 25,700 to 18,631 tons;

[1] For detailed descriptions of gypsum deposits in the United States not treated more fully in this article, see Mineral Resources of the United States, 1882, 1883–84, 1885, and 1886.

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Kansas from 72,947 to 49,435 tons; New York from 33,587 to 23,325 tons; and South Dakota from 6,400 to 6,100 tons.

The details of production, by States, for the past two years are shown in the following tables:

Product of gypsum in the United States in 1896, by States.

State.	Total product.	Sold crude.		Ground into land plaster.		Calcined into plaster of paris.			Total value.
		Quantity.	Value.	Quantity.	Value.	Before calcining.	After calcining.	Value.	
	Short tons.	*Short tons.*		*Short tons.*		*Short tons.*	*Short tons.*		
California	1,452	100	$463	506	$4,220	846	706	$7,055	$11,738
Colorado	1,600	.....	.....	.....	.....	1,600	1,287	10,547	10,547
Iowa	18,631	15	15	637	650	17,979	14,285	33,355	34,020
Kansas	49,435	42	63	250	500	49,143	37,214	147,808	148,371
Michigan	67,634	700	875	6,582	9,133	60,352	46,921	136,416	146,424
New York	23,325	10,256	6,177	13,069	26,635	.....	.....	.....	32,812
Virginia	5,955	115	195	4,640	13,710	1,200	966	3,359	17,264
Other States (*a*)	56,222	6,074	11,346	1,670	4,901	48,478	36,126	155,921	172,168
Total	224,254	17,302	19,134	27,354	59,749	179,598	137,505	494,461	573,344

a Includes the product of Indian Territory, 8,000 tons; Montana, 385 tons; Ohio, 22,634 tons; South Dakota, 6,115 tons; Texas, 16,022 tons; Utah, 2,866 tons; and Wyoming, 200 tons. The distribution of the output in these States and the value are combined in order to maintain the confidential nature of individual reports, there being only one or two operators in each State.

Product of gypsum in the United States in 1895, by States.

State.	Total product.	Sold crude.		Ground into land plaster.		Calcined into plaster of paris.			Total value.
		Quantity.	Value.	Quantity.	Value.	Before calcining.	After calcining.	Value of calcined plaster.	
	Short tons.	*Short tons.*		*Short tons.*		*Short tons.*	*Short tons.*		
California	5,158	.....	.....	1,368	$13,194	3,790	.....	$37,820	$51,014
Colorado	1,371	.....	.....	.....	.....	1,371	1,060	8,281	8,281
Iowa	25,700	.....	.....	1,200	600	24,500	16,000	36,000	36,600
Kansas	72,947	290	$452	250	500	72,407	54,465	271,579	272,531
Michigan	66,519	6,488	15,732	9,003	13,965	51,028	40,895	144,310	174,007
New York	33,587	12,182	6,492	16,765	36,664	4,640	3,480	16,165	59,321
Ohio	21,662	6,914	13,411	3,048	9,581	11,700	9,350	48,262	71,204
South Dakota	6,400	.....	.....	.....	.....	6,400	5,100	20,600	20,600
Texas	10,750	.....	.....	.....	.....	10,750	7,166	36,511	36,511
Virginia	5,800	750	1,750	3,201	10,001	1,849	1,648	5,618	17,369
Other States (*a*)	15,609	.....	.....	244	900	15,365	11,637	49,109	50,009
Total	265,503	26,624	37,837	35,079	85,355	203,800	150,801	674,255	797,447

a Includes Indian Territory, Utah, and Wyoming, in each of which the output is reported from only one company.

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Comparative statistics of gypsum production for eight years.

State.	1889.		1890.		1891.		1892.	
	Product.	Value.	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*		*Short tons.*	
California	.....	.....	.....	.....	.....	.....	(a)	(a)
Colorado	7,700	$28,940	4,580	$22,050	.....	.....	(a)	(a)
Iowa	21,789	55,250	20,900	47,350	31,385	$58,095	(a)	(a)
Kansas	17,332	94,235	20,250	72,457	40,217	161,322	46,016	$195,197
Michigan	131,767	373,740	74,877	192,099	79,700	223,725	139,557	306,527
New York	52,608	79,476	32,903	73,093	30,135	58,571	32,394	61,100
Ohio	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
South Dakota	320	2,650	2,900	7,750	3,615	9,618	.....	.....
Virginia	6,838	20,336	6,350	20,782	5,959	22,574	6,991	28,207
Other States	29,420	109,491	20,225	138,942	17,115	94,146	31,301	104,461
Total	267,769	764,118	182,995	574,523	208,126	628,051	256,259	695,492

State.	1893.		1894.		1895.		1896.	
	Product.	Value.	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*		*Short tons.*	
California	(a)	(a)	(a)	(a)	5,158	$51,014	1,452	$11,738
Colorado	(a)	(a)	(a)	(a)	1,371	8,281	1,600	10,547
Iowa	21,447	$55,538	17,906	$44,700	25,700	36,600	18,631	34,020
Kansas	43,631	181,599	64,889	301,884	72,947	272,531	49,435	148,371
Michigan	124,590	303,921	79,958	189,620	66,519	174,007	67,634	146,424
New York	36,126	65,392	31,798	60,262	33,587	59,321	23,325	32,812
Ohio	(a)	(a)	20,827	69,597	21,662	71,204	(a)	(a)
South Dakota	5,150	12,550	4,295	16,050	6,400	20,600	(a)	(a)
Texas	.....	.....	6,925	27,300	10,750	36,511	(a)	(a)
Virginia	7,014	24,359	8,106	24,431	5,800	17,369	5,955	17,264
Other States	15,657	53,256	4,608	27,875	15,609	50,009	56,222	172,168
Total	253,615	696,615	239,312	761,719	265,503	797,447	224,254	573,344

a Included in other States.

The following table shows the annual production of gypsum in the United States since 1880. It will be noticed that the largest production was in 1889, though the value in that year was less than in 1895:

Production of gypsum in the United States since 1880.

Year.	Product.	Value.	Year.	Product.	Value.
	Short tons.			*Short tons.*	
1880	90,000	$400,000	1889	267,769	$764,118
1881	85,000	350,000	1890	182,995	574,523
1882	100,000	450,000	1891	208,126	628,051
1883	90,000	420,000	1892	256,259	695,492
1884	90,000	390,000	1893	253,615	696,615
1885	90,405	405,000	1894	239,312	761,719
1886	95,250	428,625	1895	265,503	797,447
1887	95,000	425,000	1896	224,254	573,344
1888	110,000	550,000			

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IMPORTS.

The imports of gypsum are chiefly from Canada, the product from the Dominion being very pure and well adapted for the manufacture of plaster of paris. The following table exhibits the total amount and value of gypsum imported into the United States since 1867:

Gypsum imported into the United States from 1867 to 1896.

Year ended—	Ground or calcined.		Unground.		Value of manufactured plaster of paris.	Total.
	Quantity.	Value.	Quantity.	Value.		
	Long tons.		*Long tons.*			
June 30, 1867	.....	$29,895	97,951	$95,386	.....	$125,281
1868	.....	33,988	87,694	80,362	.....	114,350
1869	.....	52,238	137,039	133,430	$844	186,512
1870	.....	46,872	107,237	100,416	1,432	148,720
1871	.....	64,465	100,400	88,256	1,292	154,013
1872	.....	66,418	95,339	99,902	2,553	168,873
1873	.....	35,628	118,926	122,495	7,336	165,459
1874	.....	36,410	123,717	130,172	4,319	170,901
1875	.....	52,155	93,772	115,664	3,277	171,096
1876	.....	47,588	139,713	127,084	4,398	179,070
1877	.....	49,445	97,656	105,629	7,843	162,917
1878	.....	33,496	89,239	100,102	6,989	140,587
1879	.....	18,339	96,963	99,027	8,176	125,542
1880	.....	17,074	120,327	120,642	12,693	150,409
1881	.....	24,915	128,607	128,107	18,702	171,724
1882	5,737	53,478	128,382	127,067	20,377	200,922
1883	4,291	44,118	157,851	152,982	*a* 21,869	218,969
1884	4,996	42,904	166,310	168,000	.....	210,904
1885	6,418	54,208	117,161	119,544	.....	173,752
1886	5,911	37,642	122,270	115,696	.....	153,338
1887	4,814	37,736	146,708	162,154	.....	199,890
Dec. 31, 1888	3,340	20,764	156,697	170,023	.....	190,787
1889	5,466	40,291	170,965	179,849	.....	220,140
1890	7,568	55,250	171,289	174,609	.....	229,859
1891	9,560	97,316	110,257	129,003	.....	226,319
1892	6,882	75,608	181,104	232,403	.....	308,011
1893	3,363	31,670	164,300	180,254	.....	211,924
1894	2,027	16,823	162,500	179,237	.....	196,060
1895	3,295	21,526	192,549	215,705	10,352	247,583
1896	3,292	21,982	180,269	193,544	11,722	227,248

a Not specified from 1883 to 1894.

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As the imports of gypsum into the United States are principally from the Provinces of Ontario, New Brunswick, and Nova Scotia, in the Dominion of Canada, the following table, showing the production in and the exports from the Dominion, will be found interesting:

Production and exports of Canadian gypsum from 1886 to 1896.

Year.	Production.		Exports.	
	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*	
1886	162,000	$178,742	142,833	$155,213
1887	154,008	157,277	132,724	146,542
1888	175,887	179,393	125,508	121,389
1889	213,273	205,108	178,182	194,404
1890	226,509	194,033	175,691	192,254
1891	203,545	192,096	172,496	184,977
1892	226,568	225,260	175,518	194,304
1893	192,568	196,150	*a* 176,489	178,979
1894	223,631	202,031	162,412	160,082
1895	226,178	202,608	*a* 160,898	156,897
1896	205,203	174,403	.....	.....

a Entire exports went to the United States.

THE CHEMICAL COMPOSITION OF SOME KANSAS GYPSUMS.

Messrs. E. H. S. Bailey and W. M. Whitten have made interesting analyses of some of the gypsum rocks of Kansas. The result of their investigations has been published in the Kansas University Quarterly, Vol. VI, January, 1897. The samples were collected by Mr. G. P. Grimsley, who exercised great care to obtain average representations of the deposits. There are three areas in Kansas where gypsum deposits are now worked: in the vicinities of Blue Rapids, Gypsum, and Medicine Lodge. Only the two latter have been so far studied. In their report Messrs. Bailey and Whitten speak of the two grades of material used in the manufacture of plaster, the rock itself and a soft disintegrated material called "dirt."[1]

In the analyses which are given below seven specimens are from Dickinson County, three from Saline, and one each from Barber and Clay counties. There has been an active industry carried on in Dickinson County for the past ten years. Coupled with the analyses is a calculation for each rock showing the probable existence in nature of the constituents.

[1] In this respect the gypsum deposits of Kansas resemble those of Quanah, Texas, mentioned in the first part of this report.

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It is the intention of the investigators to treat the geological occurrence, methods of manufacture, and composition of the manufactured products in a subsequent report.

Chemical composition of some Kansas gypsum rocks.

Constituents.	1	2	3	4	5	6
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Silica and insoluble residue..	0.19	0.52	0.34	0.41	12.13	17.10
Iron and aluminum oxides...	.10	.26	.16	.29	.99	2.04
Calcium oxide	32.53	32.28	32.64	32.53	29.14	27.62
Magnesium oxide	.16	.98	.62	.29	.42	.59
Sulphuric anhydride.....	45.73	44.61	45.28	46.03	37.49	33.28
Carbon dioxide (calculated).	.81	1.90	1.42	.56	2.03	4.04
Water	20.46	19.47	19.63	19.70	16.75	15.16
Total.....	99.98	100.02	100.09	99.81	[a]98.95	99.83

Constituents.	7	8	9	10	11	12
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Silica and insoluble residue..	0.35	0.55	0.38	4.54	3.06	18.69
Iron and aluminum oxides...	.12	.23	.16	.54	.34	1.21
Calcium oxide	32.57	32.64	32.04	22.31	33.90	26.71
Magnesium oxide	.27	.22	.46	.28	.41	.43
Sulphuric anhydride.....	46.12	45.95	45.77	42.10	39.60	33.27
Carbon dioxide (calculated).	.57	.63	.50	2.54	5.34	3.15
Water	19.96	19.54	20.37	17.82	17.24	15.29
Total.....	99.96	99.76	99.68	100.13	[a]99.89	[a]98.75

[a] Alkalies undetermined.

According to the above analyses the probable composition of the rocks in nature is shown below:

Probable composition, in nature, of the gypsum rocks of Kansas.

Constituents.	1	2	3	4	5	6
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Silica and insoluble residue..	0.19	0.52	0.34	0.41	12.13	17.10
Iron and aluminum oxides...	.10	.26	.16	.29	.99	2.04
Calcium sulphate	77.46	75.84	76.98	78.25	64.63	56.58
Calcium carbonate.....	1.43	1.87	1.68	.55	3.57	7.71
Magnesium carbonate.....	.34	2.06	1.30	.51	.88	1.24
Water	20.46	19.47	19.63	19.70	16.75	15.16
Total.....	99.98	100.02	100.09	99.81	98.95	99.83

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Probable composition, in nature, of the gypsum rocks of Kansas—Continued.

Constituents.	7	8	9	10	11	12
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Silica and insoluble residue..	0.35	0.55	0.38	4.54	3.06	18.69
Iron and aluminum oxides...	.12	.23	.16	.54	.34	1.21
Calcium sulphate	78.40	78.11	77.81	71.57	67.32	56.56
Calcium carbonate.....	.56	.86	.....	5.07	11.03	6.10
Magnesium carbonate.....	.57	.47	.96	.59	.90	.90
Water	19.96	19.54	20.37	17.82	17.24	15.29
Total.....	99.96	99.76	99.68	100.13	99.89	98.75

The localities from which the above samples were taken are: No. 1, Medicine Lodge; No. 2, Hope shaft; No. 3, shaft west of Hope; No. 4, from bowlders on a hill near Hope; No. 5, "dirt" used at Dillon mill; No. 6, "dirt" from a place 3 miles south of Dillon; No. 7, rock from a small quarry a little south of Dillon; No. 8, rock from mine at Solomon Mills; No. 9, rock about one-fourth of a mile east of Solomon mills (No. 9 is mixed in small quantities with No. 8); No. 10, "dirt" from Acme Cement Plaster Company's property near Gypsum city; No. 11, "dirt" from Acme Cement Plaster Company's property at Rhodes; No. 12, dirt from Longford mill.

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SALT.

By Edward W. Parker.

PRODUCTION.

Salt production in the United States has shown an increase since 1889, and, except for one year, since 1883. In 1896 the amount of salt made and mined in the United States amounted to 13,850,726 barrels of 280 pounds, valued at $4,040,839. Compared with the output in 1895, this shows an increase of 181,077 barrels in amount, but a decrease in value of $382,245. In fact, the value of the 13,850,726 barrels produced in 1896 was $113,829 less than it was in 1893, when the product was 11,897,208 barrels, nearly two million barrels less than it was in 1896. Considering the production of salt in the past four years, it will be seen that the manufacturers have found very little profit or encouragement. In 1893 the output amounted to 11,897,208 barrels, valued at $4,154,668, a little less than 35 cents per barrel of 280 pounds.

In 1894 the product increased over a million barrels—to 12,967,417 barrels, valued at $4,739,285—about 36½ cents per barrel. In the following year the price dropped to 32 cents a barrel with an output of 13,669,649 barrels. A still further increase is noted in the product for 1896, but the price declined to 29 cents per barrel—little more than one-tenth of a cent per pound. It must be remembered that this includes not only the cheap grades of salt, such as coarse salt made by solar evaporation, but it also includes the very finest grades of table and dairy salt, which are prepared with great care and at expense, and which constitute about 16 per cent of the total product. Thirteen per cent of the product in 1896 was rock salt. The product of "coarse solar" was 18 per cent of the total. Common fine salt constitutes nearly one-half of the entire product, 47 per cent of the output in 1896 being of this grade.

Common fine salt is a medium between the higher grades, prepared especially for dairy and table use, and the coarser grades used by packers, agriculturists, stockmen, silver smelters, etc. It is largely used for table and dairy purposes when the higher prices charged for the finer grades render them undesirable on economical grounds. The average price per barrel received by manufacturers in 1896 for common fine salt was 23. 9 per barrel. The largest producer of common fine salt

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is Michigan, whose product of this grade in 1896 was 2,954,608 barrels, averaging 19 cents per barrel. Ohio produced 1,173,295 barrels, at an average price of 26 cents per barrel. New York produced 1,021,228 barrels, which sold for an average of 26 cents per barrel. The output of Kansas in common fine salt was 922,623 barrels, bringing an average of 29 cents per barrel. Pennsylvania produced 177,312 barrels and West Virginia 171,921 barrels, averaging 26.7 cents and 30 cents, respectively.

During the ten years following 1883 salt of domestic production replaced a great deal of English and other imported salt, because of improved methods of refining adopted in this country, which have enabled producers to successfully compete in quality of the product with the output of the best works of the Old World. In 1881 the imports of salt exceeded 1,000,000,000 pounds, though this was exceptional. The importations in 1883 amounted to 867,915,603 pounds; in 1888, five years later, they had decreased to 625,030,735 pounds, and in another five years (1893) to 348,519,173 pounds. The placing of salt on the free list in August, 1894, increased importations in that year to 434,155,708 pounds, in 1895 to 559,161,669 pounds. In 1896 the imports amounted to 520,411,822 pounds.

The following tables exhibit the details of salt production in the United States in 1895 and 1896 by States, with approximate distribution according to grades.

Production of salt in 1896, by States and grades.

State.	Table and dairy.	Common fine.	Common coarse.	Packer's.	Coarse solar.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
California	41,714	1,429	30,371	22,500	306,250
Kansas	93,174	922,623	4,310	42,250	.....
Michigan	152,388	2,954,608	2,400	31,565	13,622
New York:					
Onondaga district	.....	64,347	.....	.....	2,164,071
Warsaw district	961,721	800,055	97,786	.....	.....
Southern New York and Genesee dist.	387,277	156,826	12,626	60,473	30,000
Rock salt	.....	.....	.....	.....	.....
Ohio	400,263	1,173,295	83,765	5,035	.....
Pennsylvania	715	177,312	19,714	855	.....
Utah	70,886	15,657	49,393	357	7,143
West Virginia	5,000	171,921	.....	.....	.....
Illinois, Nevada, Texas, Louisiana, and Virginia	117,271	160,660	.....	.....	10,000
Total	2,230,409	6,598,733	300,365	163,035	2,531,086

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Production of salt in 1896, by States and grades—Continued.

State.	Rock.	Milling.	Other grades.	Total prpduct.	Total value.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	
California	25,714	.....	2,143	430,121	$198,963
Kansas	344,608	.....	1,642	1,408,607	397,296
Michigan	.....	.....	9,655	3,164,238	718,408
New York:					
Onondaga district	.....	.....	.....	2,228,418	575,432
Warsaw district	.....	.....	82,729	1,942,291	729,324
Southern New York and Genesee dist.	.....	.....	10,679	657,881	270,612
Rock salt	1,240,450	.....	.....	1,240,450	321,313
Ohio	.....	.....	.....	1,662,358	432,877
Pennsylvania	.....	.....	.....	198,596	56,717
Utah	.....	133,271	3,093	279,800	96,550
West Virginia	.....	.....	.....	176,921	50,717
Illinois, Nevada, Texas, Louisiana, and Virginia	173,114	.....	.....	461,045	192,630
Total	1,783,886	133,271	109,941	13,850,726	4,040,839

Production of salt in 1895, by States and grades.

State.	Table.	Dairy.	Common fine.	Common coarse.	Packer's.	Coarse solar.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*	*Barrels.*
California	21,536	14,571	3,321	14,286	33,929	193,571
Illinois	.....	.....	67,119	.....	.....	.....
Kansas	47,499	33,815	924,625	10,714	.....	.....
Louisiana	.....	.....	.....	.....	.....	.....
Michigan	105,021	36,405	2,977,507	122,000	61,031	30,000
Nevada	[a]7,000	.....	.....	.....	.....	.....
New York:						
Onondaga dist. [b]	.....	.....	55,247	.....	.....	632,870
Genesee district	131,257	236,473	118,179	14,980	2,827	.....
Warsaw district	.....	[a]1,178,166	985,082	79,153	13,000	.....
Rock salt	.....	.....	.....	.....	.....	.....
Ohio	.....	[a]295,256	458,832	21,366	3,000	.....
Pennsylvania	787	609	141,855	849	.....	13,143
Texas	.....	.....	125,000	.....	.....	.....
Utah	14,300	39,250	21,171	7,936	5,014	114,286
Virginia	4,000	.....	52,000	9,000	.....	.....
West Virginia	7,178	.....	169,542	.....	.....	.....
Total	338,578	1,834,545	6,099,480	280,284	118,801	983,870

[a] Includes both dairy and table salt.

[b] Salt in brine used in chemical works at Syracuse is included in product of Onondaga district, although the wells are not within the reservation.

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Production of salt in 1895, by States and grades—Continued.

State.	Rock.	Milling.	Other grades.	Total product.	Total value.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*	
California	24,864	.....	12,857	318,935	$158,683
Illinois	.....	.....	.....	67,119	31,548
Kansas	313,714	.....	11,250	1,341,617	483,701
Louisiana	159,771	.....	.....	159,771	78,169
Michigan	.....	.....	11,431	3,343,395	1,048,251
Nevada	.....	.....	.....	7,000	5,600
New York:					
Onondaga dist. (*a*)	.....	.....	1,651,707	2,339,824	576,999
Genesee district	.....	.....	82,955	586,671	108,537
Warsaw district	.....	.....	64,735	2,320,136	916,662
Rock salt	1,585,700	.....	.....	1,585,700	341,200
Ohio	.....	.....	2,579	781,033	326,520
Pennsylvania	.....	.....	.....	157,243	67,411
Texas	.....	.....	.....	125,000	55,000
Utah	5,714	40,107	46,707	294,485	121,762
Virginia	.....	.....	.....	65,000	40,000
West Virginia	.....	.....	.....	176,720	63,041
Total	2,089,763	40,107	1,884,221	13,669,649	4,423,084

a Salt in brine used in chemical works at Syracuse is included in product of Onondaga district, although the wells are not within the reservation.

ESTABLISHMENTS AND PROCESSES.

Exclusive of the rock-salt mines there were 154 establishments producing salt in the United States in 1896. More than one-third of the total number of establishments were in Michigan, 54 concerns in that State reporting production in 1896. New York produced salt from 39 establishments, of which 20 used solar heat for evaporation in the manufacture of coarse salt at Syracuse. California reported from 23 establishments, of which 21 used solar heat. Kansas had 10 establishments, all but one of which used artificial heat. From Ohio 12 concerns reported, all of which used artificial heat. Out of 5 establishments in Utah 4 used solar heat, and 1 used steam. Four establishments in West Virginia and 3 in Pennsylvania used artificial heat. There was but one establishment in each of the other four States—Illinois, Nevada, Texas, and Virginia.

Out of the total of 154 establishments, 49 used solar heat, 26 used open pans, 18 used vacuum pans, 6 used kettles, and 82 used grainers. A seeming discrepancy exists between this and the total. The explanation is simple. In quite a number of establishments more than one process is employed. Some concerns use both open pan and grainer

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or vacuum pan and grainer, and the one establishment in Texas used three methods of evaporation—solar, open pan, and grainer. When open pans are used heat is usually applied direct, the pans being placed over a long combustion chamber, through which the flames from the furnace are carried. Direct heat is also used for kettles. Out of the 18 producers using vacuum pans, 13 reported the use of steam heat and 5 employed direct heat. The grainer process requires steam exclusively. The steam is carried through pipes submerged in the brine. This process is used much more generally than any other, there being 82 concerns using grainers in 1896, and only 50 in which the other three processes together were employed.

The total number of salt establishments in each State, the processes employed, and the methods of using heat, are shown in the following table:

Processes employed in evaporating salt from brine in 1896.

State.	Solar.	Open pan.	Vacuum pan.	Kettle.	Grainer.	Heat applied.		Number of works reporting.
						Direct.	By steam.	
California	21	1	.....	.....	1	1	1	23
Illinois	.....	.....	.....	.....	1	.....	1	1
Kansas	1	5	1	.....	5	5	7	10
Michigan	1	5	8	.....	45	4	51	54
Nevada	1	.....	.....	.....	.....	.....	.....	1
New York:								
Onondaga	20	.....	.....	5	.....	5	.....	25
Warsaw, Genessee, Southern New York	.....	8	4	.....	15	7	13	14
Ohio	.....	3	5	1	8	6	9	12
Pennsylvania	.....	1	.....	.....	2	1	2	3
Texas	1	1	.....	.....	1	1	1	1
Utah	4	1	.....	.....	.....	.....	1	5
Virginia	.....	1	.....	.....	.....	.....	1	1
West Virginia	.....	.....	.....	.....	4	1	4	4
Total	49	26	18	6	82	31	91	154

NOTE.—Rock salt mines are not included in the above table. Of these there were one in California, two in Kansas, one in Louisiana, and two in New York.

In reporting production some operators use the bushel as a unit of measurement, some the short ton, and some the barrel. For the sake of convenience the product of each State in the preceding and following tables has been reduced to one unit, the barrel, containing 280 pounds, or 5 bushels of 56 pounds, and a ton being equal to 7⅐ barrels.

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PRODUCTION IN PREVIOUS YEARS.

Comparative table of production of salt in States and Territories from 1883 to 1896.

State or Territory.	1883.		1884.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	2,894,672	$2,344,684	3,161,806	$2,392,536
New York	1,619,486	680,638	1,788,454	705,978
Ohio	350,000	231,000	320,000	201,600
West Virginia	320,000	211,000	310,000	195,000
Louisiana	265,215	141,125	223,964	125,677
California	214,286	150,000	178,571	120,000
Utah	107,143	100,000	114,285	80,000
Nevada	21,429	15,000	17,857	12,500
Illinois, Indiana, Virginia, Tennessee, Kentucky, and other States and Territories (*a*)	400,000	377,595	400,000	364,443
Total	6,192,231	4,251,042	6,514,937	4,197,734

State or Territory.	1885.		1886.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3,297,403	$2,967,663	3,677,257	$2,426,989
New York	2,304,787	874,258	2,431,563	1,243,721
Ohio	306,847	199,450	400,000	260,000
West Virginia	223,184	145,070	250,000	162,500
Louisiana	299,271	139,911	299,691	108,372
California	221,428	160,000	214,285	150,000
Utah	107,140	75,000	164,285	100,000
Nevada	28,593	20,000	30,000	21,000
Illinois, Indiana, Virginia, Tennessee, Kentucky, and other States and Territories (*a*)	250,000	243,993	240,000	352,763
Total	7,038,653	4,825,345	7,707,081	4,825,345

a Estimated.

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Comparative table of production of salt in States and Territories from 1883 to 1896—Cont'd.

State or Territory.	1887.		1888.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3,944,309	$2,291,842	3,866,228	$2,261,743
New York	2,353,560	936,894	2,318,483	1,130,409
Ohio	365,000	219,000	380,000	247,000
West Virginia	225,000	135,000	220,000	143,000
Louisiana	341,093	118,735	394,385	134,652
California	200,000	140,000	220,000	92,400
Utah	325,000	102,375	151,785	32,000
Kansas	.....	.....	155,000	189,000
Other States and Territories	250,000	150,000	350,000	143,999
Total	8,003,962	4,093,846	8,055,881	4,374,203

State or Territory.	1889.		1890.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3,856,929	$2,088,909	3,837,632	$2,302,579
New York	2,273,007	1,136,503	2,532,036	1,266,018
Ohio	250,000	162,500	231,303	136,617
West Virginia	200,000	130,000	229,938	134,688
Louisiana	325,629	152,000	273,553	132,000
California	150,000	63,000	162,363	57,085
Utah	200,000	60,000	427,500	126,100
Kansas	450,000	202,500	882,666	397,199
Other States and Territories	300,000	200,000	300,000	200,000
Total	8,005,565	4,195,412	8,876,991	4,752,286

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Comparative table of production of salt in States and Territories from 1883 to 1896—Cont'd.

State or Territory.	1891.		1892.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3,966,784	$2,037,289	3,829,478	$2,046,963
New York	2,839,544	1,340,036	3,472,073	1,662,816
Ohio	(a)	(a)	899,244	394,720
West Virginia	(a)	(a)		
Louisiana	173,714	102,375	200,000	100,000
California	200,949	90,303	235,774	104,938
Utah	969,000	265,350	1,292,471	340,442
Nevada	60,799	39,898	22,929	22,806
Kansas	855,536	304,775	1,480,100	773,989
Illinois	39,670	34,909	60,000	48,000
Virginia	70,442	70,425	60,000	50,000
Pennsylvania	.....	.....	25,571	10,741
Texas	.....	.....	121,250	99,500
Other States and Territories	811,507	430,761	.....	.....
Total	9,987,945	4,571,121	11,698,890	5,654,915

State or Territory.	1893.		1894.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3,057,898	$888,837	3,341,425	$1,243,619
New York	5,662,074	1,870,084	6,270,588	1,999,146
Ohio	543,963	209,393	528,996	187,432
West Virginia	210,736	68,222	194,532	51,947
Louisiana	191,430	97,200	186,050	86,134
California	292,858	137,962	332,246	172,678
Utah	189,006	130,075	268,186	209,077
Nevada	6,559	4,481	3,670	4,030
Kansas	1,277,180	471,543	1,382,409	529,392
Illinois	59,161	30,168	50,000	27,500
Virginia	.....	.....	64,222	43,580
Pennsylvania	280,343	136,436	203,236	83,750
Texas	126,000	110,267	142,857	101,000
Total	11,897,208	4,154,668	12,967,417	4,739,285

a Included in "Other States."

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Comparative table of production of salt in States and Territories from 1883 to 1896—Cont'd.

State or Territory.	1895.		1896.	
	Quantity.	Value.	Quantity.	Value.
	Barrels.		*Barrels.*	
Michigan	3,343,395	$1,048,251	3,164,238	$718,408
New York	6,832,331	1,943,398	6,069,040	1,896,681
Ohio	781,033	326,520	1,662,358	432,877
West Virginia	176,720	63,041	176,921	50,717
Louisiana	159,771	78,169	(*a*)	(*a*)
California	318,935	158,683	430,121	198,963
Utah	294,485	121,762	279,800	96,550
Nevada	7,000	5,600	(*a*)	(*a*)
Kansas	1,341,617	483,701	1,408,607	397,296
Illinois	67,119	31,548	(*a*)	(*a*)
Virginia	65,000	40,000	(*a*)	(*a*)
Pennsylvania	157,243	67,411	198,596	56,717
Texas	125,000	55,000	(*a*)	(*a*)
Other States	.....	.....	461,045	192,630
Total	13,669,649	4,423,084	13,850,726	4,040,839

a Included in "Other States."

REVIEW OF THE INDUSTRY IN 1896.

The history of the salt industry in 1896 was one of overproduction, depression, and low prices. In the face of conditions unparalleled in the history of the trade, the domestic production of salt was the largest on record. In addition to the increased production of domestic salt, importations were also heavy, being within 6 per cent of 1895, when the amount of salt imported was about 560,000,000 pounds, or 2,000,000 barrels. The removal of the tariff of 8 cents per hundred pounds enabled foreign salt to be placed at the Atlantic seaboard cities at cheaper rates than domestic salt could be laid down. The import duty on salt was removed in 1894. In 1893 the amount of salt imported into the United States was 348,519,173 pounds, equivalent to 1,244,711 barrels of 280 pounds. The imports in 1894 increased to 434,155,708 pounds, or 1,550,555 barrels, and in 1895 to 559,151,669 pounds, or nearly 2,000,000 barrels. They decreased slightly to 520,411,822 pounds, or 1,858,614 barrels, in 1896.

The influence of these larger importations was felt in a well-defined manner. Producers who had hitherto marketed their salt in the Eastern cities were obliged either to reduce their prices or seek a new market. They did both. Salt which would have gone east from Syracuse and Warsaw, New York, and the Ohio Valley regions, sought a new market farther west. This brought it more directly into competition with

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Michigan and Kansas salt, and prices have been reduced accordingly. Another disturbing element was a largely increased production in Ohio. The works in Cleveland, which were destroyed by fire in August, 1894, were rebuilt and enlarged in 1895. Favorably situated for the economical manufacture of salt and for its transportation by water, operations here have been considerably increased in spite of low prices. Ohio's product increased from 781,033 barrels in 1895 to 1,662,358 barrels in 1896. California increased her output 111,186 barrels, from 318,935 barrels in 1895 to 430,121 barrels in 1896. Kansas's product increased about 47,000 barrels, and Pennsylvania's about 41,000 barrels.

The principal losses in product were experienced in New York, whose output decreased 763,291 barrels, of which 345,250 barrels were rock salt and 428,041 barrels were evaporated salt. Michigan's output decreased 179,157 barrels, and Utah's about 15,000 barrels. The aggregate output of the five States, in each of which there was but one establishment (Louisiana, Nevada, Illinois, Texas, and Virginia), increased about 38,000 barrels over their production in 1895.

The exports of domestic salt have not much influence on the trade, amounting to but 10,853,759 pounds, or 38,763 barrels, in 1894; 7,203,024 pounds, or 25,725 barrels, in 1895, and 10,711,314 pounds, or 38,255 barrels, in 1896. The imports added to the domestic product and the exports deducted from the total in 1894, 1895, and 1896 show that the salt consumed or placed upon the market in the United States increased from 14,479,209 barrels in 1894 to 15,640,894 barrels in 1895 and 15,671,085 barrels in 1896. This is illustrated in the following table:

Supply of salt for domestic consumption in 1893, 1894, 1895, and 1896.

Sources.	1893.	1894.	1895.	1896.
	Barrels.	*Barrels.*	*Barrels.*	*Barrels.*
Domestic product	11,897,208	12,967,417	13,669,649	13,850,726
Imports	1,244,711	1,550,555	1,996,970	1,858,614
Total	13,141,919	14,517,972	15,666,619	15,709,340
Exports	20,686	38,763	25,725	38,255
Domestic consumption	13,121,233	14,479,209	15,640,894	15,671,085
Increase over preceding year		1,357,970	1,161,685	30,191

IMPORTS AND EXPORTS.

The imports of salt into the United States exhibit an almost constant decrease from 1881 to 1893. The decrease was particularly noticeable in the imports of refined salt, due in great measure to the improvements inaugurated in the manufacture of table and dairy salts by American producers, which has made the domestic product equal if not superior to salts of foreign make. The tariff act of 1894 placed salt

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upon the free list, and importations have since been larger, increasing from 348,519,173 pounds in 1893 to 434,155,708 pounds in 1894, and nearly 560,000,000 pounds in 1895. In 1896 the imports of foreign salt amounted to 520,411,822 pounds.

Salt imported and entered for consumption in the United States, 1867 to 1896, inclusive.

Year ended—	In bags, barrels, and other packages.		In bulk.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
June 30, 1867.....	254,470,862	$696,570	229,304,323	$336,302
1868.....	308,446,080	915,546	219,975,096	365,458
1869.....	297,382,750	895,272	256,765,240	351,168
1870.....	288,479,187	797,194	349,776,433	507,874
1871.....	283,993,799	800,454	274,730,573	355,318
1872.....	258,232,807	788,893	257,637,230	312,569
1873.....	239,494,117	1,254,818	388,012,132	525,585
1874.....	358,375,496	1,452,161	427,294,209	649,838
1875.....	318,673,091	1,200,541	401,270,315	549,111
1876.....	331,266,140	1,153,480	379,478,218	462,106
1877.....	359,005,742	1,059,941	444,044,370	532,831
1878.....	352,109,963	1,062,995	414,813,516	483,909
1879.....	375,286,472	1,150,018	434,760,132	532,706
1880.....	400,970,531	1,180,082	449,743,872	548,425
1881.....	412,442,291	1,242,543	529,361,041	658,068
1882.....	329,969,300	1,086,932	399,100,228	474,200
1883.....	312,911,360	1,035,946	412,938,686	451,001
1884.....	340,759,010	1,093,628	441,613,517	433,827
1885.....	351,276,969	1,030,029	412,322,341	386,858
Dec. 31, 1886.....	319,232,750	966,993	363,621,223	371,000
1887.....	275,774,571	850,069	343,216,331	328,201
1888.....	238,921,421	620,425	272,650,231	246,022
1889.....	180,906,293	627,134	234,499,635	249,232
1890.....	172,611,041	575,260	243,756,044	252,848
1891.....	150,033,182	492,144	220,309,985	224,569
1892.....	150,799,014	488,108	201,366,103	196,371
1893.....	98,037,648	358,575	146,945,390	63,404
1894.....	60,793,685	206,229	101,525,281	86,718
1895.....	601,086	1,723	1,874,644	1,874
1896.....	350,620	814	1,627,030	1,640

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Salt imported and entered for consumption in the United States, etc.—Continued.

Year ended—	For the purpose of curing fish.		Not elsewhere specified.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		
June 30, 1867	.....	.....	.....	.....	$1,032,872
1868	.....	.....	.....	.....	1,281,004
1869	.....	.....	.....	.....	1,246,440
1870	68,597,023	$87,048	.....	.....	1,392,116
1871	64,671,139	66,008	.....	.....	1,221,780
1872	57,830,929	60,155	.....	.....	1,161,617
1873	86,756,628	86,193	.....	.....	1,866,596
1874	105,613,913	126,896	.....	.....	2,228,895
1875	110,294,440	119,607	.....	.....	1,869,259
1876	118,760,638	126,276	.....	.....	1,741,862
1877	132,433,972	140,787	.....	.....	1,733,559
1878	100,794,611	96,898	.....	.....	1,643,802
1879	94,060,114	95,841	.....	.....	1,778,565
1880	109,024,446	119,667	.....	.....	1,848,174
1881	133,395,065	144,347	.....	.....	2,044,958
1882	134,777,569	147,058	.....	.....	1,708,190
1883	142,065,557	154,671	.....	.....	1,641,618
1884	126,605,276	122,463	.....	.....	1,649,918
1885	140,067,018	121,429	.....	.....	1,538,316
Dec. 31, 1886	103,360,362	94,721	.....	.....	1,432,714
1887	105,577,947	107,089	.....	.....	1,285,359
1888	113,459,083	111,120	.....	.....	977,577
1889	97,960,624	100,123	.....	.....	976,489
1890	98,279,719	96,648	.....	.....	924,756
1891	103,990,324	89,196	.....	.....	805,909
1892	105,192,086	90,327	.....	.....	774,806
1893	103,536,135	87,749	.....	.....	509,728
1894	93,723,885	79,482	178,112,857	$263,707	636,136
1895	8,668,490	12,195	548,007,449	739,122	754,914
1896	8,351,913	11,814	510,082,259	687,890	702,158

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Salt of domestic production exported from the United States from 1790 to 1896, inclusive.

Year ended—	Quantity.	Value.	Year ended—	Quantity.	Value.
	Bushels.			*Bushels.*	
Sept. 30, 1790..	31,935	$8,236	June 30, 1863..	584,901	$277,838
1791..	4,208	1,052	1864..	635,519	296,088
1830..	47,488	22,978	1865..	589,537	358,109
1831..	45,847	26,848	1866..	70,644	300,980
1832..	45,072	27,914	1867..	605,825	304,030
1833..	25,069	18,211	1868..	624,970	289,936
1834..	89,064	54,007	1869..	442,947	190,076
1835..	126,230	46,483	1870..	298,142	119,582
1836..	49,917	31,943	1871..	120,156	47,115
1837..	99,133	58,472	1872..	42,603	19,978
1838..	114,155	67,707	1873..	73,323	43,777
1839..	264,337	64,272	1874..	31,657	15,701
1840..	92,145	42,246	1875..	47,094	16,273
1841..	215,084	62,765	1876..	51,014	18,378
1842..	110,400	39,064	1877..	65,771	20,133
June 30, 1843*a*.	40,678	10,262	1878..	72,427	24,968
1844..	157,529	47,755	1879..	43,710	13,612
1845..	131,500	45,151	1880..	22,179	6,613
1846..	117,627	30,520	1881..	45,455	14,752
1847..	202,244	42,333	1882..	42,085	18,265
1848..	219,145	73,274	1883..	54,147	17,321
1849..	312,063	82,972	1884..	70,014	26,007
1850..	319,175	75,103	1885..	*b*4,101,587	26,488
1851..	344,061	61,424	Dec. 31, 1886..	4,828,863	29,580
1852..	1,467,676	89,316	1887..	4,685,080	27,177
1853..	515,857	119,729	1888..	5,359,237	32,986
1854..	548,185	159,026	1889..	5,378,450	31,405
1855..	536,073	156,879	1890..	4,927,022	30,079
1856..	698,458	311,495	1891..	4,448,846	23,771
1857..	576,151	190,699	1892..	5,208,935	28,399
1858..	533,100	162,650	1893..	5,792,207	38,375
1859..	717,257	212,710	1894..	10,853,759	46,780
1860..	475,445	129,717	1895..	7,203,024	30,939
1861..	537,401	144,046	1896..	10,711,314	43,202
1862..	397,506	228,109			

a Nine months. *b* Pounds from 1885.

In connection with the above tables it is interesting to note the sources from which our imported salt is obtained and the markets supplied by our exports of domestic salt. For this purpose the following tables, showing the countries from which we import, the amount and value of the salt received from each, and also the amount and value of the

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salt exported to each country and the ports through which exported, are given for the three fiscal years ending June 30, 1894, 1895, and 1896. It will be observed that the principal source of supply is the United Kingdom, from which we imported 136,550,196 pounds out of a total of 345,479,066 in 1894, 266,090,597 pounds out of a total of 496,810,501 in 1895, and 329,381,633 pounds out of a total of 553,279,500 pounds in 1896. The imports from Great Britain were about 40 per cent of the total in 1894, more than 50 per cent in 1895, and nearly 60 per cent in 1896. Italy exported over 93,000,000 pounds to this country in 1894, and the West Indies nearly 100,000,000 pounds, so that the amount received from these three sources was 329,016,443 pounds, or 95 per cent of the total. In 1895 the imports from Italy fell off to 81,725,686 pounds, while those from the West Indies increased to 137,325,128 pounds. In 1896 the imports from Italy were 78,768,053 pounds, and from the West Indies 136,396,990 pounds. The total from the same three sources was 485,141,411 pounds in 1895, and 544,546,676 pounds in 1896, or about 98 per cent.

The principal exports are through the port of San Francisco, and to the Central American States, Mexico, the Hawaiian Islands, Japan, and Asiatic Russia. About 25 per cent, or a little more, goes across the Great Lakes to the Dominion of Canada.

The imports and exports for the past three fiscal years, with the countries from which imported and to which exported, have been as follows:

Imports of salt during the fiscal years ending June 30, 1894, 1895, and 1896, with the countries from which exported.

Country from which exported.	Year ending June 30, 1894.		Year ending June 30, 1895.			
			Free.		Dutiable. (a)	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Belgium	10,286	$14	2,020	$30	.....	.....
France	4,783,980	3,636	.....	.....	1,400	$46
Germany	672,963	1,748	.....	.....	186,413	871
Italy	93,205,163	67,148	65,461,114	42,761	16,264,572	11,388
Portugal	2,572,735	1,833	419,844	348	3,618,272	3,259
Spain	2,349,078	1,596	.....	.....	3,680,272	2,376
United Kingdom:						
England	136,538,796	422,007	244,566,953	431,642	21,523,644	46,025
Scotland	11,400	56				
Canada:						
Nova Scotia, New Brunswick, etc.	4,415,581	9,549	275,400	425	2,297,390	6,528
Quebec, Ontario	1,141,350	6,183	840	7	327,284	1,413
British Columbia	.....	.....	.....	.....	.....	.....

a The tariff act of 1894 provides that salt is free of duty, but when in bags or other packages the coverings shall pay duty as if imported separately, and salt imported from countries imposing a duty on salt exported from the United States shall pay the rate of duty imposed prior to the act of 1894.

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Imports of salt during the fiscal years ending June 30, 1894, 1895, and 1896, with the countries from which exported—Continued.

Country from which exported.	Year ending June 30, 1894.		Year ending June 30, 1895.			
			Free.		Dutiable. (a)	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Central America:						
Nicaragua	7,500	$50				
Mexico	226,413	387			230,580	$440
West Indies:						
British	93,549,034	72,023	56,093,688	$55,788	50,978,337	40,101
Dutch	4,726,544	5,201	21,726,311	26,073	1,851,386	2,075
French	984,506	993	2,847,905	4,028	1,466,650	1,573
Danish			27,000	45	233,851	243
Puerto Rico					1,200,000	1,613
Brazil	99,853	80				
Hongkong	284	2				
Portuguese Africa	183,600	216			527,275	361
Hawaiian Islands			100,000	330		
Egypt			2,100	13		
Total	345,479,066	592,722	392,423,175	561,490	104,387,326	119,312

Country from which exported.	Year ending June 30, 1896.			
	Free.		Dutiable. (a)	
	Pounds.	Value.	Pounds.	Value.
Germany	2,010,595	$7,506	356,110	$2,201
Italy	78,768,053	50,511		
Portugal			784,992	581
United Kingdom:				
England, Scotland	329,381,449	552,794	184	3
Canada:				
Nova Scotia, New Brunswick, etc	186,667	254	4,083,414	9,354
Quebec, Ontario			194,546	912
British Columbia	4,000	28	58,300	218
Mexico	30	2	717,903	456
West Indies:				
British	115,477,302	110,092		
Dutch	19,309,198	22,357		
French	1,610,490	2,140		
Portuguese Africa			330,670	228
Hawaiian Islands	4,000	40		
Egypt	1,397	19		
Total	546,753,181	745,743	6,526,319	13,953

a The tariff act of 1894 provides that salt is free of duty, but when in bags or other packages the coverings shall pay duty as if imported separately, and salt imported from countries imposing a duty on salt exported from the United States shall pay the rate of duty imposed prior to the act of 1894.

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Exports of salt during the fiscal years ending June 30, 1894, 1895, and 1896, and countries to which exported.

Country to which exported.	Year ending June 30, 1894.		Year ending June 30, 1895.		Year ending June 30, 1896.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
United Kingdom	.....	.....	112,000	$350	.....	.....
Bermuda	.....	.....	.....	.....	20,375	$205
British Honduras	4,600	$47	2,462	33	21,615	97
Dominion of Canada:						
Nova Scotia, New Brunswick, etc.	663,150	5,635	195,900	1,753	20,093	211
Quebec, Ontario, etc.	3,743,978	10,245	2,344,683	5,457	1,393,105	3,042
British Columbia	748,952	3,574	224,100	1,618	373,874	2,690
Newfoundland and Labrador	.....	.....	.....	.....	18,150	151
Central American States:						
Costa Rica	99,320	735	41,057	535	33,635	427
Guatemala	328,277	1,761	475,040	2,279	129,102	1,152
Honduras	23,370	422	30,897	412	859,190	4,490
Nicaragua	208,482	1,749	238,955	2,134	183,105	1,603
Salvador	1,791,200	8,818	1,405,000	7,241	66,100	341
Mexico	590,640	6,329	810,575	6,652	1,064,276	8,871
West Indies:						
British	2,000	15	1,500	12	20,467	210
Haiti	.....	.....	.....	.....	1,200	13
Santo Domingo	.....	.....	.....	.....	18,325	190
Spanish—Cuba	.....	.....	.....	.....	300	4
Colombia	11,910	94	7,300	70	.....	.....
Japan	146,000	438	20,000	78	125,600	409
China	.....	.....	.....	.....	8,500	25
Russia, Asiatic	2,954,000	8,959	2,180,000	7,340	4,608,640	12,134
French Oceanica	79,450	439	69,000	374	143,400	728
British Australasia	.....	.....	.....	.....	24,500	245
Hawaiian Islands	495,450	2,811	541,300	2,721	632,000	3,304
Total	11,890,779	52,071	8,699,769	39,059	9,765,552	40,542

HISTORY OF SALT MAKING IN THE UNITED STATES.

In the preparation of this historical sketch of the salt industry the writer has obtained valuable assistance from Mr. H. G. Piffard, president of the Genesee Salt Co., New York City; Mr. J. P. Samson, manager of the Le Roy Salt Co., Le Roy, N. Y.; Mr. E. L. Fuller, president Retsof Mining Co., Scranton Pa.; The Ithaca Salt Co., Ithaca, N. Y.; Mr. Thos. Molloy, secretary Onondaga Coarse Salt Association, Syracuse, N. Y.; Myles & Co., New Orleans, La.; Hon. Dudley Avery, Avery Island, La.; Dr. J. P. Hale, Charleston, W. Va.; Mr. Geo. W. Hill, salt inspector, Saginaw, Mich.; The Commissioner of Labor of Kansas; Mr. J. C. Baddeley, secretary Kansas Salt Co., Hutchinson, Kans.; Mr. D. C. Earnest, secretary Lone Star Salt Co., Dallas, Tex.; Mr. Chas. G. Yale, San Francisco, Cal.; Messrs. Plummer Bros., San Francisco; Mr. A. A. Oliver, Mt. Eden, Cal.; and Mr. J. W. Heywood, manager Inland Crystal Salt Co., Salt Lake City, Utah.

The history of salt making and mining in the United States presents some interesting features, but the records of the earlier attempts at salt

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making are obscure. The first salt made was undoubtedly from sea water. One of the early agricultural reports of the United States Government (published in 1858) contains an historical sketch on salt manufacture by Wm. C. Dennis, from which the writer has obtained some of the data relating to the early efforts at salt manufacture. According to this report the first trial is recorded in Beverly's History of Virginia, wherein it is stated that as early as 1620 "a salt work was set up at Cape Charles, on the Eastern Shore." What manner of success was attained is not reported. Prince's Chronological History of New England records an attempt made at Plymouth, Massachusetts, four years later, but it was not successful. From this time until shortly before the breaking out of the Revolutionary war, the probability is that the colonists obtained their supplies of salt from England. Owing to restrictions placed upon our commerce, and later, when the war broke out, to the cutting off of importations, the colonists began the manufacture of salt from sea water by boiling, and at the termination of the struggle an extensive system of salt making was developed about New Bedford and Cape Cod. The method employed was similar to that used in the manufacture of solar salt near Syracuse, New York, at the present time, except that sea water was used instead of brine from wells. After the war of 1812 foreign salt again became supreme. It could be bought for less than 50 cents a bushel[1] and the American works were allowed to fall into decay. The last salt made in Massachusetts was in 1830.

The heavy taxes and restrictions placed upon American commerce by the British Parliament for several years before hostilities began made the price of salt so exorbitant that nearly every family along the seaboard became its own salt maker. The salt was obtained by boiling, but was a very inferior article, as no method was adopted to separate the lime, the salts of the bittern or mother liquor, and other impurities. The discovery that salt could be obtained from sea water by solar evaporation in that climate, was made through the observation of small salt crystals in clam shells on the beach, and led indirectly to the then important industries before mentioned.

Salt making from brine other than sea water began in the later years of the Eighteenth century. This, of course, does not refer to that made by the American Indians. In New York the first salt was made by white men in 1788. Three years later, in 1791, an unsuccessful attempt was made to obtain salt from brine at Avery Island, Louisiana. In 1797 the first salt furnace was built in West Virginia, on the Kanawha River, near the present city of Charleston. The following year the first salt was made at the Old Scioto Works in Ohio. The details of these early attempts and the history of salt making in other States are discussed in the following pages.

[1] This price seemed cheap at that time. Salt to-day is sold at less than one-tenth this figure.

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NEW YORK.

ONONDAGA DISTRICT.

The salt resources of western New York were known to the Indians. Le Moyne, a French Jesuit, mentioned them in his journal published in 1653. In 1770 salt from the Onondaga region was in use among the Delaware Indians and was sold by them in Albany and as far north as Quebec. The first salt made by white men in the district was in 1788. The first laws regulating salt making in New York were passed in 1797, and for 100 years the State has maintained control of the Onondaga Reservation, furnishing brine to those who paid for it at the rate of 1 cent for every bushel (56 pounds) of salt made. The State has had the expense of building and repairing the settling tanks from which the brine is delivered to the lessees.

At the time this report is written (June, 1897,) steps are being taken by the State Historical Association to celebrate the centennial anniversary of the organization of the Onondaga Salt Springs Reservation under State control. The law placing the salt springs under State control went into effect June 20, 1797. This chapter is written on June 19, 1897. It is, therefore, not inappropriate to quote a short historical sketch, which was published in the Syracuse Daily Herald, June 12, 1897:

> The centennial of the Onondaga salt springs, under organized State supervision, occurs on the 20th instant, when the first State superintendent, William Stevens, was appointed and the first lease of salt lands was issued. There had been difficulties as to the priority of rights under "squatter sovereignty," and April 1, 1797 (chap. State laws, 90), an act passed the legislature requiring the surveyor-general (Simeon DeWitt) to survey the salt lands in person and lay out the same in lots of not more than 10 acres each. This law went into effect June 20 of the same year. Each lessee was required to manufacture not less than 10 bushels of salt per annum and was probibited from charging more than 60 cents a bushel therefor, and was further required to pay a State duty of 4 cents a bushel in lieu of rent. In the original leases the State reserved the right, upon their expiration, of renewing them for the term of seven years or of purchasing any or all of the salt works at their true value. The same act authorized the governor, by and with the advice of the council of appointment, to appoint a superintendent of the salt springs, at an annual salary of $800, he to hold office at the pleasure of the council.
>
> There has been much legislation relating to the salt springs since that time. The salt duty in 1805 was fixed at 3 cents per bushel and in 1812 it was advanced to 12½ cents, and thereafter the sum of $2,055,458.06 was contributed by the salt revenues to the construction of the canals of the State. The duty was reduced to 6 cents in 1834 and to 1 cent per bushel in 1846.
>
> In 1859 the legislature enacted that leases to all manufacturers should be made for thirty years. These leases expired in 1889. Since then legislative action looks to the sale by the State of its property in the Onondaga Salt Springs Reservation, allowable since the constitutional prohibition was dropped in the new constitution.
>
> The supervision of the Onondaga salines has been for one hundred years under a

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State superintendent, with ample power to care for the State's interests and to promote the manufacture. The superintendents have been as follows:

1797—William Stevens.
1801—Sheldon Logan.
1802—Asa Danforth.
1805—William Kirkpatrick.
1807—P. H. Ransom.
1808—Nathan Stewart.
1809—John Richardson.
1810—William Kirkpatrick.
1831—N. H. Earll.
1836—Rial Wright.
1840—Thomas Spencer.
1843—Rial Wright.
1845—Enoch Marks.
1849—Robert Gere.
1851—Hervey Rhoades.
1855—Vivus W. Smith.
1865—George Geddes.
1871—John M. Strong.
1874—Archibald C. Powell.
1879—Calvin C. Hinkley.
1880—N. Stanton Gere.
1883—Peter J. Brummelkamp.
1896—Charles Hiscock.

The salt springs were at the foundation of the growth and prosperity of Syracuse, but of late years, under competition, with the nonfavoring conditions, the business has ceased to be of its former importance here. It has in some years produced an output of nearly 10,000,000 bushels of salt. The competition of western New York and Michigan has reduced this great business to a minimum.

The centennial of this important industry should be celebrated in an appropriate way. The proposition is before the Historical Association.

Col. Comfort Tyler and Asa Danforth were the first manufacturers of salt at Onondaga Lake in May, 1788. In September of that year the chiefs of the Onondagas conveyed the salt lands to the State by treaty at Fort Schuyler. The salt lands were forfeited by the Indians who took up arms against the United States in the Revolutionary war, but the forfeiture was never availed. The Onondaga Indians are in receipt of annual annuities from the State under treaty. Early manufacturers among the whites were Moses DeWitt, James Van Vleck, and James Geddes. Elisha Alvord, grandfather of ex-Governor Alvord, made the first salt under a permanent building. James Van Vleck, in 1793, first made salt from a caldron kettle. Solar salt manufacture was begun in 1821. Pumping works were established in 1805. Previous to that time the brine had been gathered in a rude way. The first salt boiled was made in kettles suspended over crotched sticks by Tyler and Danforth. The manufacture by the boiling process has been mainly by individuals owning blocks, and the solar works have been owned and managed by companies on a large scale. Some business is still done in boiled salt and considerable in coarse or solar salt. The market for Onondaga salt is now principally in the Eastern States.

As seen above, the law regulating the salt springs was passed April 1, 1797. One hundred years and fifteen days later, namely, April 15, 1897, an act amending the salt springs regulations and repealing previous laws conflicting with it became a law. Sections 36, 37, and 38 of this new act provide for the sale of the State's rights in the springs, and as they are of especial interest at this time, these sections are quoted.

Sale of lands on the Onondaga Salt Springs Reservation.—The commissioners of the land office shall cause to be appraised and sell and convey in fee any of the lands of the Onondaga Salt Springs Reservation upon the request of any of the lessees of said lands, or their legal representatives, upon their releasing absolutely all right to have, demand, or receive from the State any money by way of damages either on account of the termination of the leases by which such lots are held or on account of the destruction or removal of any salt blocks, their appurtenances, or any other property or buildings therefrom. Such lessees or their legal representatives, after the

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appraisement of the value of such lands is returned to and approved by the commissioners of the land office, may, for thirty days after the date of such approval, become the purchasers of such lands at the appraised value thereof; but if the lessee or his legal representatives does not purchase such lands at such appraisal within said thirty days the title thereof shall vest and be in the people of the State released and discharged from the terms and conditions of any leases, and such lands shall be advertised and sold under the direction and control of the commissioners of the land office to the highest bidder, in accordance with the provisions of the public-lands law; but the lessee or his legal representatives may, for thirty days after such sale, remove therefrom the buildings and other property placed thereon by him. In case of failure to so remove such buildings or other property within said time the same shall be considered as given up and abandoned, and shall become and be the property of the person or persons so purchasing said land.

The title of all lands of the Onondaga Salt Springs Reservation which shall not have been sold or disposed of in accordance with the foregoing provisions of this chapter on or before the first day of March, eighteen hundred and ninety-eight, shall vest and be in the people of the State released and discharged from the terms and conditions of any leases, and the buildings, structures, and property thereon shall be deemed abandoned and shall become and be the property of the people of the State of New York.

Moneys arising from sale.—All moneys arising from the sale of the Onondaga Salt Springs Reservation or any part thereof, by virtue of the foregoing provisions of this chapter, shall be placed by the comptroller in the State treasury. The State shall cease to furnish brine at any expense to said State on or before the first day of January, eighteen hundred and ninety-nine, and shall cease to operate its works at any expense to the State upon the Onondaga Salt Springs Reservation on or before the first day of January, eighteen hundred and ninety-nine, and the commissioners of the land office are authorized and directed to sell all the right, title, and interest of the State, or the people thereof, at public or private sale, in or to any or all of the personal property upon said Onondaga Salt Springs Reservation or connected therewith. The lessees of any such personal property, if any there be, shall have the first opportunity of purchasing the same, but all such personal property which shall not have been disposed of on or before the first day of April, eighteen hundred and ninety-eight, shall vest absolutely in the people of the State of New York free from all claims in behalf of any lessee or his legal representatives.

In reply to an inquiry as to what would be the result of the State's selling its interest in the salt reservations, Mr. Thomas Molloy, secretary and treasurer of the Onondaga Coarse Salt Association, writes as follows:

We are making salt here as in the past, and expect to continue doing so, notwithstanding that the State of New York after another year or so may cease to furnish us brine, thus obliging the manufacturers or owners of the salt works to supply themselves with it, as some of them are prepared to do at very little expense, while others not so favorably located may be put to some inconvenience. However, no one at the present time engaged in the manufacture of salt here contemplates retiring from the business when the State of New York ceases to furnish brine.

The State of New York does not own the salt erections, but merely the pumping stations and distributing conduits, which are of no particular value except to those engaged in the manufacture of salt. So far as the mere furnishing of brine to the works is concerned, it can be done by the State without loss, within the revenue derived from the manufacture; therefore, the State may yet continue furnishing brine, if indemnified against loss, as it can be. Nearly all the land occupied by the salt works upon which the manufacture of salt is conducted is owned in fee by the manufacturers, and no doubt within a year all will be.

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Amount of salt inspected.—The following table exhibits the amount of salt inspected since 1797, as reported by the superintendent of the springs. It will be observed that the amounts do not exactly agree with the production reported elsewhere. This is because the reports to the Survey are for the amounts *sold*. In order to obtain this from the inspectors' reports the amount of salt in bins at the first of each year should be added, and the amount in bins at close of the year subtracted. It must also be remembered that the amount of salt in brine used in chemical works at Syracuse is included in the production of the Onondaga district, although the wells are outside of the reservation.

Salt inspected at Onondaga Reservation for 100 years.

[Bushels of 56 pounds.]

Year.	Solar.	Fine.	Total.	Year.	Solar.	Fine.	Total.
	Bushels.	*Bushels.*	*Bushels.*		*Bushels.*	*Bushels.*	*Bushels.*
1797	.....	25,474	25,474	1835	.....	1,209,867	1,209,867
1798	.....	59,928	59,928	1836	.....	1,912,858	1,912,858
1799	.....	42,704	42,704	1837	.....	2,167,287	2,167,287
1800	.....	50,000	50,000	1838	.....	2,575,033	2,575,033
1801	.....	62,000	62,000	1839	.....	2,864,718	2,864,718
1802	.....	75,000	75,000	1840	.....	2,622,305	2,622,305
1803	.....	90,000	90,000	1841	.....	220,247	3,120,520	3,340,767
1804	.....	100,000	100,000	1842	.....	163,021	2,128,882	2,291,903
1805	.....	154,071	154,071	1843	.....	318,105	2,809,395	3,127,500
1806	.....	122,577	122,577	1844	.....	332,418	3,671,134	4,003,552
1807	.....	175,448	175,448	1845	.....	353,455	3,408,903	3,762,358
1808	.....	319,618	319,618	1846	.....	331,705	3,507,146	3,838,851
1809	.....	128,282	128,282	1847	.....	262,879	3,688,476	3,951,355
1810	.....	450,000	450,000	1848	.....	342,497	4,394,629	4,737,126
1811	.....	200,000	200,000	1849	.....	377,735	4,705,834	5,083,569
1812	.....	221,011	221,011	1850	.....	374,732	3,894,187	4,268,919
1813	.....	226,000	226,000	1851	.....	378,967	4,235,150	4,614,117
1814	.....	295,000	295,000	1852	.....	633,595	4,288,938	4,922,533
1815	.....	322,058	322,058	1853	.....	577,947	4,826,577	5,404,524
1816	.....	348,665	348,665	1854	.....	734,474	5,068,873	5,803,347
1817	.....	408,665	408,665	1855	.....	498,124	5,584,761	6,082,885
1818	.....	406,540	406,540	1856	.....	709,391	5,257,419	5,966,810
1819	.....	548,374	548,374	1857	.....	481,280	3,830,846	4,312,126
1820	.....	458,329	458,329	1858	.....	1,514,554	5,518,665	7,033,219
1821	.....	526,049	526,049	1859	.....	1,345,022	5,549,250	6,894,272
1822	.....	481,562	481,562	1860	.....	1,462,565	4,130,682	5,593,247
1823	.....	726,988	726,988	1861	.....	1,884,697	5,315,694	7,200,391
1824	.....	816,634	816,634	1862	.....	1,983,022	7,070,852	9,053,874
1825	.....	757,203	757,203	1863	.....	1,437,656	6,504,727	7,942,383
1826	.....	811,023	811,023	1864	.....	1,971,122	5,407,712	7,378,834
1827	.....	983,410	983,410	1865	.....	1,886,760	4,499,170	6,385,930
1828	.....	1,160,888	1,160,888	1866	.....	1,978,183	5,180,320	7,158,503
1829	.....	1,129,280	1,129,280	1867	.....	2,271,892	5,323,673	7,595,565
1830	.....	1,435,446	1,435,446	1868	.....	2,027,490	6,639,126	8,666,616
1831	.....	1,514,037	1,514,037	1869	.....	1,857,942	6,804,295	8,662,237
1832	.....	1,652,985	1,652,985	1870	.....	2,487,691	6,260,422	8,748,113
1833	.....	1,838,646	1,838,646	1871	.....	2,464,464	5,910,492	8,374,956
1834	.....	1,943,252	1,943,252	1872	.....	1,882,604	6,048,321	7,930,925

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Salt inspected at Onondaga Reservation for 100 years—Continued.

Year.	Solar.	Fine.	Total.	Year.	Solar.	Fine.	Total.
	Bushels.	*Bushels.*	*Bushels.*		*Bushels.*	*Bushels.*	*Bushels.*
1873....	1,691,359	5,768,998	7,460,357	1885.....	2,439,332	4,494,967	6,934,299
1874....	1,667,368	4,361,932	6,029,300	1886.....	2,772,348	3,329,409	6,101,757
1875....	2,655,955	4,523,491	7,179,446	1887.....	3,118,974	2,576,823	5,695,797
1876....	2,308,679	3,083,998	5,392,677	1888.....	3,115,314	2,542,053	5,657,367
1877....	2,525,335	3,902,648	6,427,983	1889	2,916,922	2,448,117	5,365,039
1878....	2,788,754	4,387,443	7,176,197	1890.....	2,726,471	2,201,651	4,928,122
1879....	2,957,744	5,364,418	8,322,162	1891.....	2,113,727	1,735,186	3,848,913
1880....	2,516,485	5,482,265	7,998,750	1892.....	3,122,789	1,282,885	4,405,674
1881....	3,011,461	4,905.775	7,917,236	1893.....	2,332,052	733,854	3,065,906
1882....	3,032,447	5,307,733	8,340,180	1894.....	2,355,394	871,859	3,227,254
1883....	2,444,374	5,053,057	7,497,431	1895.....	2,608,289	605,835	3,214,125
1884....	2,353,860	4,588,410	6,942,270	1896.....	2,464,422	342,178	2,806,601

The ownership of the Onondaga salt springs reservation has been a losing investment for the State for some years. In 1896 the revenue derived from the brine furnished to manufacturers was $28,066; the expenses for salaries amounted to $18,710, and for repairs to $24,780; a total of $43,490, and leaving a deficit of $15,424. In 1893 the revenue amounted to $30,659, the expenses to $74,165, leaving a deficit of $43,506. The deficit in 1894 was $29,127, the difference between $32,278 revenue and $61,405 expenses.

The State has in the past obtained considerable profit from the reservation, but keen competition, particularly that of the Warsaw district in recent years, has reduced the production and the revenue without a corresponding decrease in the expenses.

WARSAW DISTRICT.

Prior to 1883 all of the salt produced in the State of New York was from the Onondaga reservation. The manufacture of fine salt from brine was begun in the Warsaw district in 1883. The first well was put down about 1880 for oil, but instead of oil found salt. This was near Wyoming. Very little salt, however, was made from this well. The first well for salt itself was sunk in the fall of 1882 by the Warsaw Dairy Salt Company. They began salt making in 1883. The Crystal Salt Company began shortly afterwards. There are now twelve companies operating in the field. In 1883 the amount of salt made in the Warsaw district was 600,000 bushels of 56 pounds. Four years later the industry had assumed such proportions that the production of solar and fine salt in the Onondaga reservation was exceeded by the output of fine salt at Warsaw. In 1894 the output of fine salt in the Warsaw district was four times the production in the reservation.

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The following table shows the annual output of salt in the Warsaw district from the time of its opening to the close of 1896:

Salt product of the Warsaw district, New York, since 1883.

Year.	Bushels.	Year.	Bushels.
1883	600,000	1890	7,732,060
1884	2,000,000	1891	*a*10,248,505
1885	4,589,635	1892	*a*12,954,705
1886	6,056,060	1893	*a*11,599,640
1887	6,072,000	1894	*a*13,809,270
1888	5,935,000	1895	*b*11,600,680
1889	6,000,000	1896	9,711,455

a Including Genesee district.
b Including southern New York district.

GENESEE DISTRICT.

The record of this region is not so brilliant as that of the Warsaw district. In all six companies have worked in the Genesee Valley, but only one of them has survived the storms of competition and hard times. The opening of the field was nearly contemporary with that of the Warsaw. The first well was put down by the Livingston Salt Company in the spring of 1883, and commenced manufacturing salt the same year. Their output was about 80,000 barrels of common fine salt per year. This company discontinued salt making in 1893. Two other companies began salt making in the following year. These were the Lackawanna Salt Company and the Royal Salt Company. The former made about 60,000 barrels of common fine salt per year, the latter about 100,000 barrels, of which about one-half was common fine and one-half dried. Both of these companies discontinued in 1892. In 1885 three other companies started salt making. These were the Leicester Salt Company, which made about 30,000 barrels of common fine salt for ten years, discontinuing in 1894; the York Salt Company, making 100,000 barrels of common fine salt until January 1, 1896, when it discontinued, and the Genesee Salt Company, the only one of the half dozen in the district existing to-day. The Genesee Company's works are at Piffard. This company makes a specialty of table and dairy grades of salt, about 70 per cent of its product being of these two qualities. It probably owes its existence to-day to the excellent quality of the dairy and table salts manufactured.

ITHACA OR SOUTHERN NEW YORK DISTRICT.

The development of this district is very recent. Drilling was begun here April 1, 1895, the well being completed in about a year. The production for the part of the year the works were in operation amounted to 74,000 barrels.

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ROCK-SALT MINING.

The mining of rock salt in New York began in December, 1885. The shaft of the Retsof Mining Company, located near York, Livingston County, was the first shaft put down for rock salt in the State of New York. This shaft was completed in December, 1885, and the first shipment made during that month. The next shaft sunk was that of the Lehigh Salt Mining Company, near Le Roy, Genesee County. This shaft was completed in 1892, and the first shipments of salt were made in November of that year. The shaft of the Livonia Salt and Mining Company, at Livonia, Livingston County, was the next one sunk. It was also completed in 1892, and shipments were made in the latter part of the year. The fourth and last shaft sunk was that of the Greigsville Salt and Mining Company at Greigsville, also in Livingston County. This shaft was completed in the latter part of 1892, the first shipments being made in September of that year.

The consumption of rock salt in this country is very small when compared with the consumption of evaporated salt, the purposes for which rock salt can be advantageously used being comparatively few. The market that can be reached from the New York field could be supplied by running any one of the above four mines up to its full capacity. In the past few years there has been a large overproduction of rock salt, resulting in the practical abandonment of two of the mines. The other two are run only a portion of the time.

The shaft of the Retsof mine is 1,100 feet in depth, the Lehigh shaft 804 feet, the Livonia shaft 1,432 feet, and the Greigsville shaft 1,150 feet.

The production of rock salt in New York for each year since mining began is shown in the following table:

Production of rock salt in New York from 1886 to 1896.

Year.	Tons.	Year.	Tons.
1886	14,458	1892	130,878
1887	60,374	1893	192,000
1888	105,490	1894	226,328
1889	127,617	1895	222,000
1890	155,260	1896	173,663
1891	135,130		

LOUISIANA.

So far as known, the discovery of salt was made in 1791, on what is now known as Avery Island, by a man named John Hays, who found a salt spring while hunting. Not long after this an attempt was made to make salt by boiling. This was not successful. The supply of brine was too limited to pay the expenses. In 1812, during the war with Great Britain, the price of salt became so high that operations were

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resumed by one John C. Marsh, who continued the work until 1815. The island was subsequently purchased by Judge D. D. Avery, but no attempt at salt making was made until after the breaking out of the civil war. Boiling was renewed in 1861, when, on account of the blockade, salt became dear. In order to increase the supply of brine an attempt was made to deepen the wells, and at the depth of about 16 feet a bed of solid rock salt was struck. This was in May, 1862. Mining the salt by pits was then introduced, and about ten pits were dug, salt being struck at from 14 to 20 feet. Some of the operations were carried on under the auspices of the Confederate government.

The work was continued until April, 1863, when the works were destroyed by the Federal forces under General Banks. It is stated that from 400 to 600 men were working day and night, and that in the eleven months 22,000,000 pounds of salt were mined. This ended pit mining, which must have ended soon anyway. The nature of rock salt would not have admitted a very long continuance of this system of mining, which was primitive and exercised only because of the necessities of the times. The admission of water and quicksands into the pits, which could not have been avoided, would have stopped pit mining and possibly endangered subsequent successful shaft mining.[1]

To Mineral Resources for 1882 Mr. E. W. Hilgard contributed a comprehensive report on the Avery Island or "Petite Anse" salt deposit. Fifteen years before that date Mr. Hilgard had visited the island on behalf of the Smithsonian Institution. At that time the old system of pit mining had been abandoned, and the improvements consisted of a shaft 8 by 8 feet and 83 feet in depth, of which 58 feet was in solid salt. Galleries 8 to 10 feet high and 25 feet wide had been driven 150 feet east and west from the shaft, but owing to difficulties experienced in getting the salt to market very little mining was done prior to 1880. In 1880 the mine was leased to the American Salt Company with the stipulation of 130 tons per day as a minimum output. This was frequently exceeded and as much as 500 tons was mined in one day. The shaft was continued to a depth of 190 feet, of which 165 feet was through solid and unchanged salt. The galleries were extended to 270 feet east and 370 feet west, and crosscuts made from them 190 feet north and south.

As the mining company could not induce the Morgan's Louisiana and Texas Railroad to supply railway transportation, a canal was cut through two miles of marsh to deep water, and an active coastwise shipping trade was developed between the mines and Galveston, New Orleans, and Mobile. In 1886 the railroad company, under new management, built a branch line of ten miles from New Iberia to the mines. About this time the American Salt Company was reorganized as the New Iberia Salt Company. The latter company surrendered its lease and was succeeded by Messrs. Myles & Co., of New Orleans, in 1893.

[1] Report of the American Bureau of Mines, 1867.

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The mines are now in active operation. New works are to be established in 1897, and a large increase in the output is anticipated.

The production of rock salt from the Petite Anse mine has been as follows:

Production of rock salt at Petite Anse mine.

Year.	Short tons.	Year.	Short tons.
Prior to 1883.....	60,000	1890.....	39,979
1883.....	37,130	1891.....	24,320
1884.....	31,355	1892.....	28,000
1885.....	41,898	1893.....	26,800
1886.....	41,957	1894.....	26,047
1887.....	47,750	1895.....	22,368
1888.....	25,214	1896.....	24,236
1889.....	45,588		

WEST VIRGINIA.

Dr. J. P. Hale, of Charleston, W. Va., in a contribution to a pamphlet on the Resources of West Virginia, published in 1876 by the State board of centennial managers, gives some interesting history of early salt making in that State. Dr. Hale has kindly furnished the writer with a copy of this pamphlet, and from it the following has been abstracted:

The principal points at which salt has been manufactured in the State are at Charleston, on the Great Kanawha River; at Hartford, Mason City, Clifton, and other places in Mason County along the Ohio River; at Bulltown, on the Little Kanawha; in Mercer County, on New River; near Birch, on Elk River, and at a few other unimportant places, on a small scale, for local use. The seat of the industry at present is along the Ohio River in Mason County, there being but one establishment of any importance in the State outside of Mason County.

The earliest attempts at salt making in West Virginia were on the Kanawha River in Kanawha County, not far from the present city of Charleston. The Kanawha "licks" were known to be used by the Indians, and were the gathering places for buffalo, elk, deer, and other wild animals before the advent of the white man. The earliest settlement in this region was made in 1774 by Walter Kelley and family at the mouth of the creek bearing his name. They were all killed by Indians. Later, in 1785, when life in that section had become a little more secure, Joseph Ruffner, an enterprising farmer from the Shenandoah Valley of Virginia, purchased about 500 acres of land at the mouth of Campbell's Creek from one John Dickinson, on Dickinson's representations as to the valuable salt springs on the property. Ruffner also purchased 900 acres, extending from Elk River up the Kanawha and embracing the present site of Charleston. Joseph Ruffner did not live to carry out his designs for making salt, but transmitted them with

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the property to his sons David and Joseph, enjoining upon them to carry out his plans for building extensive salt works. All that the elder Ruffner had accomplished was the leasing of the "licks" to one Elisha Brooks, with the right to manufacture salt. Brooks, in 1797, erected the first salt furnace in Kanawha County, which was also the first one west of the Allegheny Mountains. It consisted of two dozen small kettles set in a double row, with a flue beneath, a chimney at one end and the fire bed at the other.

In order to obtain a supply of brine, Brooks sank two or three "gums" into the mire and quicksand of the lick and dipped up the brine with a bucket and sweep. In this crude way he manufactured about 150 pounds of salt a day, which he sold at from 8 to 10 cents a pound. No attempt was made to purify the salt from the "bitterns" and other impurities, either organic or inorganic. This salt soon acquired a reputation for its strong pungent taste and superior qualities for curing meat, etc. The presence of iron gave the salt a reddish tinge, and it became widely and favorably known as "that strong red salt from the Kanawha Licks."

In 1806 the two brothers Ruffner, inspired by the growing needs of an increasing population, began to look for the source of the brine springs in the hope of finding a larger and better supply, from which to manufacture salt on a much larger scale. The history of their struggle as recorded by Dr. Hale is very interesting. They began by sinking a "gum" consisting of a hollow sycamore tree, which reached what they supposed was bed rock at 13 feet. With the primitive means at their command even this little was only accomplished after much hard work and many and trying delays. Upon cutting at the bottom with crowbars it was found to be only about 6 inches of shale, which when penetrated, furnished a larger stream of brine, but much weaker than the lick at the surface.

The brothers, disappointed at this, decided to sink a well in the bottom land about 100 yards from the river. This was the source of more disappointment. After penetrating 45 feet of alluvial deposit, they struck the same shale as at the gum, and only a slightly brackish water.

They then decided to return to the "gum" and continue work until they struck bed rock, which they finally did at about 17 feet. All of this was accomplished only after extremely hard and patient toil. The gum was made sufficiently tight to allow the water to be bailed out, and that which came through the rock was tested. The quantity was small, but strong. Encouraged by this, they decided to drill in the rock. This was done by means of a long drill with a 2½-inch chisel bit attached at the upper end to a spring pole, and the pole to a rope. Boring by this means was slow, difficult, and tedious, but on the 1st of November, 1807, at 17 feet in the rock, they struck a larger flow of strong brine. Continuing the work, at 28 feet a still larger and stronger flow

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was obtained. On January 15, 1808, at 40 feet in the rock, they found a stream amply large and strong for all their purposes, and ceased boring.

Another difficulty had yet to be overcome. They had no pipes in which to bring the strong brine, undiluted by the surface seepage, to the top of the ground. It was finally accomplished by whittling out two half tubes from long strips of wood, fitting the edges carefully together and wrapping the whole from end to end with small twine. This remarkable ingenuity solved the problem. The brine came up free and strong from below, the "gum" floor was made water-tight and from the gum the brine was raised to the surface by bucket and sweep. This is said to be the first rock-bored salt well west of the Alleghany Mountains if not in the United States. It required a year and a half to accomplish it. The success is the surprising feature. As Dr. Hale says: "Without preliminary study, previous experience, or training; without precedents in what they undertook; in a newly settled country, without steam power, machine shops, skilled mechanics, suitable tools or materials, failure, rather than success, might reasonably have been predicted."

Meanwhile their furnace, a reproduction of Brooks's on a larger plan, was under construction and was completed in time for the brine. On February 8, 1808, Ruffner Brothers secured their first output of salt from the furnace and immediately cut the former price in half, selling it at the unprecedented low figure of 4 cents per pound.

The neighbors who had watched the progress and result of the Ruffners' struggle began boring on their own lands with more or less success, and in 1817 there were about 30 furnaces and 15 or 20 wells in operation. Improvements in mechanical methods of raising the brine were adopted, the bucket and sweep giving way to the winch, and the winch in 1828 to steam. Coal, too, began to be used for fuel, David Ruffner being the enterprising pioneer in this as in the boring.

In 1831 one William, or "Billy," Morris invented an ingenious but simple tool for boring salt wells, which is to-day used in boring oil and gas wells. It was the tool known as "slips" or "jars" and is so common now as to need no description here. Morris's invention was never patented, and, like the hydraulic ram, has not been improved upon.

In 1835 there were about 40 furnaces along the Kanawha River, producing annually about 2,000,000 bushels of salt. But the activity in salt making in West Virginia has since that time been transferred to the region along the Ohio River in Mason County. The change began in 1849. In this year Messrs. Williams & Stevens bored for salt water, at West Columbia and struck a good flow of strong brine at 700 feet and erected the first salt furnace on the Ohio River. This was soon after sold to New York parties and enlarged and improved by them to a capacity of 1,200 bushels per day.

The second furnace on the Ohio was built in 1854 at Hartford City

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by a company formed by Hartford, Connecticut, parties. The first one was located at the southern limits of the coal exposures, and the other at the northern limit. The third well or wells were sunk and the third furnace was erected at Mason City, about halfway between the others. Within the next few years 10 more furnaces were erected, making a total of 13, with an annual salt-making capacity of 3,700,000 barrels. At the time of the writing of Dr. Hale's report (1875) 4 of these furnaces were idle, and the actual output of salt from the other 9 furnaces was reported by him at 2,500,000 bushels, or 500,000 barrels.

The salt-making industry in West Virginia has since suffered from the competition brought about by the development of other fields. Statistics are wanting for the production between 1876, reported by Dr. Hale, and 1882, when the first volume of Mineral Resources was published. In the latter year the production of salt in West Virginia had fallen to 400,000 barrels. In 1883 the now famous Warsaw district of New York was opened, and we see that there has been an almost steady decrease in the annual production in West Virginia since that time. In 1889 it had dropped to 200,000 barrels, only 50 per cent of what it was in 1882, and 40 per cent of what it was in 1876. In 1895 and 1896 it was a little more than 175,000 barrels. These facts are illustrated in the following table:

Production of salt in West Virginia for 16 years.

Years.	Barrels.	Years.	Barrels.
1876	500,000	1889	200,000
1882	400,000	1890	229,938
1883	320,000	1891	225,000
1884	310,000	1892	216,000
1885	223,184	1893	210,736
1886	250,000	1894	194,538
1887	225,000	1895	176,720
1888	220,000	1896	176,921

As previously stated, four of the 13 furnaces in Mason County were idle in 1875. Not only are they still idle, but other establishments have ceased making salt. Some of the furnaces have been destroyed by fire, others have been abandoned, and in 1896 there were but 4 furnaces in the State, 3 of which are in Mason County.

OHIO.

An account of the early manufacture of salt in Ohio, by Dr. S. P. Hildreth, is found in Silliman's American Journal of Science, Vol. XXIV, page 46. This report was published in 1833. Dr. Hildreth also contributed a report on the Ohio salines to the first annual report

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of the Geological Survey of Ohio, published in 1838. The important or interesting features of early salt making in the State are condensed in the later report. According to Dr. Hildreth, the first attempt at making salt in Ohio was at what is now called the "Old Scioto Salt Works." This was as early as 1798. The works were located on Salt Creek, a branch of the Scioto River, in Jackson County. The wells were dug only to the rocks below the surface soil, the brine flowing through the rock crevices into the wells. The brine was weak, requiring from 600 to 800 gallons for a bushel of salt. The product was dark and full of bittern, no attempt being made to purify the salt even by draining. It was transferred direct from the kettles to pack horses and transported to other settlements, where it was sold for $3 and $4 a bushel as late as 1808. These brine springs were thought to be so important to the country that when the Territory of Ohio was admitted to statehood in 1802 a tract 6 miles square, embracing the saline, was set apart for the use of the State. Two other reservations were made, each of 640 acres. One was in Muskingum County, the other in Delaware County. These resources were considered too valuable to be allowed to get into individual hands so that a monopoly would be created.

In 1804 the legislature enacted a law regulating the management of the salt reservations, and an agent or superintendent was appointed to lease lots to manufacturers, inspect the salt made, and carry out the other provisions of the law. The manufacturers were taxed 16 cents per year on every gallon of their kettle capacity, no one being allowed to have less than 600 or more than 4,000 gallons to a furnace. The revenue produced to the State did not exceed $500 in any one year, and as stronger wells were discovered on navigable streams the old works became unprofitable, were abandoned, and the reservations sold.

Salt from deep wells was first obtained in 1808 on the Kanawha River, in West Virginia (see report on that State). Here brine of such strength as to require only 75 gallons to make a bushel of salt was procured, whereas it took six or eight times that much brine from the Scioto Works.

In 1817 the first attempt was made at procuring salt on the Muskingum River, followed in 1819 by another well a few miles farther down the river. Brine was found at 350 feet, but it was weak and in insufficient quantities to prove profitable. A few years later other wells were bored in the vicinity, but usually farther down the river. It was found that with the fall of the stream the wells had to be bored to greater depth to find the salt water, but when found the brine was stronger and more plentiful. It is not possible to state how much salt was produced here or even to make an estimate of the production. There are no records obtainable.

The statistics of salt production in Ohio were not compiled until the preparation of the report on Mineral Resources of the United States

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was undertaken by the United States Geological Survey, and the first year for which the information was obtained was 1883. Since that time the output has been as follows:

Production of salt in Ohio since 1883.

Year.	Barrels.	Year.	Barrels.
1883	350,000	1890	231,303
1884	320,000	1891	300,000
1885	306,847	1892	400,000
1886	400,000	1893	543,963
1887	365,000	1894	528,996
1888	380,000	1895	781,033
1889	250,000	1896	1,662,358

MICHIGAN.[1]

As in New York and West Virginia, the salt springs of Michigan were known to and used by the aboriginal Indians, but the history of the development by white men begins with the report of the State geologist, published as a legislative document in 1838. On March 4 of that year the governor of the State approved an act directing the State geologist to bore for salt at one or more of the springs and appropriating $3,000 for the purpose, and also directing a report on the result to be made at the next session of the legislature. The report was made on January 1, 1839. In his report the State geologist says: "The brine springs of our State, like those of Ohio, Pennsylvania, and Virginia [now West Virginia], emanate from a rock which lies deep, being covered with a mass of rock and earthy matter which it is necessary to penetrate. In this respect they differ most essentially from those of New York."

Dr. Houghton, then State geologist, bored two wells, one at a point 3 miles below Grand Rapids, on the Grand River, the other at the mouth of Salt River, in Midland County. He exceeded his appropriation by $800 and requested additional appropriations to continue the work. The legislature responded by appropriating $15,000, but the work was soon suspended because the money appropriated could not be realized. In the spring of 1840 work was again resumed under two appropriations of $5,000 each, and other appropriations were made in 1841 and 1842. Summing up the work done by the State, Dr. Garrigues says:

> By act of February 16, 1842, the governor was authorized to cause the salt spring lands of the State to be platted into lots, and to lease the right to manufacture salt, provided that every lease should contain a clause requiring at least 14 cents per

[1] Much of the historical data herein is obtained from the report of S. S. Garrigues, Ph. D., State salt inspector, published in 1881.

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bushel of 56 pounds to be paid to the State for the water. The report of the State geologist, dated January 23, 1843, shows considerable progress in the work on Grand River; but at the spring on the Tittabawassee River no further progress was made, and no disbursements except enough to keep the machinery in repair. The reason assigned for not going on with the work implies a doubt concerning the title of the State to the lands where the salt well was commenced.

The above constitutes the entire action of the State on the development of the salt wells prior to 1859. It remained for private enterprise to establish an industry in the Saginaw Valley. It was done by men without experience and without knowledge of the geology of the country, but, as in West Virginia, it was attended with success. The first well was bored in 1859, in what is now East Saginaw. Brine of one degree strength was struck at 90 feet. It gained in strength until a depth of 636 feet was reached, when the brine registered 90 degrees in strength. The first salt was made in the summer of 1860. On July 4 of that year the pioneer salt blocks of the East Saginaw Company were opened for inspection and were thronged all day by visitors.

The industry soon became an important one, but irregularities in manufacture developed the necessity for salt inspection. This was at first done locally, and ten years later, in 1869, the legislature enacted a State inspection law. Dr. Garrigues was appointed inspector and served for twelve years, being succeeded in 1881 by Mr. George W. Hill, who continues to serve. His long term of office is the best testimonial to the faithful discharge of his duties. In Mr. Hill's report for 1896 (fiscal year ending November 30) he shows that salt is made in nine counties in the State, namely, Saginaw, Bay, Huron, St. Clair, Midland, Iosco, Manistee, Mason, and Wayne. The amount of salt inspected by him in 1896 was 3,336,242 barrels. From this should be deducted the difference between the amount of salt in bins on November 30, 1895, and on November 30, 1896, namely, 260,328 barrels, leaving 3,075,914 barrels manufactured in 1896, fiscal year. The amount of salt product reported to the Survey for the calendar year 1896 was 3,164,238 barrels.

The reports of receipts and disbursements show a condition very different from that of the Onondaga reservation in New York. At the reservation the duty is 1 cent per bushel, equivalent to 5 cents per barrel. The revenue to the State in 1896 was $28,066. The disbursements were $43,490, leaving a deficit of $15,424, and there has been a deficit ranging from this to about $45,000 for several years. In Michigan the duty is 3 mills per barrel, only 6 per cent of the duty in New York. The revenue derived in 1896 was $10,008.72; the expenses were $9,796.52, leaving a balance of $212.20. It must be remembered, however, that in the Onondaga reservation the State is obliged to keep the wells and distributing works in repair, the expenses for repairs in 1896 being $24,780.

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The following tables exhibit the production of salt in Michigan since 1860, according to the inspector's report:

Salt manufactured in the State of Michigan prior to the enactment of the State inspection law in 1869.

Year.	Barrels.
1860	4,000
1861	125,000
1862	243,000
1863	466,000
1864	529,073
1865	477,200
1866	407,997
1867	474,721
1868	555,690
Total	3,283,037

Salt manufactured in the State of Michigan since the enactment of the State inspection law in 1869.

Year.	Barrels.
1869	561,288
1870	621,352
1871	728,175
1872	724,481
1873	823,346
1874	1,026,970
1875	1,081,856
1876	1,482,729
1877	1,660,997
1878	1,855,884
1879	2,058,040
1880	2,676,588
1881	2,750,299
1882	3,037,317
1883	2,894,672
1884	3,161,806
1885	3,297,403
1886	3,677,257
1887	3,944,309
1888	3,866,228
1889	3,846,979
1890	3,838,637

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Salt manufactured in the State of Michigan since the enactment of the State inspection law in 1869—Continued.

Year.	Barrels.
1891	3,927,671
1892	3,812,054
1893	3,514,485
1894	3,138,941
1895	3,529,362
1896	3,336,242
Total	70,851,377
The total amount of salt which Michigan has produced to date	74,134,414

KANSAS.

BRINE SALT.

The Eleventh Annual Report of the Kansas Bureau of Labor, published in 1895, contains a report on the salt industry of the State, from which the following is abstracted:

Those who traveled over the great plains of Kansas in the early days would often have given almost any price for a few pounds of salt. The myriads of buffalo, deer, and antelope depended for their supply of this indispensable article upon the various salt marshes which are scattered over central Kansas. The pioneer travelers, hunters, traders, and surveyors were often led by the deep paths of the buffalo to these marshes, which are the salty remains of decomposed saline strata. They are large shallow lakes which almost dry up in the summer, and a thin white scale of salt is deposited over hundreds of acres of grassless territory.

As late as 1870 the pioneer could get 10 cents a pound for salt evaporated from the water of these marshes. The hunters when on the chase would often bring their buffalo hams to the marshes to make "jerked beef" of them. This was often done by merely dipping the long strips of meat every few hours into the salty water and allowing it to dry in the sun.

The primitive salt manufacturers of Kansas erected almost identically the same kind of plants as those described in ancient history. They erected stone arches about their kettles, and chimneys were built in order to economize the fuel and heat as much as possible. Until 1868 these crude factories, which were found about the marshes in Republic, Cloud, Jewell, Lincoln, Stafford, and Sumner counties, were the only ones in Kansas. In 1867 the Continental Salt Company of New Bedford, Massachusetts, began drilling for brine near the Salt

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Spring at Solomon City. Very good brine was struck at about 75 feet. At this time there were but two popular methods of making salt, i. e., the kettle process, which was used on a small scale at the above-named salt marshes, and the solar process. As good fuel was scarce in this prairie country, the solar process was adopted. In 1874 a second solar plant was erected at Solomon City, by William Dewar. These plants were later owned by one firm and are in active operation to-day. It was the manufacture of salt at this place that first put Kansas among the salt-producing States of the Union.

In 1887–88 central Kansas was undergoing a wonderful change and development. Farms were being developed, factories were springing up, cities were putting in all modern improvements and struggling for superiority in every line, and ready money was at hand for any kind of speculation. Companies and syndicates with thousands of dollars of capital were formed in a few hours to undertake the most daring enterprise. It was during this period of boom that Ellsworth, Lyons, Hutchinson, Kingman, Anthony, Wellington, Rago, Pratt, Great Bend, Sterling, Nickerson, and Kanopolis organized companies to bore for coal and gas, or any valuable mineral that might chance to be found. In the fall of 1887 and during the year 1888 rock salt was struck at the above towns. In most cases they were seriously disappointed in not finding either coal or gas in large quantities, and they were very slow to appreciate the real value of such an important mineral as rock salt. Lyons and Kingman took the lead in the salt-mining industry, but Hutchinson interested Guinlock & Humphrey, of New York, in the salt wells of that place, and they soon took the lead in the evaporation of brine. A fairly complete account of the salt-mining industry of this State was given in the report of the Kansas Bureau of Labor for 1893. The following description of rock-salt mining in Kansas is obtained from the report mentioned:

ROCK SALT.

Rock salt was discovered at Lyons, Rice County, Kansas, in the year 1887 while boring a series of experimental wells in search of oil and natural gas. The drill penetrated the body of salt at a depth of 800 feet from the surface, and passed through it at a depth of nearly 1,100 feet. This bed of rock salt was deposited during the Triassic period of the Mesozoic age of the geological section by the solar evaporation of an inland sea whose waters held the salt in solution. The above process of salt formation was not continuous, as is proven by the bed of rock salt being interlaid with layers of shale, which also proves that the inland sea was subject to sudden inflows of large bodies of fresh, muddy water, arresting the deposition of the salt for a time and depositing mud, from which shale is formed in its stead.

In the year 1890 the Lyons Rock Salt Company was organized by some of the principal bankers and business men of Lyons, Kansas, and St. Louis, Missouri, headed by Mr. A. Bevis, of St. Louis, as president,

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for the purpose of sinking a shaft and mining the rock salt and placing it on the market in commercial quantities. About three-fourths of a mile northeast from the center of the city of Lyons the shaft of the Lyons Rock Salt Company is situated, at about the center of the 4,000 acres of the salt lands controlled by this company. Work was commenced on this shaft in the month of August, 1890, the size of the shaft being 7 by 16 feet, divided into three compartments, two for hoisting purposes and one for ventilation. The bed of rock salt was reached in the following January. The shaft penetrates the bed of salt to a depth of 265 feet, or a total depth of shaft of 1,065 feet from the surface, there being some 30 or 40 feet of salt strata below the bottom of the shaft.

On sinking the shaft through this 265 feet of salt strata, 15 workable veins of rock salt were passed through, ranging from 4 to 18 feet in thickness, the veins of salt being separated by the above-mentioned veins or layers of shale, running from one-fourth of an inch to 5 feet in thickness. A vein of salt 18 feet in thickness and of exceptional purity was selected for mining purposes, the lower 10 or 12 feet of this vein being mined. From the bottom of the shaft the mine is laid off somewhat similarly to the streets of a city, the main streets, 25 feet in width, running parallel east and west and the cross streets, of the same width, running north and south. From these cross streets rooms or chambers are driven, having a width of 50 feet, there being pillars 50 feet in thickness left standing between each chamber. It is in these chambers that the principal mining operations are carried on.

In mining rock salt it is at first undercut with mining or channeling machines operated by compressed air. Holes are then driven into the salt with air drills and dynamite placed in them, which is then exploded with electricity, bringing the salt down to the floor of the mine. The loose salt is then loaded on cars, each holding about two tons, conveyed to the shaft over underground railroads, placed on the elevators or cages, and hoisted to the top of a five-story mill building, located directly over the mouth of the shaft. The salt is then dumped from the mine cars into crushers over dumps that work automatically and passes down through different-sized crushers by gravity to the screen room below, where, by passing the salt over screens of various sizes, it is separated into nine different grades or sizes, the salt then passing into large bins, from which it is loaded into railway cars. The various grades of rock salt are used for almost every purpose for which salt is required.

Mr. J. C. Baddeley, secretary of the Kansas Salt Company, Hutchinson, Kansas, reports that salt was first discovered underneath the city of Hutchinson in 1887. Some prospectors were drilling for oil or whatever they could find, and discovered a bed of rock salt over 300 feet in thickness at a depth of 400 feet from the surface. The first plant or salt works was built in the spring of 1888, but was not operated until late in the summer of that year. The output in that year was 155,000 barrels. Since then the product, including rock salt mined at Lyons

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and brine salt evaporated at Kingman, Sterling, Kanopolis, and other places, has been as follows:

Production of salt in Kansas since 1888.

Year.	Barrels.	Year.	Barrels.
1888	155,000	1893	1,277,180
1889	450,000	1894	1,382,409
1890	882,666	1895	1,341,617
1891	855,536	1896	1,408,607
1892	1,480,100		

TEXAS.

There are two wells producing brine for salt making in Texas. Both are of recent development and both are owned and operated by the Lone Star Salt Company, of Dallas. The first well to be driven was at Colorado, Texas, in 1884. Salt was struck at a depth of 7 feet, and the work of making salt from brine was begun in 1885. The average annual production from this well since then has been about 20,000 barrels.

The second well was begun at Grand Saline early in 1889 and completed before the close of the year. Salt making was begun at once, and from and including 1890 the output has been something over 100,000 barrels annually.

The exact statistics of production in the State have been obtained only since 1892, since which time the following output has been recorded:

Salt production in Texas since 1892.

Year.	Barrels.
1892	121,250
1893	126,000
1894	142,857
1895	125,000
1896	125,000

CALIFORNIA.

Salt is manufactured from brine in five counties in California, namely, Alameda, Riverside, Colusa, San Luis Obispo, and San Diego. Rock salt is mined in San Bernardino County. The largest works are those of Alameda County, on the shores of San Francisco Bay. Vast stretches of overflowed tide lands, or salt marshes, extend along the south arm of the bay, and on these the salt is made. The different salt works contain

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from 20 to 1,200 acres each. Nearly all of the land is about flush with a 5-foot tide, so that the high tides of 6.4 feet will cover the land from 15 to 18 inches. Mr. A. A. Oliver, of Mount Eden, has furnished the following description of the methods employed in that locality:

The land having been cleared of grass and weeds is first diked with a good levee 3 or 4 feet high. It is then partitioned off into reservoirs of different sizes for receiving and evaporating the water. Crystallizing ponds are excavated and platforms for stacking the salt are built. The ground is principally peat bog overlying blue clay. The crystallizing ponds are dug in the peat, of which enough is left to form a bottom or carpet in the pond. The salt crystals are readily removed from the peat floor. There are usually seven evaporating reservoirs to a plant, the brine being drawn from one to another as it strengthens and decreases in volume by evaporation. The last three—i. e., Nos. 5, 6, and 7—are called lime ponds, because large quantities of gypsum and other matter, precipitated before the salt, settles in them. The brine is retained in the seventh reservoir until it reaches a density of 25° Baeumé. When this strength of brine is attained the crystallizing ponds are filled to a depth of 10 or 12 inches and the brine evaporated until 29° by the hydrometer is reached. The mother liquor is then drawn off and the salt gathered up and conveyed into warehouses to drain. This completes the solar process.

Much of the salt is sold after drying in the warehouses, but many thousand tons are taken to refining works in San Francisco, where it is more thoroughly dried by artificial heat and ground into various grades for chlorination works, packing houses, and silver mills, and for dairy and table uses. The regular trade winds which blow in the summer months are quite strong in this locality and greatly aid evaporation. Mr. Charles G. Yale states that at some places they permit a complete natural evaporation without changing the water from the ponds. The industry has not been as prosperous recently as it was in former years and overproduction has brought prices down very low. The cheapest kind of labor only is employed. One large company or "trust" now controls most of the ponds.

At Salton, in Riverside County, in that portion of the Colorado desert which is below the level of the sea, are works where salt water is pumped from wells and evaporated until crystals are formed. Here from 5,000 to 10,000 tons are made annually.

At National City, in San Diego County, several thousand tons are made yearly by evaporating the water of San Diego Bay. Better prices are obtained for the salt in that part of the State than are received for the product in Alameda County.

Thirty miles south of Danby, in San Bernardino County, rock salt of exceptionally fine quality is found. Some 3,000 or 5,000 tons a year are mined. The cost of hauling to railroad and distance from market prevents a much larger production. The salt mined is very transparent and pure.

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Near Sites, Colusa County, salt is made from brine springs, on the edge of a shallow lake, which dries up in the summer. Shallow bore-holes in the bed of the lake develop salt water and inflammable gas. The product of salt in this section is comparatively small, but the article is very pure and good.

A little salt for local use is made at Black Lake, near the summit of the San Jose Mountains, in San Luis Obispo County. In the vicinity are numerous salt springs and large deposits of rock salt.

Messrs. Plummer Bros., of San Francisco, state that prior to 1864 there was very little demand for salt on the Pacific Coast. All salted fish and meats were brought from the North Atlantic seaports via Cape Horn. Salted codfish from Newfoundland was received in this way, one brig in 1863 discharging about 400 tons of salt codfish in drums at San Francisco. All this is changed. Instead of importing salted meats and fish California now exports them. Cheap salt made almost at their doors enables San Francisco packers to cure beef and pork in large quantities, much of which is exported to foreign countries. The Newfoundland salt cod have been replaced by Alaskan codfish packed in California salt, and the finest of cured salmon are those caught in Alaskan waters and packed in California salt.

California salt, produced by solar evaporation at the Alameda County salt marsh lying adjacent to the Bay of San Francisco, was put on the market in 1856, but only in very limited quantities. As soon as a demand for salt arose, some attention was given to local production, and several ponds were walled in for the purpose of retaining the sea water. This produced sufficient salt to supply the market, hitherto dependent upon England for fine salt, and upon Lower California, Hawaii, China, and South America for coarse grades. During 1858 San Francisco Bay salt was sold for $16 per ton of 2,000 pounds. This was coarse salt of poor quality, containing bittern and other impurities. The late J. A. Plummer erected the Crystal Salt Works in 1864. These consisted of ponds for receiving and settling the sea water, evaporating reservoirs, brine ponds, and large floored vats, the water at different stages of density being pumped from one to the other. After the salt had formed and the mother liquor drained off, the product is stated to have shown 99.63 per cent sodium chloride, and was, and still is, known as "California crystal salt." Other salt works, employing similar methods, were built, and in 1871 all foreign salt, except English, was driven from the market. California salt now supplies all the Pacific States, the Alaska fisheries, and Siberia. The production is so large that it exceeds the demand, with the usual result of competition and low prices. As shown in the table of production in the preceding pages, the output of California salt has increased from 214,286 barrels, or 30,000 short tons, in 1883, to 430,121 barrels, or 60,217 short tons, in 1896. Statistics of production for years prior to 1883 are not obtainable.

The first salt gathered in Alameda County, according to Mr. Oliver, was a purely natural product. Along the shore was what were called

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"tide lands"—land which was overflowed by the high tides of June and July. In these tide lands were a number of natural ponds or sinks in which the water from the high tides was retained, and as the tides of August and September did not reach them, the retained water all evaporated, leaving small quantities of salt in the bottoms of the ponds (1845 to 1852). The Spaniards, Mexicans, and Indians would gather this impure salt annually, the harvest sometimes amounting to but a few buckets full. In 1853 one John Johnson and some others observed the salt gathering, and as the land was public domain (school lands) they bought it, paying the State $1.25 per acre. During 1854 Johnson surrounded some of the land with levees for the more complete retention of the water. As far as Mr. Oliver is able to ascertain, Johnson gathered in that year 40 or 45 tons of salt for which he received $50 a ton. In the following year, other persons having followed Johnson's example, about 150 tons were gathered. This brought about $40 per ton. As the number of people engaged in the industry increased, and as the methods were crude and the product impure, the price fell to $2 and $3 per ton. As previously stated, the first attempt to improve the quality of the product was made in 1864.

UTAH.

As in most of the other salt-producing States, the exact data in regard to the earliest manufacture of salt in Utah is lacking. Mr. J. W. Heywood, manager of the Inland Crystal Salt Company at Salt Lake City, states that the Indians obtained a supply of salt at what is now Salina. So far as known, the first salt made by white men was by the pioneer band of Mormons in Salt Lake Valley. A few days after their arrival, in July, 1847, they began the manufacture of salt by boiling the water of Great Salt Lake. Thereafter it was customary to proceed periodically to the shores of Great Salt Lake, 13 miles west of the city established by them, and boil sufficient brine of the lake to make the salt supply for the various families. This mode of procedure was carried on for several years, and as the population increased, it became necessary to turn the making of salt into an industry, which was done in a limited way.

In former years the eastern shores of the lake were marked by little bayous or sloughs, and the prevailing winds being from the west, these bayous or sloughs were filled with water from the lake. Upon the abatement of the wind the sloughs were left full. The water was evaporated by solar heat, and in the dry atmosphere the evaporation was very rapid. The salt was harvested by scraping it off the ground. It contained more or less dirt, according to the care exercised in gathering it. It also contained the usual impurities—gypsum, sulphate of soda, etc. The evolution from this to improved methods of salt making was slow. It was not until 1887 that a company of Mormons conceived the idea of leveling some three or four hundred acres of ground, sub-

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dividing them into shallow ponds, and filling them with water pumped from the lake. After a considerable time spent in experimenting, the company finally succeeded in eliminating most of the impurities. In 1891, the Inland Crystal Salt Company, which may be said to be the pioneer granulated crystal salt company of the West, was able, by pumping continuously and draining continuously, to produce a practically pure salt. This product is crushed and sifted by special machinery, kiln dried, and sold. It is claimed that it will not cake in sacks and saltcellars. In 1893 another plant was established, modeled on lines similar to the one described, and there are to-day four plants in Utah working on the principle established by the Inland Company in 1891.

The rock-salt deposits of Utah are at Nephi and Salina. At both places the characteristics of the salt indicate solar evaporation at some past time. The deposits are more or less impregnated with dirt and sand, making the salt inferior to the salt of Kansas or Louisiana for stock-feeding purposes. Large lumps as clear and transparent as glass are, however, frequently found.

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FLUORSPAR AND CRYOLITE.

By EDWARD W. PARKER.

FLUORSPAR.

PRODUCTION.

The amount of fluorspar produced in the United States in 1896 was 6,500 short tons, valued at $52,000, against 4,000 tons, valued at $24,000 in 1895, indicating an advance from $6 to $8 per ton in the price. The price in 1896 was higher than ever before, the nearest approach to it being in 1891, when the product of 10,044 short tons was valued at $78,330, an average of $7.80 per ton. In 1892 the output amounted to 12,250 tons, worth $7.26 per ton, increasing in amount the following year to 12,400 tons, but declining in value to $6.77 per ton. The product dropped to 7,500 tons in 1894, and the price declined to $6.33. With a further decrease in product to 4,000 tons in 1895, the value again declined to $6 per ton. The increase in 1896, both in amount and value, was quite pronounced, and a healthy reaction from the depressed condition of the two or three years just preceding. Prior to 1896 Rosiclare, Illinois, has furnished the entire domestic supply of fluorspar. During 1896, however, operations were begun on deposits of fluorspar at Marion, Kentucky, and 1,500 tons were mined there. These are the only two deposits of commercial importance known to exist in the United States. The mineral is used in the manufacture of hydrofluoric acid and opalescent glass. It is also valuable as a flux in iron smelting.

The following table shows the annual production of fluorspar since 1882:

Production of fluorspar in the United States from 1882 to 1896.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1882	4,000	$20,000	1890	8,250	$55,328
1883	4,000	20,000	1891	10,044	78,330
1884	4,000	20,000	1892	12,250	89,000
1885	5,000	22,500	1893	12,400	84,000
1886	5,000	22,000	1894	7,500	47,500
1887	5,000	20,000	1895	4,000	24,000
1888	6,000	30,000	1896	6,500	52,000
1889	9,500	45,835			

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CRYOLITE.

This mineral is used to a considerable extent in the manufacture of alum and sodium salts, for making white porcelain-like glass, and for other technical purposes. In the preparation of alum and sodium salts from cryolite, alumina is left as a residue; and from this, metallic aluminum is extracted by electrolytic process. The only source of supply of the mineral is Greenland, although traces of this mineral were long ago shown by Cross and Hillebrand to occur in the neighborhood of Pikes Peak, Colorado.

IMPORTS.

The imports of cryolite for a series of years are shown in the following table:

Imports of cryolite from 1871 to 1896.

Year ended—	Amount.	Value.	Year ended—	Amount.	Value.
	Long tons.			*Long tons.*	
June 30, 1871..	.....	$71,058	June 30, 1884..	7,390	$106,029
1872..	.....	75,195	Dec. 31, 1885..	8,275	110,750
1873..	.....	84,226	1886..	8,230	110,152
1874..	.....	28,118	1887..	10,328	138,068
1875..	.....	70,472	1888..	7,388	98,830
1876..	.....	103,530	1889..	8,603	115,158
1877..	.....	126,692	1890..	7,129	95,405
1878..	.....	105,884	1891..	8,298	76,350
1879..	.....	66,042	1892..	7,241	96,932
1880..	.....	91,366	1893..	9,574	126,688
1881..	.....	103,529	1894..	10,684	142,494
1882..	3,758	51,589	1895..	9,425	125,368
1883..	6,508	97,400	1896..	3,009	40,056

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MICA.

By Edward W. Parker.

PRODUCTION.

Mica production in 1896 showed an improvement over 1894 and 1895, but did not reach the production of 1891, 1892, and 1893. The mica industry during the past decade has been one of uncertainty and discouragement. In the five years from 1880 to 1884, inclusive, the production of mica in the United States averaged $256,000 in value. In 1884 importations of India mica began, and while the domestic product was valued in that year at $368,525, the value of the output in 1885 dropped to $161,000, and in 1886 to $70,000. In the eleven years from 1886 to 1896, inclusive, the value of the domestic production averaged a little less than $80,000. The value of the production in 1896 was $67,191, nearly $13,000, or 16 per cent less than the average in eleven years. The product included $65,441 worth of cut or sheet mica, and $1,750 worth of scrap or waste. Comparisons of the domestic production with the imports are made under the heading "Review of the industry."

The following table shows the annual production of mica in the United States since 1880:

Production of mica since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Pounds.			*Pounds.*	
1880	81,669	$127,825	1889	49,500	$50,000
1881	100,000	250,000	1890	60,000	75,000
1882	100,000	250,000	1891	75,000	100,000
1883	114,000	285,000	1892	75,000	100,000
1884	147,410	368,525	1893	.....	88,929
1885	92,000	161,000	1894	.....	52,388
1886	40,000	70,000	1895	.....	55,831
1887	70,000	142,250	1896	.....	67,191
1888	48,000	70,000			

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IMPORTS.

The following table shows the imports of unmanufactured mica from 1869 to 1896:

Unmanufactured mica imported and entered for consumption in the United States, 1869 to 1896, inclusive.

Year ended—	Value.	Year ended—	Value.
June 30, 1869	$1,165	June 30, 1883	$9,884
1870	226	1884	28,284
1871	1,460	1885	28,685
1872	1,002	Dec. 31, 1886	*a* 56,354
1873	498	1887	*a* 49,085
1874	1,204	1888	*a* 57,541
1875	.....	1889	*a* 97,351
1876	569	1890	*a* 207,375
1877	13,085	1891	95,242
1878	7,930	1892	218,938
1879	9,274	1893	147,927
1880	12,562	1894	126,184
1881	5,839	1895	174,886
1882	5,175	1896	169,085

a Including mica waste.

USES.

The greater part of the cut or sheet mica produced is used by stove manufacturers. The remainder goes into the manufacture of electrical dynamos, for which its nonconductive properties, when free from iron, render it very valuable. Ingenuity has developed a method of using also the smaller sizes of mica for electrical purposes, and some demand has been created for them. Heretofore they went to the scrap pile and were either wasted or ground. The final scrap or waste from cutting is ground for the manufacture of lubricants, for giving a crystal effect to wall papers, and for other decorative purposes. A new use for scrap mica is reported by Mr. H. C. Mitchell, in a paper read before the Ontario Mining Institute April, 1897. On account of its infusibility, except at very high temperatures, and its nonconductive properties, Mr. Mitchell recommends it as the principal ingredient for boiler and steam-pipe covering, supplementing his recommendations with a report of results of trials made with such a compound. Some of the trials were made on railway locomotives when subjected to constant and heavy vibrations, and after two years' trial the material was found to be in perfect condition. Mr. Mitchell also suggests the use of mica

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waste for fireproofing, and for insulating cold-storage chambers, and it is possible that mica waste may be found an excellent substitute for asbestos for these purposes.

REVIEW OF THE INDUSTRY.

While the value of the output in 1896 was nearly 20 per cent more than that of 1895, the increase can hardly be considered as indicative of any real improvement in the condition of the industry. With the exception of some promising developments at Shelby, Cleveland County, North Carolina, the condition of the industry was about the same as reported in Mineral Resources for 1895. The mine at Shelby was opened in July, 1896, and by the middle of March, 1897, had shipped 30,000 pounds of sheet mica. Some of the mica obtained from this mine is of exceptionally large size and of first quality. Mr. J. Shirley Smith, owner of the mine, presented to the Smithsonian Institution, through the United States Geological Survey, some sheets of mica fully 30 inches in diameter. These are the largest pieces ever received by the Institution, and have been placed on exhibition in the National Museum.

In other portions of the United States mica mining is in about the same condition as in 1895. The condition of the industry at the mines in North Carolina, the principal source of supply, has not been one to encourage the investment of large capital and the introduction of modern methods. Chief among the obstacles to large investment is the general uncertainty as to the character of the deposits. Mica occurs in pockets, some of which are very rich, while work may be carried on upon promising prospects, for weeks or months, without finding merchantable mica. Then, too, the mica regions are remote from railroad transportation. All of the mica mined in North Carolina, except that produced at Shelby, is hauled over mountain roads from 25 to 50 miles to Asheville or Marion, North Carolina, or Johnson City, Tennessee. These roads are always bad. In rainy weather they are practically impassable, and the rivers, never bridged, are frequently too high for fording. Mining, therefore, has been for the most part carried on by the native mountaineers in a primitive manner, the uncertainty of reward, but chance of good returns, acting as a sort of gambling incentive to effort. Taken as a whole, it is doubtful if the mica mined in North Carolina has paid average daily wages for the labor spent upon it. As in the hunt for gold, it is the chance of an occasional rich find which induces the mining.

The conditions at present are not so favorable as they were fifteen or twenty years ago, for since primitive methods of mining were originally employed, as they are to-day, the future of a mine did not enter into the calculations as exploitation proceeded, and the result naturally was that as mines were deepened the work became more difficult and

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expensive, each pound of mica costing more to obtain. Added to this, the miners of mica have had for the past decade to contend with a formidable competitor in the mica imported from India. The importations of India mica began in 1884. The value of the mica imported in the fifteen years from 1869 to 1883, inclusive, averaged $4,658, the largest value being in 1877, when $13,085 worth of mica was imported. The value of the mica imported in 1883 was $9,884. During 1884 and 1885, when India mica first began to be used in this country, the value of mica imported was $28,284 and $28,685, respectively. In the thirteen years from 1884 to 1896, inclusive, the value of the imports has averaged $112,072, as compared with $4,658 for the preceding fifteeen years. The statistics of domestic production are available only since 1880. From 1880 to 1884, inclusive, the domestic production averaged $256,000 in value annually. Since and including 1885, the value of the domestic production has averaged $86,000 annually, about one-third of what it was prior to the introduction of India mica.

Mica was on the free list prior to 1891. From 1891 to 1894, and for a part of 1895, there was imposed a duty of 35 per cent ad valorem. Under the "Wilson" bill the tariff was reduced to 20 per cent. The mica producers are now endeavoring to secure a specific instead of an ad valorem duty. They claim, and with some degree of reason, that only experts can place a proper valuation on mica. This is especially true when the mica is imported in rough or unmanufactured condition. The claim is made that the imports are undervalued and that the statistics of the value of imported mica do not represent the real value. The producers of domestic mica also assert that the best grades of imported mica are sold as North Carolina mica, indicating the general superior quality of the home product.

Among the States producing mica in 1896, outside of North Carolina, were Idaho, New Hampshire, South Dakota, Virginia, and Wyoming. Idaho yielded 800 pounds of cut mica, worth $800; New Hampshire's product consisted of 4,006 pounds of cut mica, valued at $1,276, and 5 tons of scrap, worth $130; South Dakota produced 8,100 pounds of mica, which was sold uncut for $3,000; Virginia contributed 1,580 pounds of sheet mica, worth $4,610, and 41 tons of scrap, valued at $513; Wyoming's product was 20 pounds of cut mica, worth $60. The total value of the product of these five States was $10,389, making the value of North Carolina's output $56,802, or 84 per cent of the total.

Interest has been created in the discovery of some mica deposits about half a mile from Bloomingdale Station, Passaic County, New Jersey, on the line of the New York, Susquehanna and Western Railroad. The location is on the western slope of what is known as Federal Hill. Samples of this mica received at the United States Geological Survey are of an olive-green color and possess a toughness characteristic of Canadian phlogopite, which is used extensively for electrical purposes. The samples, however, contain cut lines, or "rulings,"

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which would render it unfit for many purposes. The samples were taken from material obtained near the surface, and it is possible the objectionable features will disappear at greater depth.

Other States in which mica deposits have been worked, or may be worked in the future, but from which no production was reported in 1896, are Alabama, Connecticut, Georgia, Kentucky, Maine, Massachusetts, Minnesota, Nevada, New Mexico, Pennsylvania, and Rhode Island.

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ASBESTOS.

By Edward W. Parker.

PRODUCTION.

Compared with the output of 1895, the production of asbestos in 1896 shows a decrease of about 36 per cent and a decline of 54 per cent in value. In 1895 the amount of asbestos produced in the United States was 795 short tons, valued at $13,525. The product in 1896 was 504 short tons, worth $6,100. The manufacturers and users of asbestos in the United States depend, principally, upon the mines of Canada, as the material obtained there is superior to the American product for the manufacture of textiles. Canadian "asbestos," while so classed commercially, is in reality chrysotile, a fibrous variety of serpentine. It possesses greater strength and elasticity and has a finer fiber than true asbestos, which is usually found associated with soapstone. Chrysotile also possesses the same heat-resisting qualities as asbestos, and is altogether much to be preferred for many purposes.

Deposits of chrysotile, similar to the Canadian mineral, have been found in the United States; specifically, one in Loudoun County, Virginia, and several near Casper, Wyoming; but they have not been sufficiently exploited to prove their ability to supplant the Canadian article in the market. True asbestos, as mined in the United States, is of value in the manufacture of fireproofing paints, boiler and safe packing, and for other purposes where fineness of texture and strength of fiber are not essential. Deposits of this material are found in many States, but usually in small quantities. Workable deposits are found in California, Georgia, Maryland, Montana, Oregon, South Dakota, and Washington. Most of them have produced asbestos in the past, but from one cause or another operations have been suspended in all but two States—Georgia and South Dakota. The Sall Mountain mines in the former State produced 500 tons in 1896, and 4 tons were obtained from the recently opened mines in Lawrence County, South Dakota, by the Black Hills Asbestos Company of Deadwood. During 1896 new discoveries of asbestos deposits were reported in Fulton County, Georgia; near Grants Pass, Jackson County, Oregon; in the vicinity of Lyman, Skagit County, Washington; near Badger City, Colorado; in the West Gallatin Basin, southern Montana; and near Hyattville, Big Horn County, Wyoming.

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The following table exhibits the annual production of asbestos in the United States since 1880, with the value:

Annual production of asbestos from 1880 to 1896.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1880	150	$4,312	1889	30	$1,800
1881	200	7,000	1890	71	4,560
1882	1,200	36,000	1891	66	3,960
1883	1,000	30,000	1892	104	6,416
1884	1,000	30,000	1893	50	2,500
1885	300	9,000	1894	325	4,463
1886	200	6,000	1895	795	13,525
1887	150	4,500	1896	504	6,100
1888	100	3,000			

Comparing the above table with that of the table of imports, which is given below, it will be seen that there is a profitable market to be supplied with domestic fiber if any be found which is equal in quality to that of the Canadian chrysotile, nearly all of the imports into the United States being from the Canadian mines.

IMPORTS.

The following table shows the value of asbestos imported since 1869:

Value of asbestos imported from 1869 to 1896.

Year ended—	Unmanufactured.	Manufactured.	Total.
June 30, 1869	.....	$310	$310
1870	.....	7	7
1871	.....	12	12
1872	.....	.....	.....
1873	$18	.....	18
1874	152	.....	152
1875	4,706	1,077	5,783
1876	5,485	396	5,881
1877	1,671	1,550	3,221
1878	3,536	372	3,908
1879	3,204	4,624	7,828
1880	9,736	.....	9,736
1881	27,717	69	27,786
1882	15,235	504	15,739
1883	24,369	243	24,612
1884	48,755	1,185	49,940

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Value of asbestos imported from 1869 to 1896—Continued.

Year ended—	Unmanufactured.	Manufactured.	Total.
Dec. 31, 1885	$73,026	$617	$73,643
1886	134,193	932	135,125
1887	140,264	581	140,845
1888	168,584	8,126	176,710
1889	254,239	9,154	263,393
1890	252,557	5,342	257,899
1891	353,589	4,872	358,461
1892	262,433	7,209	269,642
1893	175,602	9,403	185,005
1894	240,029	15,989	256,018
1895	225,147	19,731	244,878
1896	229,084	5,773	234,857

CANADIAN PRODUCTION.

As the supply of asbestos for the United States is drawn almost entirely from Canada, the following table of production for that country will be found of interest:

Annual product of asbestos in Canada since 1879.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Tons.			*Tons.*	
1879	300	$19,500	1888	4,404	$255,007
1880	380	24,700	1889	6,113	426,554
1881	540	35,100	1890	9,860	1,260,240
1882	810	52,650	1891	9,279	999,978
1883	955	68,750	1892	6,042	388,462
1884	1,141	75,079	1893	6,473	313,806
1885	2,440	142,441	1894	7,630	420,825
1886	3,458	206,251	1895	8,756	368,175
1887	4,619	226,976	1896	12,250	429,856

The mining and preparation of asbestos has become one of the important industries of the Province of Quebec. Operations were begun there in 1878, but only 50 tons were mined in that year. In the following year 300 tons, representing a value of $19,500, were mined. After this the product increased annually, as seen in the above table, until 1887, when 4,619 tons, valued at $226,976, were produced. The product in 1888 showed a slight decrease in amount and an increase of $28,031 in value. The most prosperous years for the industry were 1890 and 1891, when the output was 9,860 and 9,279 tons, respectively, having a

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value of $1,260,240 and $999,978. The largest product was in 1896, when the amount was a little more than one-third greater than in 1891, but having a value less than half that of the former year. The comparatively small value does not necessarily mean greatly reduced profits. During the earlier years of the industry operators worked to a considerable extent in the dark. Latterly, improved methods of mining and treatment have lessened the cost to the producer, and enabled him to place his product on the market at lower figures. Competition, however, has had no little effect in reducing prices, and in causing operators to adopt modern methods. Although the district in which asbestos is found is quite extensive, nearly all of the asbestos produced comes from the mines at Thetford and Black Lake, two stations 4 miles apart on the Quebec Central Railway. At these two places 12 or 13 different companies are operating, and all, with few exceptions, are fitted with the latest machinery. The present output could probably be doubled without increase of mechanical appliances.

Before the development of the asbestos mines of Quebec, Italy furnished the markets of the world. The Italian asbestos was considered the standard. The flossy asbestos fiber used extensively in gas stoves is from the northern mountain slope of the Lusa Valley in Italy. Mining is carried on at a height of from 6,000 to 10,000 feet above sea level.

The Italian asbestos industry is on the decline. Mining is very difficult and expensive. The best grades have become very scarce, and this, with the high cost of mining and transportation, militate against the industry. In fact, at the present time consumers of asbestos look to Canada almost entirely for their supply, although European consumers procure some fiber from the recently discovered deposits in eastern Russia and Russian Siberia, and large quantities are reported as existing in South Africa. The Russian deposits are said to be of enormous extent, but the fiber is of inferior quality when compared with the Canadian, with which it is mixed when making textile products. The Canadian asbestos possesses all the qualities to meet the requirements of the many new and exacting uses to which it is applied.

SOME USES FOR ASBESTOS.[1]

The process of manufacture is intensely interesting, more especially from the fact that as the industry is constantly entering upon novel phases, new methods of treatment and special machinery have to be devised. One of its special uses is for wall plaster. This is a new application which will have a distinct effect in modifying the practice of indoor plastering. Instead of the ordinary tedious and elaborate preparation of studs and strips, and the use of inferior and dust-creating mortar, with its after scoring, which is necessary to give cohesion to the final coat of plaster of paris, a single coating of the asbestos is

[1] Canadian Mining Review, July, 1896.

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laid on. It has a glossy surface that will not crack, as, while firm, it is perfectly flexible. It can be put on the raw brick; and a room of which the walls have been built in the morning can, before night, have a smoothly finished interior surface, shining like glass and hard as a rock. A kindred application of asbestos is now coming into vogue in the shape of uninflammable decorations for walls and ceilings. These are used a great deal for the saloons of steamships. They are embossed in very beautiful designs, and can be treated with gold, varnish, lacquers, or any other substance, for the enhancement of their ornamental effect.

Firemen clad in asbestos clothing and masks, as are those of London and Paris, can approach very close to the hottest flame with comparative impunity. Asbestos fireproof curtains have reduced the mortality of theater fires in a very appreciable degree. In torpedoes, the difficulty of dealing with the charges of wet gun cotton is overcome by inclosing them in asbestos, the employment of which has also, in a great measure, brought the dynamite shell to its present efficiency. Asbestos is made into a cloth available for aëronautical purposes. A balloon made of this uninflammable material escapes one of the most terrible dangers to which an ordinarily constructed balloon is liable. Probably one of the first applications of asbestos in this country was to roofing. To buildings covered with this material the shower of sparks from a neighboring conflagration involves no danger. The fact that woodwork can by its use be made uninflammable has come to be an important factor in the insurance of buildings. One of the largest branches of asbestos manufacture is that of sectional cylinders for pipe coverings for retaining the heat of steam and other pipes, felt protective coverings for boilers, frost-proof protections for gas or water pipes, and cement felting, which can be laid on with a trowel, for the covering of steam pipes, boilers, or stills. In some of these cases, where it is only necessary to retain the heat, the asbestos is mixed with other substances, but where the protection must be fireproof as well only asbestos is used.

The utility of such a covering is well illustrated in the heating system of railway cars. The main pipe from which the individual cars draw their respective heat supplies by side mains, if not covered with asbestos, would lose a large proportion of its caloric from the rapid motion of the car through the air. An interesting innovation in this class of manufacture is asbestos sponge. It is not generally known that sponge has great powers of fire resistance. The discovery was made accidentally not long ago, and the result was that a consignment of scraps of sponge picked up on the southern coasts was ordered for experimental purposes. The sponge was finely comminuted and mixed intimately with asbestos fiber. The combination was found so successful for any covering which had to be fireproof as well as heat proof that the material has become standard. Being full of air cells, it necessarily makes an excellent nonconductor. Another very extensive department

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in asbestos manufacture is that of packings. Of these there are an infinite number of forms. In these days of high pressures and ocean records it is of supreme importance to marine engineers that they should have jointing and packing materials on which absolute reliance can be placed. In order to meet modern exigencies every possible form of packing has been constructed, particularly with asbestos and metallic wire, and with asbestos and rubber cores for gland packing. The making of asbestos paper varies from the building up of the thickest millboard to the production of a writing paper which, from its indestructibility, is invaluable in case of fire for preserving charters, policies, agreements, and other important documents.

To the electrical engineer asbestos is absolutely indispensable. Many parts of electrical devices and machinery and wires through which the electric current passes become heated, and were it not for the electrical insulation and heat-resisting qualities which asbestos possesses the apparatus would be completely destroyed, particularly in the case known to electricians as "short circuiting." For such purposes it has been found advisable to combine asbestos with rubber and other gums, and this combination is now used universally for not only electrical, but also steam and mechanical, purposes.

A considerable part of an asbestos factory is devoted to weaving, the asbestos being first drawn into thread for that purpose. Here again is an apparently endless diversity. There is the fireplace-curtain blower, which, with an automatic spring-roller attachment, takes the place in the frame of the fireplace of the less sightly sheet-iron blower; and filtering cloths for many purposes, from straining molten metal to clarifying saccharine juices in beet-root sugar refineries. A cloth is made for straining and filtering acids and alkalies in chemical laboratories. This is specially useful when the liquid to be treated is of a caustic or strongly acid nature. The filter can be thrown in the fire, and after the residual matter has been consumed the web is as good as new. For filtering purposes generally, asbestos has a unique adaptability, and in tropical countries it is held in grateful estimation as a cooler and purifier of water. The newest departure in the asbestos field is the construction of electro-thermic apparatus. The heating effect of the electric current is utilized by embedding the wire in an asbestos sheet or pad. The pad is used by physicians and nurses for maintaining artificial heat in local applications, and is said to be already largely used in hospitals. Another application of the same principle is to car heaters. A sheet of asbestos with the embedded wires is clamped between two thin steel plates, and the portable heater thus provided, or a series if need be, is connected to the car circuit quickly and easily. It gives an even and healthful heat, and can be so regulated as not to overheat the car.

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ASBESTOS MINING AND DRESSING.

Mr. H. Nelles Thompson, of the McGill University, Montreal, has contributed to the Canadian Mining Review the following description of the methods of mining and dressing asbestos at King Brothers' mines, Thetford. The methods used by other companies differ only in minor details, such as the use of steam instead of compressed air, different makes of drills or patterns of cars, etc. This may be taken as representing the methods employed throughout the district:

Canadian asbestos, as is now pretty well known, is not the asbestos proper of the mineralogist, which is a variety of hornblende, but is a fibrous form of serpentine called chrysotile. It is an hydrated silicate of magnesia, and is easily distinguished from asbestos proper by its yielding water when heated in a closed tube. It occurs in that part of the great serpentine belt of the eastern townships which extends from the township of Broughton on the northeast to that of Ham on the southwest, and includes the townships of Thetford, Coleraine, Ireland, and Wolfstown. The asbestos-bearing serpentine is from 10 to 100 feet wide, and contains veins varying from a mere thread up to 4 inches in width, and which intersect the mass of rock in every conceivable direction.

Asbestos mining at Thetford is conducted wholly by quarrying. The quarries are in some cases from 70 to 120 feet deep. Drilling is carried on by means of compressed air, the form of drill used being Rand's Little Giant, No. 3, working at a pressure of about 80 pounds to the square inch. The steel used is 1¼-inch, and has an X-shaped bit. Holes are drilled from 8 to 12 feet in depth, and an average day's work of ten hours is about 60 feet. Dualin, which contains 40 per cent nitroglycerin, is the explosive used for blasting. The holes are about one-third filled with this, and then tamped lightly with loose borings, by means of a wooden rod. The firing is done with a 25-hole "pull-up" battery, several holes being connected in series, and thus fired simultaneously. In block holing, i. e., blasting detached blocks of rock which are too large to be conveniently handled, hand drilling with five-eighths inch steel is employed, and the holes are fired by fuse.

Pumping is a very small item in the expenses of the mine, as very few springs are met with, and the surface water which falls into the pit is quickly disposed of by steam pumps.

Hoisting from the pit is accomplished by boom derricks, the boom being usually about 50 feet long. Copeland & Bacon hoists are used to operate the derricks. These are driven by compressed air conveyed from a Rand duplex compressor by a 4-inch wrought-iron pipe. This method of working the hoists is found to be much more convenient than that by steam, as work is kept up to some extent most of the winter. Cable derricks are now being used by the Bell's Asbestos Company in addition to the ordinary boom derricks. These consist of a mast with a 2-inch to 3-inch steel cable stretched from it across the pit. A traveler runs on this cable, and hoisting may take place from any point of the pit directly below the cable. This system, although often slower than the boom derrick, presents many advantages, as the cable may be stretched a distance of over 400 feet, and its anchorage is easily moved.

The ropes used in hoisting are generally of three-fourths-inch steel, and last about two years when properly cared for. The cages or baskets are of wood, ironbound and with iron-lined bottoms. They measure about 4½ by 6 by 1 feet and are open at the front. They have a piece of metal rail fastened across the bottom on the outside, which fits into a groove when landed on the cars. A load for one of the baskets is from 1 to 2 tons.

A simple type of side-dumping car is used. This consists of a platform car with pieces of wood fastened across the top. The loaded basket hoisted from the pit is

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landed on the car. Each car holds two baskets, which empty on opposite sides. A carload is thus from 2 to 4 tons, as each basket load is from 1 to 2 tons, as previously stated.

The car being loaded runs down a trestle, built on a grade of about 1 in 16, passes the dressing establishment, or "mill" as it is called, and empties at the dump. The loads containing asbestos are discharged upon the trestle in the rear of the mill. This material is then shoveled down a chute into an iron self-dumping skip. This, when loaded, is hoisted up an incline of about 45 degrees to the top story of the mill, by means of a small friction hoist, and dumped in front of the crusher. The empty cars are brought back to the quarry by horse.

At the dump several boys are employed hand cobbing, as many pieces of the waste rock have asbestos still attached to them in small quantities.

Before describing the "dressing," a few words on grading are necessary. This is done in five qualities: (1) No. 1 being the longest fiber, from three-fourths inch up, and especially valuable for spinning. (2) No. 2 from one-half up to three-fourths inch, also used for spinning. (3) No. 3, shorter than No. 2 and used in the manufacture of millboard, etc. (4) "Waste" (not to be confounded with the term waste rock previously employed), consisting of still shorter pieces of fiber mixed with a large proportion of serpentine sand, and used in manufacture of bricks, cements, etc. (5) Fiber, a very soft variety almost free from rock, and used for purposes such as steam packing.

The crude material is first put through a Blake crusher, the jaws of which are set at three-fourths of an inch. From the crusher it goes on to an inclined one-sixteenth-inch mesh preliminary screen. Thence it goes to a traveling picking table, which has a division along its center. Here boys are busily engaged removing the barren rock to one side, and that containing asbestos to the other. At the end of the table the former drops into a chute, while the latter falls on to a carrier and is conveyed to the rolls. These are of the geared Cornish type. Their springs are adjusted so as not to exert too great a pressure between the faces of the rolls, as this would cause the rock passing through to cut the fibers. From the rolls the stuff passes over inclined screens shaken by an eccentric, this being arranged in the following order, viz: One-sixteenth, one-half, and three-fourths inch. From the preceding remarks on grading, the object of this arrangement becomes apparent; the waste dropping through the one-sixteenth-inch mesh, No. 3 through the one-half inch, No. 2 through the three-fourths, and No. 1 over the end. The waste from the one-sixteenth-inch mesh screen is conveyed by a chain elevator to the waste box. No. 2, to insure a more uniform product, is screened a second time on a one-fourth-inch mesh screen and the screenings from this, consisting of pieces of serpentine with asbestos attached, are put through the process for obtaining the fiber.

The plant for this consists of a cyclone mill opening on to a screen. This screen has 11 meshes to the inch, is covered for about two-thirds of its length, and is suspended from the ceiling of an air-tight room by four hickory rods. Over the lower end of it hangs a funnel, connected by pipe with a circular blowing machine on the next floor. From the blower a pipe runs to a small room above, the window of which is covered by a fine screen.

The material being shoveled into the cyclone, which is run at the high speed of 2,300 revolutions per minute, is caught by two whirlwinds revolving in opposite directions, and the pieces of material thus become pulverized by attrition. The lumps of serpentine being broken up by this means the fiber is freed and both pass together to the screen, where most of the pulverized rock is shaken out; the rest passes over the end of the screen, while the fiber is sucked up through the funnel by the blower, which makes 2,700 revolutions per minute, and is blown into the room above, the screen on the window preventing it from being blown outside. About 35 per cent of the material put through this process is obtained as fiber.

The different grades are put up in bags of 100 or 200 pounds and shipped by the Quebec Central Railway.

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The material from the dressing establishment is put through a machine for the purpose of separating the fibers from one another and from the nonfibrous material, a quantity of which is still present.

One form of this machine consists of two rollers covered with teeth, revolving usually at equal peripheral speeds, and at the same time having a sideways motion in relation to one another. By the pressure the fibers are loosened, and, being loosened, are combed apart by the reciprocating motion. After this operation there is nothing special, the long fiber being spun and woven as any other textile, and the short fiber being treated like paper pulp.

An interesting feature of the Canadian asbestos industry in 1896 was the purchase of the old Jeffrey mine at Danville by a new organization known as the Asbestos and Asbestic Company, Limited, of London. The new company is supplied with abundant capital and has spent large sums of money in erecting a suitable plant fitted with all modern appliances for mining and treating the product. It is stated that before putting in their machinery the company had obtained contracts for marketing 5,000 tons a year, the bulk of which goes to the H. W. Johns Manufacturing Company, of New York City.

ASBESTOS IN SOUTH AFRICA.

Large deposits of asbestos have recently been found in Cape Colony, many claims being made for its quality and special adaptability for certain purposes. It is said to be different from Russian, Italian, or Canadian asbestos, in that it is blue in color and considerably lighter. The fiber, it is claimed, is of great tensile strength, and can be spun into netting twine, cordage, and ropes, having two thirds the tensile strength of hemp. Special stress is made on its availability for ropes to be used in mines. Ropes made of it, according to the testimony given, will withstand influences that speedily destroy hempen ropes and cables. Changes from wet to dry, conditions of heat, extreme heat or extreme cold, alkalies, chemical fumes, the acid water of mines, and rot are alike powerless to attack these ropes. In India and other hot countries ropes of hemp or other organic material are frequently destroyed by ants. Asbestos ropes have no attractions for them.

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USES.

The utilization of graphite in the manufacture of crayons, lead pencils, lubricants, and crucibles is so well known as to need no extended notice in this report. Its use as a base for paint is receiving particular attention at the present time. Such a paint is not intended to supplant the ordinary pigments in covering wood surfaces, but as a protective covering for iron and other metal substances. Especial merit is claimed for it in covering boiler stacks and tubes. Specimens of iron cut from a boiler stack covered with this paint, which have been in use three years, have shown no appreciable deterioration. Materials protected with this have also been subjected to acid, alcohol, boiling beer, boiling brine, ammonia, and other severe tests without injury.

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MINERAL PAINTS.

By Edward W. Parker.

MINERALS USED AS PIGMENTS.

Included under this heading are those mineral substances mined and prepared primarily as pigments. They consist of iron ores (usually hematites) which are ground and used in the manufacture of red and brown pigments, and which are not included in the production of iron ores for iron making; clay and other earths containing iron, used in making yellow and brown pigments, such as ocher, umber, sienna, etc.; barytes (barium sulphate) or "heavy spar," used as a substitute for or an adulterant of white lead; slate, or shale; soapstone; asbestos; graphite; and a pure form of gypsum producing terra alba. All of these pigments are made directly from the crude minerals and may be considered natural pigments. It is not always possible, however, to segregate the amount of soapstone, asbestos, and graphite which goes into paint, and when such is the case reports of the product are included in the papers relating to those subjects. Venetian red, obtained from iron sulphate by roasting, is also included among the mineral paints, as the amount of iron so consumed is so small when compared with the iron product that it would not affect the total. Zinc white is produced directly from the ores, and properly belongs in the product of pigments.

To the above should be added the preparations made from pig lead, namely, white lead, red lead, litharge, and orange mineral; also, vermilion, made from quicksilver; chrome yellow, made from potassium bichromate; blanc fixe, made by treating barium carbonate with sulphuric acid and precipitating artificial barytes. The bases from which these pigments are obtained are included in the production of pig lead, quicksilver, chromium, etc., and the pigments themselves being the results of chemical decomposition and combination, are not included in the "mineral paints." It has also been customary to treat barytes separately. This custom is adhered to in this report.

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GRAPHITE.

PRODUCTION.

The product of graphite in the United States in 1896 consisted of 535,858 pounds from Ticonderoga, New York, 100 tons from Baraga County, Michigan, and 660 tons of graphite and graphitic coal from near Providence, Rhode Island. The entire output was valued at $48,460, against a value of $52,582 in 1895, when 644,700 pounds were shipped from Ticonderoga, and 2,793 short tons were mined in Rhode Island, Michigan, Alabama, and North Carolina. The two last-mentioned States did not contribute to the product in 1896.

The Rhode Island product is used in the manufacture of crucibles, paints, roofing material, etc.; the Michigan output is used almost exclusively for making graphite paint, while the Ticonderoga graphite goes into the manufacture of crayons, lead pencils, crucibles, lubricants, paints, and all other purposes for which graphite is used. The following table shows the annual production of graphite since 1880:

Production of graphite since 1880.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1880..pounds.	622,500	$49,800	1890.....	.....	$77,500
1881.... do...	400,000	30,000	1891..pounds..	1,559,674	110,000
1882.... do...	425,000	34,000	1892....do	1,398,365	87,902
1883.... do...	575,000	46,000	1893....do	843,103	63,232
1884.... do...	500,000	35,000	1894....do	918,000	64,010
1885.... do...	327,883	26,231	1895 ...do	644,700	52,582
1886.... do...	415,525	33,242	1895 short tons	2,793	
1887.... do...	416,000	34,000	1896 pounds...	535,858	48,460
1888.... do...	400,000	33,000	1896 short tons	760	
1889.....	.....	72,662			

IMPORTS.

As will be seen in the following table, when compared with the imports the value of the domestic product is small, though there was a considerable decline in the imports in 1894 and 1895. The imports of 1896 exceeded those of 1894 and 1895 combined. From 1890 to 1893 the amount of graphite imported ranged from 212,360 hundredweight in 1891 to 288,740 hundredweight in 1893, the average for four years

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being 247,649 hundredweight, or 12,382 tons, the average value being $670,745. The average value per pound for the four years was 2.7 cents. In 1894 the imports amounted to 5,814 long tons, equivalent to 13,023,360 pounds, valued at $225,720, or about 1.7 cents per pound. In 1895 the imports were 8,814 long tons, or 19,743,360 pounds, worth $260,090, or about 1.3 cents per pound. The imports in 1896 were 15,225 long tons, or 34,104,000 pounds, valued at $437,159, or about the same per pound as the previous year.

Graphite imported into the United States from 1867 to 1896.

Year ended—	Unmanufactured.		Manufactured.	Total.
	Quantity.	Value.		
	Cwt.			
June 30, 1867	27,113	$54,131	.....	$54,131
1868	68,620	149,083	.....	149,083
1869	74,846	351,004	.....	351,004
1870	80,795	269,291	$833	270,124
1871	51,628	136,200	3,754	139,954
1872	96,381	329,030	.....	329,030
1873	157,539	548,613	.....	548,613
1874	111,992	382,591	.....	382,591
1875	46,492	122,050	.....	122,050
1876	50,589	150,709	17,605	168,314
1877	75,361	204,630	18,091	222,721
1878	60,244	154,757	16,909	171,666
1879	65,662	164,013	24,637	188,650
1880	109,908	278,022	22,941	300,963
1881	150,927	381,966	31,674	413,640
1882	150,421	363,835	25,536	389,371
1883	154,893	361,949	21,721	383,670
1884	144,086	286,393	1,863	288,256
1885	110,462	207,228	.....	207,228
1886	83,368	164,111	.....	164,111
1887	168,841	331,621	.....	331,621
Dec. 31, 1888	184,013	353,990	.....	353,990
1889	177,381	378,057	.....	378,057
1890	255,955	594,746	.....	594,746
1891	212,360	555,080	.....	555,080
1892	233,540	667,775	.....	667,775
1893	288,740	865,379	.....	865,379
1894	*a* 5,814	225,720	.....	225,720
1895	*a* 8,814	260,090	.....	260,090
1896	*a* 15,225	437,159	.....	437,159

a Long tons.

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The production, by States, in 1895 is shown in the following table:

Production of ocher, umber, and sienna in 1895, by States.

State.	Ocher.		Umber.		Sienna.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
California.....	375	$2,800	.....	.....	.....	.....
Georgia	2,105	31,080	.....	.....	.....	.....
Missouri	1,065	9,468	(a)	(a)	.....	.....
Pennsylvania ..	6,800	74,300	b 320	b $4,350	c 275	c $6,950
Other States (d)	1,700	21,680	.....	.....	.....	.....
Total	12,045	139,328	320	4,350	275	6,950

a Included in Pennsylvania.
b Includes Missouri and New York.
c Includes New York.
d Alabama, Iowa, Maryland, New York, Vermont, Virginia, and Wisconsin, having each but one establishment.

For the purposes of comparison the production for the past eight years is shown in the following table. Prior to 1889, when the statistics were compiled for the Eleventh Census, the production for each State was not published:

Production of ocher, umber, and sienna from 1889 to 1896, by States.

State.	1889.		1890.		1891.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Alabama	336	$3,500	350	$4,100	524	$5,840
Colorado	50	150	1,000	15,000	.....	.....
Georgia	2,512	29,720	800	12,800	600	9,000
Maryland	616	12,000	.....	.....	.....	.....
Massachusetts..	80	750	300	2,700	300	2,700
Missouri	.....	.....	2,200	30,000	1,850	27,500
New Jersey.....	.....	.....	.....	.....	600	7,200
New York	.....	.....	365	4,493	.....	.....
Pennsylvania ..	7,922	103,797	4,173	61,458	4,535	56,588
Vermont	1,884	7,800	.....	.....	935	11,095
Virginia	1,658	18,755	1,367	22,972	1,950	29,900
Wisconsin.....	100	1,000	.....	.....	.....	.....
Other States....	.....	.....	a 7,000	84,000	a 7,000	84,000
Total	15,158	177,472	17,555	237,523	18,294	233,823

a Includes all of Maryland and estimated product of some firms in other States not reporting.

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Production of ocher, umber, and sienna from 1889 to 1896, by States—Continued.

State.	1892.		1893.		1894.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Alabama	375	$4,050	350	$3,000	.....	.....
Georgia	1,748	26,800	2,600	39,000	1,690	$17,840
Maryland	1,000	10,000	.....	.....	.....	.....
Massachusetts	46	418	.....	.....	.....	.....
Missouri	1,922	28,220	555	5,413	1,800	23,160
New Jersey	175	3,600	.....	.....	.....	.....
Pennsylvania	7,055	90,755	5,375	71,575	4,975	47,830
Vermont	544	5,731	523	5,280	336	3,384
Virginia	1,500	23,500	.....	.....	.....	.....
Other States	.....	.....	*a* 1,744	17,560	*b* 1,392	11,801
Total	14,365	193,074	11,147	141,828	10,193	104,015

State.	1895.		1896.	
	Quantity.	Value.	Quantity.	Value.
	Short tons.		*Short tons.*	
Georgia	2,105	$31,080	2,981	$28,005
Missouri	1,065	9,468	.....	.....
Pennsylvania	*c* 7,395	85,600	*c* 3,486	34,880
Other States	*d* 2,075	24,480	8,167	81,635
Total	12,640	150,628	14,634	144,520

a Includes Kentucky, Maryland, Massachusetts, and Virginia.
b Includes Alabama, Kentucky, Maryland, Massachusetts, Virginia, and Wisconsin.
c Includes Missouri's and New York's product of umber and sienna.
d Includes Alabama, California, Iowa, Maryland, New York, Vermont, Virginia, and Wisconsin

Annual production of ocher, etc., since 1884.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1884	7,000	$84,000	1891	18,294	$233,823
1885	3,950	43,575	1892	14,365	193,074
1886	6,300	91,850	1893	11,147	141,828
1887	8,000	75,000	1894	10,193	104,015
1888	10,000	120,000	1895	12,640	150,628
1889	15,158	177,472	1896	14,634	144,520
1890	17,555	237,523			

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IMPORTS.

The following tables show the amount and value of ochers, etc., from 1867 to 1896:

Ocher, etc., imported from 1867 to 1883.

Fiscal year ended June 30—	All ground in oil.		Indian red and Spanish brown.		Mineral, French, and Paris green.		Other, dry, not otherwise specified.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
1867..	11,373	$385	.....	$35,374	.....	$2,083	1,430,118	$9,923
1868..	6,949	333	.....	11,165	.....	500	3,670,093	32,102
1869..	65,344	2,496	2,582,335	31,624	8,369	2,495	5,379,478	39,546
1870..	149,240	6,042	3,377,944	41,607	9,618	3,444	3,935,978	32,593
1871..	121,080	4,465	2,286,930	40,663	33,488	11,038	2,800,148	24,767
1872..	277,617	9,225	2,810,282	38,763	41,422	10,341	5,645,343	56,680
1873..	94,245	3,850	135,360	2,506	34,382	8,078	3,940,785	51,318
1874..	98,176	4,623	263,389	3,772	102,876	18,153	3,212,988	35,365
1875..	280,517	12,352	646,009	9,714	64,910	13,506	3,282,415	37,929
1876..	63,916	3,365	2,524,989	19,555	21,222	5,385	3,962,646	47,405
1877..	41,718	2,269	2,179,631	24,218	27,687	6,724	3,427,208	32,924
1878..	25,674	1,591	2,314,028	23,677	67,655	14,376	3,910,947	33,260
1879..	17,649	1,141	2,873,550	26,929	17,598	3,114	3,792,850	42,563
1880..	91,293	4,233	3,655,920	32,726	16,154	3,269	4,602,546	52,120
1881..	99,431	4,676	3,201,880	30,195	75,465	14,648	3,414,704	46,069
1882..	159,281	7,915	3,789,586	34,136	18,293	2,821	5,530,204	68,106
1883*a*	137,978	6,143	1,549,968	13,788	6,972	885	7,022,615	90,593

a Since 1883 classified as "dry" and "ground in oil."

Imports of ocher of all kinds from 1884 to 1896.

Year ended—	Dry.		Ground in oil.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*	
June 30, 1884..	6,164,359	$63,973	108,966	$4,717	6,273,325	$68,690
1885..	4,983,701	51,499	79,666	3,616	5,063,363	55,115
Dec. 31, 1886..	4,939,183	53,593	112,784	6,574	5,051,967	60,167
1887..	5,957,200	58,162	54,104	7,337	6,011,304	65,499
1888..	6,574,608	64,123	43,142	9,690	6,617,750	73,813
1889..	5,540,267	52,502	51,063	9,072	5,591,330	61,574
1890..	.....	.....	.....	.....	6,471,863	71,953
1891..	6,246,890	63,040	52,206	5,272	6,299,096	68,312
1892..	8,044,836	97,946	49,714	5,120	8,094,550	103,066
1893..	6,225,789	55,074	52,468	3,354	6,278,257	58,428
1894..	4,937,738	45,276	22,387	2,100	4,960,125	47,376
1895..	7,107,987	56,020	41,153	2,239	7,149,140	58,259
1896..	8,954,252	68,196	27,023	1,561	8,981,275	69,757

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Imports of umber from 1867 to 1896.

Year ended—	Quantity.	Value.	Year ended—	Quantity.	Value.
	Pounds.			*Pounds.*	
June 30, 1867..	2,147,342	$15,946	June 30, 1882..	1,923,648	$20,494
1868..	345,173	2,750	1883..	785,794	8,419
1869..	570,771	6,159	1884..	2,946,675	20,654
1870..	708,825	6,313	1885..	1,198,060	8,504
1871..	470,392	7,064	Dec. 31, 1886..	1,262,930	9,187
1872..	1,409,822	18,203	1887..	2,385,281	16,536
1873..	845,601	8,414	1888..	1,423,800	14,684
1874..	729,864	6,200	1889..	1,555,070	20,887
1875..	513,811	5,596	1890..	1,556,823	19,329
1876..	681,199	7,527	1891..	633,291	6,498
1877..	1,101,422	10,213	1892..	1,028,038	6,256
1878..	1,038,880	8,302	1893..	1,488,849	16,636
1879..	986,105	6,959	1894..	632,995	6,275
1880..	1,877,645	17,271	1895..	*a* 1,560,786	13,075
1881..	1,475,835	11,126	1896..	*b* 689,075	8,360

a Includes 6,137 pounds ground in oil and 1,554,649 pounds dry.
b Includes 5,292 pounds ground in oil and 683,783 pounds dry.

METALLIC PAINT.

The unfavorable conditions which affected the production of metallic paint in 1895 continued in 1896. The product in 1896 was less than in any year of which there is any record, the output amounting to 14,805 short tons, valued at $180,134. As previously noted, the amount of metallic paint reported in 1894 and 1895 included also the amount of iron ore used for mortar colors. About 40 per cent of the product in each year should have been included under the head of mortar colors, so that instead of 25,375 tons reported in 1894, the amount should have been 15,225 short tons, and from the 28,859 short tons reported in 1895, a deduction of 11,544 tons used for mortar colors should be made, making the output of metallic paint for that year 17,315 short tons, valued at $212,761. The value of the product has shown a steady decline since 1893. In that year the average price obtained was $14.89 per ton. The revised figures for 1894 show the average price per ton to have been $12.47. A decline of 18 cents per ton, to $12.29, is shown in the average price for 1895, and a decline of 12 cents per ton, to $12.17, occurred in 1896.

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The annual product of metallic paint for the past seven years has been as follows:

Production of metallic paint since 1889, by States.

State.	1889.		1890.		1891.	
	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Colorado	90	$2,500	1,300	$22,100	.....	.....
New York	3,658	63,698	5,224	72,952	7,352	$99,487
Ohio	540	11,123	637	16,341	800	14,500
Pennsylvania	8,849	128,036	8,955	145,243	9,175	134,138
Tennessee	3,057	24,237	5,386	46,088	4,000	30,000
Vermont	.....	.....	500	6,000	400	5,000
Wisconsin	1,832	26,700	2,125	31,035	2,343	34,375
Other States	3,000	30,000	50	610	1,072	16,955
Total	21,026	286,294	24,177	340,369	25,142	334,455

State.	1892.		1893.	
	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*	
New York	5,200	$76,500	3,885	$57,500
Ohio	879	17,090	710	5,750
Pennsylvania	10,289	176,785	8,300	143,875
Tennessee	5,000	32,000	3,000	27,500
Vermont	400	5,000	338	4,600
Wisconsin	2,448	33,826	2,246	29,500
Other States	1,495	21,765	1,481	28,564
Total	25,711	362,966	19,960	297,289

State.	1894.		1895.		1896.	
	Product.	Value.	Product.	Value.	Product.	Value.
	Short tons.		*Short tons.*		*Short tons.*	
Missouri	.....	.....	860	$11,565	.....	.....
New York	4,787	$48,899	6,023	67,161	5,882	$61,800
Ohio	1,006	13,516	.....	.....	1,346	11,937
Pennsylvania	8,683	119,674	9,098	126,400	4,824	76,879
Tennessee	5,510	37,870	5,936	38,602	6,400	47,200
Vermont	280	3,500	.....	.....	.....	.....
Wisconsin	3,057	41,889	3,486	44,476	1,417	18,958
Other States	2,052	19,535	3,456	30,938	4,596	52,960
Total	25,375	284,883	28,859	319,142	24,465	269,734
Less mortar colors	10,150	94,961	11,544	106,381	9,660	89,600
Total metallic paint	15,225	189,922	17,315	212,761	14,805	180,134

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VENETIAN RED.

There was a slight decrease in the amount of venetian red produced, from 4,595 short tons in 1895 to 4,138 short tons in 1896. The value of the product declined from $102,900 to $93,866. There was a slight advance in the average price per ton obtained, from $22.39 in 1895 to $22.68 in 1896.

Venetian red is a bright red pigment obtained by roasting iron sulphate or green vitriol. The sulphur is driven off, leaving iron oxide of a brighter red than that found native. The amount of iron so consumed is comparatively small when considered with the total iron product, and the venetian red product is accordingly included in the output of mineral paints.

The annual production since 1890 has been as follows:

Production of venetian red since 1890.

Year.	Short tons.	Value.	Year.	Short tons.	Value.
1890	4,000	$84,100	1894	2,983	$73,300
1891	4,191	90,000	1895	4,595	102,900
1892	4,900	106,800	1896	4,138	93,866
1893	3,214	64,400			

SLATE AS A PIGMENT.

The amount of slate ground for pigment in 1896 was 4,795 short tons, valued at $44,835, against 4,331 short tons in 1895, valued at $45,682. This indicates an increase in tonnage of 464 tons, and a decrease in value of $847, with a decline in the average price from $10.55 to $9.35 per ton. The product of slate includes that of black shale ground for pigment and known as mineral black.

The annual product of these pigments since 1880 has been as follows:

Amount and value of slate and shale ground for pigment since 1880.

Year.	Short tons.	Value.	Year.	Short tons.	Value.
1880	1,120	$10,000	1889	2,240	20,000
1881	1,120	10,000	1890	2,240	20,000
1882	2,240	24,000	1891	2,240	20,000
1883	2,240	24,000	1892	3,787	23,523
1884	2,240	20,000	1893	3,253	25,567
1885	2,212	24,687	1894	3,300	35,370
1886	3,360	30,000	1895	4,331	45,682
1887	2,240	20,000	1896	4,795	44,835
1888	2,800	25,100			

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WHITE LEAD, ETC.

PRODUCTION.

The production of white lead, red lead, litharge, and orange mineral, dry and in oil, with the value of each, in 1896, was as follows:

Production of white lead, etc., dry and in oil, in 1896.

	White lead.		Red lead.	
	Pounds.	Value.	Pounds.	Value.
Dry	26,638,373	$1,058,555	11,432,166	$530,260
In oil	150,578,451	7,313,033	30,000	1,800
Total	177,216,824	8,371,588	11,462,166	532,060

	Litharge.		Orange mineral.	
	Pounds.	Value.	Pounds.	Value.
Dry	12,980,221	$539,700	539,007	$33,132
In oil	.....	.....	.....	.....
Total	12,980,221	539,700	539,007	33,132

Compared with 1895 the product in 1896 shows a decrease of 2,475,446 pounds in the amount of white lead sold dry, and $140,155 in the value. White lead in oil decreased from 151,912,669 pounds in 1895 to 150,578,451 pounds in 1896, a decrease of 1,334,218 pounds, while the value declined $211,889, from $7,524,922 to $7,313,033. Dry red lead decreased 1,840,025 pounds, from 13,272,191 pounds in 1895 to 11,432,166 pounds in 1896. The amount of red lead in oil sold in 1895 was 240,794 pounds. Only 30,000 pounds were reported in 1896. The amount of litharge decreased nearly a million pounds, from 13,973,823 pounds in 1895 to 12,980,221 pounds in 1896. The product of orange mineral decreased 192,298 pounds, from 731,305 in 1895 to 539,007 pounds in 1896.

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The production of white lead, red lead, litharge, and orange mineral, dry and in oil, with the value of each, in 1895, was as follows:

Production of white lead, etc., dry and in oil, in 1895.

	White lead.		Red lead.	
	Pounds.	Value.	Pounds.	Value.
Dry	29,113,819	$1,198,710	13,272,191	$616,093
In oil	151,912,669	7,524,922	240,794	12,040
Total	181,026,488	8,723,632	13,512,985	628,133
	Litharge.		Orange mineral.	
	Pounds.	Value.	Pounds.	Value.
Dry	12,212,018	$519,524	731,305	$44,749
In oil	1,761,805	81,743	.....	.....
Total	13,973,823	601,267	731,305	44,749

The following table exhibits the annual production of white lead, red lead, etc., for a series of six years. Previous to 1894 the values were based on white lead in oil. The statistics for 1894, 1895, and 1896 include the amount of lead sold dry and in oil, with the value in the condition in which it was sold.

Production of white lead, etc., for six years.

	1891.		1892.		1893.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
White lead	78,018	$10,454,029	74,485	$8,733,620	72,172	$7,695,130
Red lead	4,607	591,730	6,122	757,787	6,377	732,968
Litharge	5,759	720,925	5,764	611,726	11,757	1,154,819
Orange mineral	330	43,300	395	60,170	217	32,893
	1894.		1895.		1896.	
	Short tons.	Value.	Short tons.	Value.	Short tons.	Value.
White lead	76,343	$6,623,071	90,513	$8,723,632	88,608	$8,371,588
Red lead	6,465	623,021	6,756	628,133	5,731	532,060
Litharge	5,652	495,406	6,987	601,267	6,490	539,700
Orange mineral	319	43,517	366	44,749	270	33,132

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The annual production of white lead since 1884 has been as follows:

Production of white lead in the United States since 1884.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1884	65,000	$6,500,000	1891	78,018	$10,454,029
1885	60,000	6,300,000	1892	74,485	8,733,620
1886	60,000	7,200,000	1893	72,172	7,695,130
1887	70,000	7,560,000	1894	76,343	6,623,071
1888	84,000	10,080,000	1895	90,513	8,723,632
1889	80,000	9,600,000	1896	88,608	8,371,588
1890	77,636	9,382,967			

IMPORTS.

The following table shows the imports of white lead, red lead, litharge, and orange mineral since 1867:

Red lead, white lead, litharge, and orange mineral imported from 1867 to 1896.

Year ended—	Red lead.		White lead.		Litharge.		Orange mineral.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
June 30, 1867	926,843	$53,087	6,636,508	$430,805	230,382	$8,941	.....	.....
1868	1,201,144	76,773	7,533,225	455,698	250,615	12,225	.....	.....
1869	808,686	46,481	8,948,642	515,783	187,333	7,767	.....	.....
1870	1,042,813	54,626	6,228,285	365,706	97,398	4,442	.....	.....
1871	1,295,616	78,410	8,337,842	483,392	70,889	3,870	.....	.....
1872	1,513,794	85,644	7,153,978	431,477	66,544	3,396	.....	.....
1873	1,583,039	99,891	6,331,373	408,986	40,799	2,379	.....	.....
1874	756,644	56,305	4,771,509	323,926	25,687	1,450	.....	.....
1875	1,048,713	73,131	4,354,131	295,642	15,767	950	.....	.....
1876	749,918	54,884	2,546,776	175,776	47,054	2,562	.....	.....
1877	387,260	28,747	2,644,184	174,844	40,331	2,347	.....	.....
1878	170,608	9,364	1,759,608	113,638	28,190	1,499	.....	.....
1879	143,237	7,237	1,274,196	76,061	38,495	1,667	.....	.....
1880	217,033	10,397	1,906,931	107,104	27,389	1,222	.....	.....
1881	212,423	10,009	1,068,030	60,132	63,058	2,568	.....	.....
1882	288,946	12,207	1,161,889	64,493	54,592	2,191	.....	.....
1883	249,145	10,503	1,044,478	58,588	34,850	1,312	.....	.....
1884	265,693	10,589	902,281	67,918	54,183	1,797	.....	.....
1885	216,449	7,641	705,535	40,437	35,283	1,091	.....	.....
Dec. 31, 1886	597,247	23,038	785,554	57,340	51,409	1,831	.....	.....
1887	371,299	16,056	804,320	58,602	35,908	1,302	.....	.....
1888	529,665	23,684	627,900	49,903	62,211	2,248	.....	.....
1889	522,026	24,400	661,694	56,875	41,230	1,412	.....	.....
1890	450,402	20,718	742,196	57,659	48,283	2,146	.....	.....
1891	651,577	23,807	718,228	40,773	94,586	3,108	.....	.....
1892	812,703	28,443	744,838	40,032	56,737	1,811	1,409,601	$64,133
1893	854,982	27,349	686,490	34,145	42,582	1,310	1,385,828	61,360
1894	947,873	29,064	796,480	40,939	38,595	1,064	1,386,464	58,614
1895	1,764,274	53,139	1,897,892	79,887	97,667	2,812	1,689,367	66,492
1896	1,543,262	47,450	1,183,538	52,409	51,050	1,615	1,359,651	51,027

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PRICES.

The following table is of interest, as it shows the average yearly prices of pig lead and white lead in oil (both at New York) and the difference between the two since 1874:

Average yearly net prices, at New York, of pig lead and white lead in oil since 1874.

[Per 100 pounds.]

Year.	Pig lead, in New York.	White lead in oil, in New York.	Difference.	Year.	Pig lead, in New York.	White lead in oil, in New York.	Difference.
1874.....	$6.00	$11.25	$5.25	1886.....	$4.63	$6.25	$1.62
1875.....	5.95	10.50	4.55	1887.....	4.47	5.75	1.28
1876.....	6.05	10.00	3.95	1888.....	4.41	5.75	1.34
1877.....	5.43	9.00	3.57	1889.....	3.80	6.00	2.20
1878.....	3.58	7.25	3.67	1890.....	4.33	6.25	1.92
1879.....	4.18	7.00	2.82	1891.....	4.33	6.37	2.05
1880.....	5.05	7.60	2.55	1892.....	4.05	6.39	2.34
1881.....	4.80	7.25	2.45	1893.....	3.73	6.03	2.30
1882.....	4.90	7.00	2.10	1894.....	3.28	5.26	1.98
1883.....	4.32	6.88	2.56	1895.....	3.12	5.05	1.93
1884.....	3.73	5.90	2.17	1896.....	3.03	4.90	1.87
1885.....	3.95	6.00	2.05				

In considering the variations between the value of pig lead and white lead in oil allowance should be made for the fluctuations in the value of linseed oil, which enters largely into the manufacture of lead in oil. The fluctuations in the price of linseed oil in three years have ranged from 31 cents to 59 cents a gallon. The highest price reached for linseed oil was in July, 1895, and the lowest in August, 1896. The fluctuations in the price of linseed oil in three years have been as follows, in cents per gallon:

	Highest.	Lowest.
1894	56	50
1895	59	42
1896	41	31

The proportions of white lead and oil vary according to trade requirements, but on an average 100 pounds of lead in oil contain 91 pounds of lead and 9 pounds of linseed oil.

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BARYTES.

By Edward W. Parker.

PRODUCTION.

The amount of barytes (heavy spar) produced in the United States during 1896 was less than in any year since 1887, amounting to 17,068 short tons, valued at $46,513. Production has decreased steadily since 1892, the product in 1896 being but little more than half of what it was four years before. The decline in value has been even more pronounced, the value of the product in 1896 being little more than one-third of what it was in 1892. With a decrease of nearly 50 per cent in amount, the value has decreased more than 64 per cent in four years. Barytes is used largely as a substitute for or an adulterant of white lead. Manufacturers claim that this and allied industries are the first to feel the effects of hard times and the last to reap the benefit of business improvement, and the continued depression has caused an almost entire suspension of barytes mining. In fact barytes mining as a separate occupation in Missouri has been practically abandoned. Formerly it was the custom among the farmers in the vicinity of Cadet, Old Mines, Mineral Point, Morrellton, and Potosi to work barytes, locally known as "tiff," at seasons when they were not otherwise engaged, but the low prices of the last three years have discouraged even this irregular industry. The peculiar association of barytes with the lead deposits of Missouri have given it the name of "lead blossom" in those regions. The output of barytes in Missouri in 1896 was almost entirely the by-product of lead mining. About one-half the product in 1896 was from Missouri. The other half was from North Carolina and Virginia. Production for the past two years has been confined to these States.

During the past year a company was organized in Wisconsin for the purpose of mining, milling, and selling barytes. A mill has been constructed at West Superior, and it is reported that 2,000 tons of barytes were treated there in 1896. The crude barytes is obtained from a small island in Lake Superior. This island belongs to the Dominion of Canada, and the product of barytes from it can not be classed with that of the United States, although treated and sold in this country.

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The production of crude barytes in the United States since 1882 has been as follows:

Production of crude barytes from 1882 to 1896.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Short tons.			*Short tons.*	
1882	22,400	$80,000	1890	21,911	$86,505
1883	30,240	108,000	1891	31,069	118,363
1884	28,000	100,000	1892	32,108	130,025
1885	16,800	75,000	1893	28,970	88,506
1886	11,200	50,000	1894	23,335	86,983
1887	16,800	110,000	1895	21,529	68,321
1888	22,400	75,000	1896	17,068	46,513
1889	21,460	106,313			

IMPORTS.

The following table shows the imports of barytes into the United States from 1867 to 1896:

Imports of barytes from 1867 to 1896.

Year ended—	Manufactured.		Unmanufactured.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
June 30, 1867	14,968,181	$141,273	.....	.....
1868	2,755,547	26,739	.....	.....
1869	1,117,335	8,565	.....	.....
1870	1,684,916	12,917	.....	.....
1871	1,385,004	9,769	.....	.....
1872	5,804,098	43,521	.....	.....
1873	6,939,425	53,759	.....	.....
1874	4,788,966	42,235	.....	.....
1875	2,117,854	17,995	.....	.....
1876	2,655,349	25,325	.....	.....
1877	2,388,373	19,273	.....	.....
1878	1,366,857	10,340	.....	.....
1879	453,333	3,496	.....	.....
1880	4,924,423	37,374	.....	.....
1881	1,518,322	11,471	.....	.....
1882	562,300	3,856	.....	.....
1883	411,666	2,489	.....	.....
Dec. 31, 1884	3,881,516	24,671	5,800,816	$8,044
1885	4,095,287	20,606	7,841,715	13,567

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Imports of barytes from 1867 to 1896—Continued.

Year ended—	Manufactured.		Unmanufactured.	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
Dec. 31, 1886	3,476,691	$18,338	6,588,872	$8,862
1887	4,057,831	19,769	10,190,848	13,290
1888	3,821,842	17,135	6,504,975	9,037
1889	3,601,506	22,458	13,571,206	7,660
1890	*a* 1,563	16,453	*a* 4,815	13,133
1891	2,149	22,041	2,900	8,816
1892	1,389	15,419	2,789	7,418
1893	1,032	11,457	2,983	7,612
1894	836	10,556	1,884	5,270
1895	1,629	17,112	2,551	7,561
1896	.....	1,348	225	321

a Tons since 1890.

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FULLER'S EARTH.

NEW DISCOVERIES.

Since the discovery of fuller's earth in Florida about two years ago, the knowledge of its occurrence in the United States has spread rapidly, with the result that persons all over the country have been searching for it, but often without success.

As fuller's earth resembles common clay in its appearance, the only way of identifying it with certainty is by means of a practical test of its bleaching or clarifying effect on oils. This, however, requires some practice, especially in the case of cotton-seed oil. The color of the earth is no guide, as it varies greatly, nor is an analysis of great value except as indicating the fact that fuller's earth has generally a high percentage of combined water and rarely over 15 per cent of alumina. Fuller's earth when dry adheres strongly to the tongue on account of its absorbent properties, but many ordinary clays do the same.

During the past year fuller's earth has been reported from Colorado, South Dakota, Nebraska, New Mexico, Indian Territory, and New York, in addition to the occurrences in Georgia, Florida, and North Carolina, which were mentioned in last year's report.

DEVELOPMENT AND PRODUCTION.

The following notes are based on personal examinations made during the past year at all the localities except those in Nebraska and Indian Territory.

SOUTH DAKOTA.

The fuller's earth beds in this State are the most extensive thus far opened up in the West. They were first found at Fairburn and subsequently at Argyle, Minnekahta, etc.

Fairburn.—Numerous claims have been staked out all around Fairburn, but up to October, 1896, shipments had been made from only one point. This is 5 miles southeast of the station and about three-fourths of a mile east of the Fremont, Elkhorn and Missouri Valley Railroad track. The mine is operated by the Mining Syndicate of Omaha. A

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small opening has been made and a platform built on which to spread out the earth so that it may dry before shipment.

The section at the mine, beginning at the top, is as follows:

Section in Fairburn fuller's earth mine.

	Feet.
Micaceous sandy clay	6
Fuller's earth	9
White micaceous sandstone	

The fuller's earth grades into the overlying micaceous clay. On the southwest side of this spur in which the mine lies a similar section is seen, and the earth also shows in several neighboring gullies. This Fairburn fuller's earth is in appearance a sandy, at times fine grained, dense clay, having a nodular structure and conchoidal fracture. An analysis of it, given in last year's report, was as follows:

Analysis of fuller's earth from Fairburn, South Dakota.

	Per cent.
SiO_2	58.72
Al_2O_3	16.90
Fe_2O_3	4.00
CaO	4.06
MgO	2.56
HO_2	8.10
Alkalies	2.11
Moisture	2.30
Total	98.45

Several shafts have been sunk by William Bodenner, about 1 mile north of Fairburn, and half a mile from the railroad.

The earth is very similar in appearance to that at the locality southeast of Fairburn, but is overlain by a white, cavernous limestone, of which there are about 4 feet. The underlying material is a sandstone.

Up to October, 1896, none had been shipped.

The following analysis of this material was made at the State School of Mines, Rapid City:

Analysis of fuller's earth from north of Fairburn, South Dakota.

	Per cent.
SiO_2	68.23
Al_2O_3	14.93
FeO	3.15
CaO	2.93
MgO	.875
Loss on ignition	6.20
Total	96.31

Argyle.—The fuller's earth deposits are 2 miles west of Argyle, in T. 6 S., R.'s 3 and 4 E. The beds are near the top of the bare, rounded hills at this locality, and the float from them is apparent in the numerous gullies around their base. One small bank about 7 feet high has been

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opened and several shafts sunk. The best section is seen in a shaft sunk to a depth of 26 feet, and was as follows, according to Mr. Smith:

Section in fuller's earth pit west of Argyle, South Dakota.

Quartz pebbles and sand	feet	2
Sandstone	inches	18
Infusorial earth	do	8
Fuller's earth	feet	18
Clay and earth		..
Sandstone		..

The infusorial earth is not always present, and the fuller's earth is of variable thickness, as in the bank, which is not more than 50 feet from the shaft above mentioned, it is only 8 feet thick.

The Argyle earth is quite similar in appearance to that around Fairburn, but contains less sand.

Only a small amount had been shipped up to October 18, 1896. The material has to be hauled 2 miles to the railroad.

Minnekahta.—The fuller's earth at this locality is 1 mile west of the station. It is a bed of Jurassic shale, about 30 feet thick, and is capped by red sandstone. The material is a fine-grained, greenish-gray shale, full of fossils. Several hundred tons have been taken out, and 6 or 8 carloads of it are said to have been shipped. A large platform has been built at the base of the bank and the earth is spread out on this to dry. This bed was located and the claim staked out in May, 1896, and the first mining was done in June, 1896.

These are the three principal localities in South Dakota at which fuller's earth has been found. With the opening of them and the circulation of various rumors concerning their value a wave of excitement has spread over the Black Hills region, with the result that dozens of fuller's earth claims have been staked out.

As clays abound in this area, and few practical tests have been made on many of the prospects, no doubt a large number of these claims will prove valueless.

Among the reported localities are points 8 miles west of Custer City; at Marietta, west of Edgemont; and 2 miles south of Buffalo Gap. A plant for pulverizing and drying the earth has been erected at Hot Springs.

NEBRASKA.

Mr. C. H. Cornell, of Valentine, Nebraska, claims to have found considerable quantities of fuller's earth south of Valentine. Some of the beds are stated to be 30 feet thick and several miles in extent.

COLORADO.

The Dakota Cretaceous sandstones at Parkdale contain numerous interbedded seams of shale fire clay, and at the base of the section, on

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the land of W. H. Murry, east of Parkdale Station, is a bed of so-called kaolin. It is a fine-grained, greenish-gray clay, with soapy feel. The bed is about 30 feet thick, and underlies a bed of red sandstone. It rests on the granite. The upper 15 feet are much stained by iron, and considerably broken up, while the lower 15 feet are comparatively massive. The bed dips southwest, and the bank is three-quarters of a mile northeast of the depot.

This material is shipped to Denver, where it is washed by the Manchester Clay Manufacturing Company. Its original use was as a filler for paper, having been so used at Denver, but more recently it has been put on the market as fuller's earth. One of the lard companies in Denver has been using it, but it was not found wholly satisfactory. Its lack of bleaching properties may be due to the fact that it was not ground sufficiently fine, for prepared samples seen were very gritty.

If this material proves to be valuable as a decolorizer, there is no doubt that an abundance of it may be found in the lower beds of the Dakota Cretaceous, extending along the eastern base of the divide.

NEW MEXICO.

Fuller's earth was thought to have been found near Las Vegas, but proved to be simply a decomposed nodular sandstone.

NEW YORK.

Twelve miles north of Rome and 2 miles west of McConnellsville, on the Rome, Watertown and Ogdensburg Railroad, is a deposit of fuller's earth which has been worked for several years by the New York Fuller's Earth Company. The material is a fine-grained, dense, Quaternary clay, in layers 2 to 8 inches thick, interbedded with layers of sand of similar thickness. The total thickness exposed is about 15 feet, and there is a capping of 4 feet of sand. To mine the earth the overlying sand has to be stripped and the layers of fuller's earth taken off one by one, separating the interbedded sand. It is then dried on racks with movable roofs. Thus far this fuller's earth has been used only for cleansing woolen goods. It is shipped to several factories in New York and neighboring States.

A second mine of the same material has been recently opened in an adjoining hill by Mr. A. Penfield, but none has been shipped thus far.

INDIAN TERRITORY.

Samples of a white clay called "glacialite," and said to be fuller's earth, were recently sent to the National Museum at Washington. The deposit is said to occur at Enid, Oklahoma Territory. The only additional information concerning it is the analysis kindly supplied by Dr. G. P. Merrill, and given in the accompanying table.

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Analyses of fuller's earth.

	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
F. E. D. Heinault, Custer City	55.45	18.58	3.82	3.40	3.50
Do	57.00	17.368	2.362	3.00	3.027
J. E. Pilcher, Custer City	63.50	14.97	4.48	2.40	2.882
George Boland, Hermosa	55.40	27.70	1.80	2.30	.703
A. M. Willard, Custer City	71.28	14.33	2.484	.33	1.199
Wm. Bodenner, three-fourths mile from Fairburn	68.23	14.93	3.15	2.93	.875
M. Palmiter, Fairburn	60.16	10.38	14.868	4.96	1.714
M. Palmiter, Fairburn (dried)	56.18	23.23	1.26	5.88	3.29
Wm. Bodenner, Fairburn	67.00	5.00	12.00	.....	.....
So-called "Glacialite," Enid, Oklahoma Territory	50.36	33.38	3.31	.....	.....

	H_2O.	Volatile matter.	Mn O.	K_2O.	Na_2O.
F. E. D. Heinault, Custer City	*Per cent.* 8.8	*Per cent.* 5.35	*Per cent.* Trace.	*Per cent.*	*Per cent.* .....
Do	9.5	5.85	Trace.	.....	.....
J. E. Pilcher, Custer City	.....	CO_2 and vol. 10.70	.....	1.116	7.20
Geo. Boland, Hermosa	.....	.....	Loss 13.00	.589	.487
A. M. Willard, Custer City	Ign. 4.30	Alk. und.	.....	.....	.....
William Bodenner, three-fourths mile from Fairburn	6.20	.....	.....	.....	.....
M. Palmiter, Fairburn	Ign. 7.20	.....	.....	.....	.....
M. Palmiter, Fairburn (dried)	11.45	.....	.....	.....	.....
Wm. Bodenner, Fairburn	15.00	.....	.....	.....	.....
So-called "Glacialite," Enid, Oklahoma Territory	12.05	TiO_2 trace.	Org. trace.	.88	

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The two following very complete analyses of fuller's earth, made by Prof. P. G. Sanford, are given in the [London] Geological Magazine, October, 1889:

Analyses of fuller's earth from Nutfield, near Redfield, Surrey, England.

	Number 1 (blue earth).	Number 2 (yellow earth).
	Per cent.	*Per cent.*
SiO_2	52.81	59.37
Al_2O_3	3.46	10.05
Fe_2O_3	1.30	3.86
CaO	1.53	1.86
MgO	.86	1.04
Insoluble residue	59.96	76.18
Fe_2O_3	2.48	2.41
Al_2O_3	3.46	1.77
CaO	5.87	4.31
MgO	1.41	1.05
P_2O_5	.27	.14
SO_3	.05	.07
NaCl	.05	.14
K_2O	.74	.84
H_2O	14.27	13.19

FLORIDA.

Production in the United States in 1896 was limited to the neighborhood of Quincy, Gadsden County, Florida, as in the previous year. Of the many deposits known in this region, the product came principally from the openings of the Owl Segar Company and of the Chesebrough Manufacturing Company, with small shipments from two or three other deposits between Quincy, Florida, and Faceville, Georgia. In addition to this it became evident that many deposits not yet opened, and the size of which had not been determined, exist in various parts of Gadsden County, and particularly exposed in the river banks at River Junction, Florida.

The additions to the known localities of fuller's earth in Florida made during 1896 are principally in the neighborhood of Tampa. These discoveries began early in the year, when Dr. Day and Mr. Ries discovered a deposit at Port Tampa. The operations of the large Bucyrus dredge in deepening the dock at this point threw out small pieces of fuller's earth, and following these indications Dr. Day drove down an iron pipe into the bottom with a pile driver, and, pulling this pipe, obtained cores showing that 17 feet below high-water mark a layer of fuller's earth is obtained from 5 to 8 feet thick, the quality of the clay

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being about the same for manufacturing purposes as that obtained at Quincy, Florida. The finding of this deposit led to further investigation by Mr. Ward, of Quincy, and others, which showed that fuller's earth occurs in small quantity at the Government works northeast of Tampa. Large supplies were found also on the shore of Clear Water Harbor, at Dunedin, and in the neighborhood of Largo. An examination of this material showed that it was fuller's earth of a slightly different type from the material at Quincy, and tests of it by the refiners of cotton-seed oil, and particularly of mineral lubricating oils, show it to be of the quality desired for these purposes. It is possible that this deposit, dipping at a small angle to the northwest, is identical with the deposit at Port Tampa.

The only definite determination which has been made of the geological horizon at which the deposits of fuller's earth in Florida have been found is the work on the fossils obtained at the Chesebrough opening, at Quincy, which Professor Dall has identified as characteristic of the Lower Miocene. A definite horizon is also given by Dr. Dall to the deposit at Ballast Point, Florida. In connection with this latter deposit it should be noted that the occurrence of nodules of chalcedony, sometimes with centers of quartz crystals and of shells of fossil coral in which the carbonate of lime has been entirely replaced by silica, was so frequent as to be characteristic of this deposit. In this connection should be noted also the fact that layers of chalcedonic silica are also quite characteristic of the fuller's earth found at Whigham, Georgia, and at Spout Springs, North Carolina, except that in both of these localities instead of fossils of silica occurring through the deposit at Whigham, Georgia, and Spout Springs, North Carolina, the silica is in definite bands, and is also accompanied by layers which seem to be intermediate between fuller's earth proper and pure silica.

Another deposit of good quality was found at the head of Tampa Bay, at Phillips Point. A deposit across the harbor from this point did not prove of good quality. This is a good illustration of the variable character of this earth, both in distribution and quality. One of the thickest layers of fuller's earth—from 9 to 12 feet—was obtained near the upper limits of steamboat navigation of the Manatee River. This deposit is quite different in appearance from the normal fuller's earth, and contains oxide of iron in sufficient quantity to color it yellow. The quality of this earth, however, is sufficiently good for many purposes to which the earth is applied.

In Bulletin No. 84 of the United States Geological Survey, Correlation Papers—Neocene, Prof. W. H. Dall, on pages 115 and 116, mentions a deposit of siliceous marl as outcropping at Conklins Bluff, about one mile and a half north of Ballast Point, on the Hillsboro River, near Tampa, which he describes as follows:

Bailey's infusorial earth.—It is to be noted that at one point on the bay shore between Ballast Point, or Newmans Landing, and the mouth

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of the Hillsboro River, the marl associated with the siliceous fossils, forming a phase of the Orthaulax bed, rises above the beach to an estimated height of 10 feet. Here Mr. Burns, of the United States Geological Survey, Colonel Bartholomew, of Tampa, and others have collected fine series of silicified fossils. At this point Prof. J. W. Bailey, U. S. A., discovered what he regarded as a bed of infusorial earth resembling that of Virginia in its lithologic character. Of this he says:[1]

> Directly on the shore of the bay I detected a highly interesting stratum of fossil marine Diatomacea or Infusoria. It is exposed for at least a quarter of a mile, and from 5 to 10 feet of its thickness may be seen. In its external characteristics (whiteness, lightness, fissility, etc.) it has some resemblance to the infusorial strata of Virginia, but is much more indurated, so that although it is easy to show that it is made up of the remains of Diatomaceæ, spicules of sponges, etc., it is difficult to isolate and determine the individual specimens. This infusorial earth, like that of Petersburg, Virginia, changes in a singular manner to a salmon color when exposed to the vapor of turpentine or Canada balsam.

This bed has not, as far as we know, been examined since Professor Bailey's visit, and in order to determine its position, stratigraphical and lithological, it was visited by the writer in January, 1891.

The most marked exposure is locally known as Conklins Bluff, and is situated on the western shore of Hillsboro Bay, about a quarter of a mile above a long wooden pier belonging to a Mrs. Chapin, and a mile and a half north of Ballast Point. It is a steep bank 6 or 8 feet above high-water mark, and is the only place on this shore between Ballast Point and Tampa which at all corresponds to Bailey's description. The land along this shore is mostly low, and the beach soft and muddy or sandy, but there are a few places where the Orthaulax bed rises above high-water mark. The rock is like that at Ballast Point. The shells are often represented by molds in the chert, but there are pockets of putty-like marl which contain the siliceous pseudomorphs and small nodules of chalcedony.

Bailey's white bed consists of a deposit of this marl, which elsewhere occurs in pockets in the harder rock, but here for a few hundred feet appears in sufficient quantity by itself to be regarded as a bed. Some of the material is pretty hard, but all of it is fissured vertically and horizontally into a profusion of angular fragments. The lower layers are the hardest and rest on siliceous rock of the Orthaulax bed, of which this must be regarded as merely a very local phase. At this place the marl is nearly destitute of fossils. The few which occur are nearly all small branches of coral; much of it has no fossils. The lower part is of a gray or pale green hue, bleaching when dry, as in the upper layers, to white. It also becomes softer and more fragmentary. It is penetrated by roots to a depth of 2 feet, and a piece large enough to form a good specimen can be found only low down in the bed, and then in drying will break into numerous fragments. The average thickness

[1] Microscop. Obs., Smithsonian Contr. Knowl., 1850, Vol. II, No. 8, p. 19.

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of the bed may be 3 feet, the maximum 6 to 8 feet. In one place it is covered by a thin layer of eolian sand rock, discolored by iron oxide. The strata along this beach are gently waved; the places where rock appears above high-water mark are the summits of these waves, which seem to trend in a northwest and southeast general direction. This marl is one of the highest of the waves, and farther back from the shore is covered by the Tampa limestone, according to reports of residents. There seemed to be no recognizable dip.

It will be noticed in Bailey's list of species collected that he mentions only three or four from this deposit, all of which are also found living over a great part of the Atlantic Coast, and especially in Florida, and around the roots of plants growing in wet places. The deposit does not seem to be properly infusorial in character, though doubtless containing, like other marl, a few such organisms. It is really a siliceous marl, formed by a decomposition of part of the rock which originally constituted the Orthaulax bed. An analysis, according to Prof. F. W. Clarke, shows the following composition:

Analysis of fuller's earth from Tampa, Florida.

Silica	70.78
Alumina and iron	11.33
Lime	2.18
Water and loss	15.71
Total	100

This indicates the material to be little different from the yellow sand, which, like it, is probably a residual product of the disintegration of indigeneous lime rock of organic origin which has lost most of its lime by solution.

An examination of some of this marl by Mr. Lewis Woolman, the well-known student of microscopic organisms, did not reveal a single diatom, though specimens doubtless occur in certain portions of the deposit as observed by Bailey.

GEORGIA.

Mr. W. W. Grant, of Atlanta, reported to the Manufacturers' Record and sent samples to the United States Geological Survey of fuller's earth from Crawford County, Georgia. A visit by Dr. Day to that region showed that at Rich Hill, 6 miles from Roberta Station, on the Atlanta and Florida Railroad, a thick deposit of impure fuller's earth occurs overlying a thicker stratum of kaolin; and again in a railroad cut between Roberta and Fort Valley, fuller's earth, apparently of purer quality, occurs in a layer about 8 feet thick overlying a peculiar black shale. No analysis or tests have been made of this material to indicate its availability for oil refining.

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LITHOGRAPHIC STONE.

OCCURRENCE.

Deposits of the peculiar variety of limestone adapted to the lithographer's art have been reported in several localities of the United States. Lithographic stone is found in Arizona, Arkansas, Illinois, Kentucky, South Dakota, Texas, Utah, and Virginia; but while some stone has been taken out in various places for experimental purposes, and with reported satisfactory results, no commercial product has been obtained. If indications are to be believed, however, lithographic stone from American quarries will be included in the mineral production for 1897. In the latter part of 1896 a lithographic stone quarry was reported to have been opened on the eastern slope of the Verde range of mountains, in a section known as Sycamore Creek, about 40 miles from Prescott. This stone is said to have been tested, and to have furnished printed work that would compare favorably with work done on Bavarian stone. Professor Blandy, formerly Territorial geologist, in one of his reports says that this stone is uniform in character and of very fine grain, and expresses the opinion that stone of any desirable size may be obtained. Water is said to be available in sufficient quantities for the power necessary to saw the stone and otherwise prepare it for market.

South Dakota also promises to furnish lithographic stone for market during 1897. To Mr. W. R. Bond, of Custer City, belongs the credit of the discovery. The deposit is located near Pringle station, Custer County. Mr. Bond has had specimens of this stone tested in Omaha with such excellent results that he was able, with little difficulty, to secure the cooperation of some Omaha business men in the organization of a company to develop the property. Some of the Omaha parties are engaged in lithographic business in that city, and their association with the enterprise is a hopeful indication. The company (known as the Lithograph Mining Company) owns claims covering about 1,000 acres, and claim the ability to supply the entire demand when the property is developed, a consummation that is expectantly looked for before the close of the present year.

Several attempts have been made in the last ten years to develop lithographic stone quarries said to exist in Kentucky, but without successful result. Interest has again been recently aroused by the announcement of the organization of the North American Lithographic

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Stone Company, of Bowling Green, for the purpose of developing a quarry near that city.

Mention has been made in previous volumes of Mineral Resources of the deposits of lithographic stone in Arkansas, Texas, Utah, and Virginia. The Arkansas deposits are remote from railroad transportation and have not been developed. Some stone was quarried near Marble Falls, Texas, but the quality of the stone obtained was marred by the presence of quartz crystals and other defects, which rendered it practically useless. No attempt has been made to quarry any stone at this place for several years. The Utah deposits have been permanently abandoned as worthless for lithographic purposes. St. Louis parties are interested in a quarry in Alexander County, Illinois, but no work was done on the property in 1896. It is probable that the depressed business conditions have discouraged active development of new enterprises of this nature. To the same cause, added to remoteness from railroads, is probably due the fact that the quarries in Botetourt County, Virginia, have had no work done upon them in the last four years, but the owners express the hope of being able to proceed with development work at an early date.

The American market, not having had any domestic supply from which to draw, has always depended for its lithographic stone upon the well-known Bavarian quarries. These quarries have, indeed, supplied the world since printing from stone was invented. Efforts have been made to substitute metals for lithographic stone, but it has been only partially successful. Aluminum and zinc plates, more especially the latter, are quite generally used in the larger printing establishments and on rather coarse grades of commercial work. Zinc plates are also used by reason of their small bulk for preserving original matter, transfer being made to stone as requirements for printing arise.

PRICES.

It is not possible, with the information at hand, to show what is the value of lithographic stone per ton or square foot or by any other unit of measurement except as to its cost to the consumer. The reports to the Bureau of Statistics of the Treasury Department show only the values. No quantities are given. As fairly indicative of the cost to the consumer, it may be stated that the Geological Survey is in itself a large user of lithographic stone for the printing of its topographic sheets and geologic folios. The prices paid for stone by the Survey in 1896 were as shown in the following table. Specifications call for "best yellow, subject to inspection and rejection and return at cost of bidder; subject, also, to selection at bidder's place of business." Gray stones are a little higher in price, usually about 10 per cent, though some of the larger stones sell for as much as 40 cents per pound. It will be noticed that in lithographic stone, as with mica and diamonds, the price per unit of weight increases with the size of the stone.

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Prices for lithographic stone paid by the Geological Survey.

	Size.	Price per pound.		Size.	Price per pound.
		Cents.			*Cents.*
1	18×22	3	10	26×38	9
2	18×24	4	11	28×36	8
3	20×26	5	12	30×40	12
4	20×30	4½	13	30×44	12
5	22×38	6	14	32×40	12
6	24×30	6½	15	34×48	14
7	24×32	7½	16	36×52	12
8	24×36	8	17	40×60	18
9	24×43	11	18	42×63	15

IMPORTS.

The following table exhibits the value of lithographic stone (all Bavarian) imported into the United States since 1867. The quantities have not been reported by the Bureau of Statistics of the Treasury Department:

Lithographic stone imported into the United States from 1868 to 1896.

Year ending—	Value.	Year ending—	Value.
June 30, 1868	$13,258	June 30, 1883	$104,313
1869	17,044	1884	128,035
1870	14,225	1885	54,022
1871	21,311	1886	71,009
1872	36,146	Dec. 31, 1887	83,182
1873	44,937	1888	113,365
1874	36,902	1889	78,077
1875	41,963	1890	105,288
1876	47,101	1891	107,339
1877	44,503	1892	107,777
1878	42,700	1893	91,849
1879	37,746	1894	74,454
1880	56,310	1895	107,670
1881	77,894	1896	74,044
1882	111,925		

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FELDSPAR AND QUARTZ.

By Heinrich Ries.

Feldspar and quartz are both of widespread occurrence in gneissic and granitic rocks, and often also in rocks of igneous origin, but it is only when they occur in large masses of considerable purity that they become of commercial value. The ordinary sources of supply are pegmatite and quartz veins, the quartz and feldspar occurring in the same vein in the former. Quartz may also be obtained from chert formations, from quartzites, or in some cases even from sand deposits.

FELDSPAR.

The commonest species of the fieldspar family is orthoclase or potash feldspar, and is the one used by potters in this country. It is the most infusible member of the feldspar group, but thus far none of the others have been found in commercial quantities in this country. The feldspar mines are in Maine, Connecticut, New York, Pennsylvania, Maryland, and Missouri.

Connecticut.—The best mines are at Branchville and Glastonbury, but others occur at Portland and Haddam Neck.

Maine.—The quarries at Georgetown and Topsham, Maine, have been in operation for nearly twenty years. During the past year the Maine Mineral Company, of Portland, began operations at their mines at North Turner and Auburn.

Missouri.—According to Wheeler,[1] only one workable deposit of spar is known in Missouri, this being in Sainte Genevieve County. Granitic rocks and coarsely crystalline ones, such as would be apt to furnish commercial feldspar, occur in Camden County, but they have not been exploited, so far as is known.

The deposits in Sainte Genevieve County are 2 miles east of Jonca, on the Dobschutz land. The rock is a red granite containing a vein of segregated feldspar. The vein is about 8 feet wide. One objection to it is the fact that it is 20 miles from a railroad.

[1] Missouri Geol. Survey, vol. xi.

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The spar in Camden County on T. 37 N., R. 16 W., Sec. 22, S. W. ¼, is pink to flesh red. It is likewise disadvantageously situated for shipping.

The following table shows the analysis of the Sainte Genevieve spar:

Analysis of Sainte Genevieve spar.

	Per cent.
Silica	64.80
Alumina	18.00
Potash	15.90
Water	.70
Lime, iron, magnesia	.60
Total	100.00

New York.—The only deposits of feldspar of commercial value in this State are at Bedford, Westchester County. At this locality there is found a remarkable series of pegmatite veins cutting the gneiss. They are all within a small area, and about 4 miles from the railroad. The pegmatite varies from a fine grained mixture of quartz and red orthoclase feldspar to large masses of feldspar, or even quartz almost free from impurities.

Mr. P. H. Kinkel's quarry near Bedford Village is the largest thus far opened, and has been in operation for over eight years. The spar is crushed and ground at the quarry. Other quarries in the vicinity are those of Messrs. Hobby and McDonald. These are not operated steadily.

The following two analyses show the composition of spar from Mr. P. H. Kinkel's quarry:

Analyses of spar from quarry of P. H. Kinkel, near Bedford, New York.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Silica, SiO_2	64.97	65.85
Alumina, Al_2O_3	20.85	19.32
Ferric oxide, Fe_2O_3	Trace.	.24
Sodium and Potassium oxides, Na_2O and K_2O	13.72	14.10
Water, H_2O (by loss)	.46	.....
Calcium oxide, CaO	.....	.56
Magnesium oxide, MgO	.....	.08
Total	100.00	100.15

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No. 1 was furnished by Mr. P. H. Kinkel, of Bedford, New York; No. 2 from Langenbeck's Chemistry of Pottery.

Pennsylvania.—All of the quarries in this State are situated near Brandywine Summit. The product requires more sorting than the Maine and Connecticut material.

The chief use of feldspar is by potters, as an ingredient of the body or the glaze of their wares, but the following abstract from an article by Mr. L. Appert,[1] on "The function of alumina in the composition of glass," opens up a new field of usefulness.

Researches on the composition of ancient glass have led the author to certain practical conclusions respecting the influence of alumina when used in the manufacture of glass. It appears that the introduction of alumina impedes, if it does not prevent, the tendency of glass to become devitrified by frequent changes of temperature, and besides, its presence admits of the substitution in equivalent proportions of lime for soda or potash, the glass thus modified being more solid, more elastic, and less alterable. Alumina substituted for silica in glass in not greater proportions than 7 to 8 per cent slightly increases its fusibility, its malleability not being sensibly diminished. One inconvenience, however, attends the introduction of alumina into colorless glass, namely, that it tends to give a color. The alumina is best introduced as pure clay or as feldspar.

The following table shows the amount and value of feldspar mined in 1896, compiled from the returns of the different producers:

Production and value of feldspar in 1896, by States.

States.	Tons (2,000 pounds).	Value at mine.
Connecticut	1,410	$5,050
Maine and Pennsylvania	3,360	12,000
Massachusetts	1,344	6,300
Maryland	2,700	9,300
New York	300	2,550
Total	9,114	35,200

QUARTZ.

Nearly all of the quartz or "flint" mined is obtained from veins, as in the case of the Pennsylvania and Maine deposits. In Illinois a rather pure sand is used, and at Riverton, Alabama, a residual chert has supplied many of the western potters with a very satisfactory material. The white sand resulting from the decay of the Oriskany

[1] Bull. de la Soc. d'Encouragement, I (3), p. 415, 1896.

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sandstone near Hancock, Maryland, has not yet been used for pottery purposes, but is washed and sold to the glass manufacturers.

The mines furnishing quartz are situated as follows: Bethel, Newtown, Cannon, and Roxbury Falls, in Connecticut; Georgetown, in Maine; Broad Creek, Dublin, and Conowingo, in Maryland; Chester, Huntington, and Russell, in Massachusetts; Bedford, in New York; and Kaolin, McVeytown, and Chambersburg, in Pennsylvania.

The following table shows the production and value of quartz by States:

Production and value of quartz in 1896, by States.

State.	Tons.	Value at mine.
Connecticut	1,568	$5,600
Maine	3,136	5,376
Maryland	5,300	10,750
Massachusetts	1,120	2,500
Total	11,124	24,226

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MINERAL WATERS.

By A. C. PEALE.

PRODUCTION.

Although 25 springs have been dropped from the list, the total number of springs for 1896 is 377, a gain of 7 over 1895, due to the fact that 32 names have been added. For this year also 15 more springs report their sales, the total number being 312. The delinquent list therefore includes 65 springs, among which are a number reporting no sales for 1896. Among the springs from which no report of any kind has been received are many whose sales in previous years have been large, and several of them produce well-known and widely used mineral waters.

The total production for 1896 is 25,795,312 gallons, which includes as usual for the delinquent springs an estimate of one-half their last reported production. The total valuation of the sales for 1896 is $4,136,192. There is, therefore, a gain over 1895 of 4,331,769 gallons. Notwithstanding this there is an apparent loss of $118,045 in the total valuation. The average price for 1896 is nearly 16½ cents per gallon instead of 19 cents as in 1895.

When the figures of the 312 springs actually reporting in 1896 are compared with the 297 springs actually reporting in 1895, there is shown an increase of 5,322,007 gallons, at an increased total valuation of $43,465 and an average price per gallon of 16 cents.

In the North Atlantic States the total number of springs in the list for 1896 is 110, a loss of 5 from the preceding year. Six names have been added to the list, but 11 springs have been dropped. Two more springs report sales than in 1895, the total being 90, showing also an increase in production of 565,983 gallons and an increase of $496,455 in the value of the product over that of 1895. Of the 20 springs not reporting their sales many are large producers. The following are the names that were not in the list for 1895:

Maine: Glenwood Mineral Spring.
Massachusetts: Farrington's Silver Spring, Undine Spring.
New York: Saratoga High Rock Spring.
Pennsylvania: East Mountain Lithia Well, Charmian Springs.

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The South Atlantic States gain 13 springs over the list of 1895, when the total was 61. Of the 74 springs now on the list 60 report in 1896, which is 9 more than reported in the previous year. There was also an increase of 352,375 in the number of gallons sold, and the total valuation of the product was $112,785 greater than in 1895. The springs new to the list are the folowing:

Maryland: Algonquin Mineral Spring, Blackiston Island Diuretic Mineral Spring.
District of Columbia: Columbia Natural Lithia Spring.
Virginia: Beaufont Lithia Springs, Bedford Chalybeate Spring, Colonial Springs, Magee's Chlorinated Lithia Spring.
South Carolina: Edisto Spring.
Georgia: Anipa Spring, Austell Lithia Springs, Daniel's Spring, Electric Spring, Hillman's Antifebrile Spring.

In the South Central States 2 springs have been dropped from the list and 1 has been added. The total number on the list for 1896 is 42, and of these 34 report, which is 1 less than in 1895. There is, however, a large increase in the production, 2,018,151 gallons more being sold in 1896 than in 1895. The increase in the value of the total product is $94,870. In Kentucky the name of St. Patrick's Well has been changed to Hecla Magnetic Spring. The only spring added to the list is Estill Springs, Tennessee.

The North Central States in 1896 are credited with 108 springs, a net loss of 1 from 1895. Although 9 new springs are added to the list 10 are dropped. Sales are reported from 97 springs, which is 5 more than in 1895. Contrary to the state of affairs in that year, when there was a decrease in the total production, with an increase in the total value, in 1896 there is an increase in the production of 1,694,498 gallons, while the total value of the product is $768,811 less than in 1895. The 9 springs new to the list are the following:

Ohio: Talewanda Mineral Springs.
Illinois: Original Okawville Mineral Spring.
Wisconsin: Solon Springs, Chippewa Spring.
Minnesota: Trio-Siloam Springs, Vitalis Mineral Springs.
Iowa: Armstrong Medical Spring.
Missouri: Albaqua Mineral Springs, McAllister Springs.

For the Western States and Territories the list shows a net gain of 1 spring, for although 2 have been dropped from the list, 3 have been added to it. The section is credited with 43 springs, of which 31 report for 1896. There is an increase in production of 691,000 gallons over the figures of 1895, and a gain of $108,166 in the total value of the product. The springs new to the list in 1896 are the following:

Colorado: Glenwood Springs.
Utah: Deseret Lithia Spring.
California: Veronica Springs.

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Production of mineral waters in 1896, by States and Territories.

State or Territory.	Springs reporting.	Product.	Value.
		Gallons.	
Alabama	3	7,800	$24,945
Arkansas	6	46,100	6,943
California	14	452,110	249,580
Colorado	8	937,875	120,538
Connecticut	4	63,050	6,585
Georgia	8	167,550	26,855
Illinois	12	49,972	10,236
Indiana	10	147,965	28,772
Iowa	5	57,695	6,438
Kansas	4	28,155	1,966
Kentucky	5	52,600	6,055
Maine	9	418,241	43,672
Maryland	6	165,610	58,339
Massachusetts	23	2,835,204	189,821
Michigan	13	594,625	99,525
Minnesota	5	2,764,025	64,277
Mississippi	4	164,695	32,392
Missouri	9	197,521	52,883
New Hampshire	2	1,720,000	682,000
New Jersey	2	104,000	75,800
New Mexico	2	17,400	1,740
New York	27	3,186,013	901,816
North Carolina	8	122,700	19,430
Ohio	11	369,965	59,322
Oregon	2	12,200	2,840
Pennsylvania	16	727,682	146,652
Rhode Island	3	116,000	6,150
South Carolina	3	99,500	19,390
Tennessee	6	87,850	13,470
Texas	10	4,005,912	172,138
Vermont	4	64,700	16,840
Virginia	28	698,078	268,549
Washington	2	49,500	4,975
West Virginia	5	25,150	3,345
Wisconsin	26	3,562,207	436,250
Other States (*a*)	7	486,550	74,463
Total	312	24,606,200	3,934,992
Estimated production of springs not reporting sales	65	1,189,112	201,200
Grand total	377	25,795,312	4,136,192

a These include the States in which only one spring each has reported. These are, District of Columbia, Florida, Idaho, Montana, Nebraska, South Dakota, and Utah.

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Production of natural mineral waters from 1883 to 1896.

Geographic division.	Springs reporting.	Gallons sold.	Value.
1883.			
North Atlantic	38	2,470,670	$282,270
South Atlantic	27	312,090	64,973
North Central	37	1,435,809	323,600
South Central	21	1,441,042	139,973
Western	6	169,812	52,787
	129	5,829,423	863,603
Estimated	60	1,700,000	256,000
Total	189	7,529,423	1,119,603
1884.			
North Atlantic	38	3,345,760	328,125
South Atlantic	27	464,718	103,191
North Central	37	2,070,533	420,515
South Central	21	1,526,817	147,112
Western	6	307,500	85,200
	129	7,715,328	1,084,143
Estimated	60	2,500,000	375,000
Total	189	10,215,328	1,459,143
1885.			
North Atlantic	51	2,527,310	192,605
South Atlantic	32	908,692	237,153
North Central	45	2,925,288	446,211
South Central	31	540,436	74,100
Western	10	509,675	86,776
	169	7,411,401	1,036,845
Estimated	55	1,737,000	276,000
Total	224	9,148,401	1,312,845
1886.			
North Atlantic	49	2,715,050	177,969
South Atlantic	38	720,397	123,517
North Central	40	2,048,914	401,861
South Central	31	822,016	58,222
Western	14	781,540	137,796
	172	7,087,917	899,365
Estimated	53	1,862,400	384,705
Total	225	8,950,317	1,284,070

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Production of natural mineral waters from 1883 to 1896—Continued.

Geographic division.	Springs reporting.	Gallons sold.	Value.
1887.			
North Atlantic	40	2,571,004	$213,210
South Atlantic	34	614,041	147,149
North Central	38	1,480,820	208,217
South Central	29	741,080	87,946
Western	12	1,236,324	288,737
	153	6,643,269	945,259
Estimated	62	1,616,340	316,204
Total	215	8,259,609	1,261,463
1888.			
North Atlantic	42	2,856,799	247,108
South Atlantic	32	1,689,387	493,489
North Central	38	2,002,373	325,839
South Central	19	426,410	71,215
Western	15	1,853,679	421,651
	146	8,828,648	1,559,302
Estimated	52	750,000	120,000
Total	198	9,578,648	1,679,302
1889.			
North Atlantic	60	4,106,464	471,575
South Atlantic	47	646,239	198,032
North Central	86	6,137,776	604,238
South Central	33	500,000	43,356
Western	32	1,389,992	431,257
Total	258	12,780,471	1,748,458
1890.			
North Atlantic	55	5,043,074	1,175,512
South Atlantic	39	647,625	245,760
North Central	71	5,050,413	737,672
South Central	30	604,571	81,426
Western	25	869,504	253,578
	220	12,215,187	2,493,948
Estimated	53	1,692,231	106,802
Total	273	13,907,418	2,600,750

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Production of natural mineral waters from 1883 to 1896—Continued.

Geographic division.	Springs reporting.	Gallons sold.	Value.
1891.			
North Atlantic	62	5,724,752	$1,591,746
South Atlantic	41	796,439	313,443
North Central	68	8,010,556	482,082
South Central	29	629,015	106,022
Western	27	1,123,640	414,564
	227	16,284,402	2,907,857
Estimated	61	2,108,330	88,402
Total	288	18,392,732	2,996,259
1892.			
North Atlantic	65	6,853,722	1,933,416
South Atlantic	47	1,062,945	353,193
North Central	74	11,566,440	1,834,732
South Central	32	693,544	109,334
Western	24	1,261,453	594,469
	242	21,438,104	4,825,144
Estimated	41	438,500	80,826
Total	283	21,876,604	4,905,970
1893.			
North Atlantic	79	8,351,192	1,844,845
South Atlantic	49	1,092,829	304,736
North Central	78	8,833,712	1,073,427
South Central	35	1,139,959	122,331
Western	29	675,041	307,623
	270	20,092,733	3,652,962
Estimated	60	3,451,762	593,772
Total	330	23,544,495	4,246,734
1894.			
North Atlantic	83	8,217,528	1,488,361
South Atlantic	55	660,120	129,143
North Central	82	6,914,900	1,115,322
South Central	37	2,319,813	273,836
Western	29	859,905	274,235
	286	18,972,266	3,280,897
Estimated	71	2,597,342	460,949
Total	357	21,569,608	3,741,846

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Production of natural mineral waters from 1883 to 1896—Continued.

Geographic division.	Springs reporting.	Gallons sold.	Value.
1895.			
North Atlantic	88	8,668,907	$1,572,881
South Atlantic	51	953,713	287,623
North Central	92	6,428,582	1,577,118
South Central	35	2,346,806	161,073
Western	31	886,185	292,832
	297	19,284,193	3,891,527
Estimated	73	2,179,350	362,710
Total	370	21,463,543	4,254,237
1896.			
North Atlantic	90	9,234,890	2,069,336
South Atlantic	60	1,306,088	400,408
North Central	97	8,123,080	808,307
South Central	34	4,364,957	255,943
Western	31	1,577,185	400,998
	312	24,606,200	3,934,992
Estimated	65	1,189,112	201,200
Total	377	25,795,312	4,136,192

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LIST OF COMMERCIAL SPRINGS.

ALABAMA.

Of the 4 springs credited to Alabama the following 3 report sales for 1896:

Bailey Springs, Bailey Springs, Lauderdale County.
Healing Springs, Healing Springs, Washington County.
Wilkinson's Matchless Mineral Water, Greenville, Butler County.

ARKANSAS.

Six of the 7 springs on the list for Arkansas report sales. They are the following:

Arkansas Lithia Springs, Hope, Hempstead County.
Blancoe Springs, near Hot Springs, Garland County.
Dovepark Springs, Dovepark, Hot Spring County.
Eureka Springs, Eureka Springs, Carroll County.
Potash Sulphur Spring, Hot Springs, Garland County.
Sulphur Springs, Sulphur Springs, Benton County.

CALIFORNIA.

One spring has been dropped from California's list and 1 spring has been added, leaving the total for 1896 at 20, as in 1895. The name of Ojai Hot Springs has been changed to Matilija Hot Springs. Six springs have sent no reports, and the following are the 14 that report sales for 1896:

Ætna Springs, Lidell, Napa County.
Alhambra Mineral Spring, Martinez, Contra Costa County.
Almaden Vichy Springs, New Almaden, Santa Clara County.
Azule Natural Seltzer Water, San Jose, Santa Clara County.
Bartlett Springs, Bartlett Springs, Lake County.
California Elixir Mineral Spring, near South Riverside, Riverside County.
Castalian Mineral Water, Inyo County.
Coronado Mineral Spring, Coronado, San Diego County.
Matilija Hot Springs, Matilija, Ventura County.
Mount Lowe Springs, near Pasadena, Los Angeles County.
Napa Soda Springs, Napa Soda Springs, Napa County.
Pacific Congress Springs, Saratoga, Santa Clara County.
Tuscan Springs, Redbluff, Tehama County.
Veronica Springs, Santa Barbara, Santa Barbara County.

COLORADO.

Colorado's list remains the same in number for 1896 as for 1895. One new spring is added and 1 dropped. Of the 8 springs credited

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to the State all report their sales of 1896. These springs are the following:

Boulder Springs, Boulder Canyon, Boulder County.
Canyon City Vichy Springs, Canyon City, Fremont County.
Carlile Soda-Iron Springs, near Pueblo, Pueblo County.
Colorado Carlsbad Springs, Barr, Arapahoe County.
Clark Magnetic Mineral Springs, near Pueblo, Pueblo County.
Glenwood Springs, Glenwood Springs, Garfield County.
Hiawatha Spring, Manitou, El Paso County.
Manitou Mineral Springs, Manitou, El Paso County.

CONNECTICUT.

Of Connecticut's 8 springs only 4 report their sales for 1896. They are as follows:

Althea Springs, Waterbury, New Haven County.
Arethusa Springs, Seymour, New Haven County.
Aspinock Mineral Springs, Putnam Heights, Windham County.
The Puritan Spring, Norwich, New London County.

DISTRICT OF COLUMBIA.

The District of Columbia is represented on the list by 1 spring, as follows:

Columbia Lithia Spring, Washington.

FLORIDA.

The 1 spring locality credited to Florida reports sales in 1896. It is:

Magnolia Springs, Magnolia Springs, Clay County.

GEORGIA.

Five new springs are added to Georgia's list, bringing the total for the State up to 8. They all report for 1896, and are as follows:

Anipa Spring, Floyd County.
Austell Lithia Springs, Austell, Cobb County.
Bowden Lithia Springs, Lithia Springs, Douglas County.
Daniels Spring, Greene City, Greene County.
Electric Spring, Hillman, Taliaferro County.
Hillman's Antifebrile Spring, Hillman, Taliaferro County.
Hughes Mineral Spring, near Rome, Floyd County.
Ponce de Leon Spring, near Atlanta, Fulton County.

IDAHO.

There is no change reported for Idaho. It is still represented by 1 spring, as follows:

Idanha Spring, Soda Springs, Bannock County.

ILLINOIS.

One spring is dropped and 1 added to the list for Illinois, leaving the total at 16, as in 1895. Of these 12 report for 1896, as follows:

American Carlsbad, Nashville, Washington County.
Aurora Lithia Spring, Montgomery, Kane County.

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Black Hawk Springs, Rock Island, Rock Island County.
Diamond Mineral Spring, Grantfork, Madison County.
Magnesia Spring, Montgomery, Kane County.
Min-ni-ni-yan Spring, Bristol, Kendall County.
Original Okawville Mineral Springs, Okawville, Washington County.
Perry Springs, Perry Springs, Pike County.
Red Avon Mineral Springs, Avon, Fulton County.
Sailor Springs, Sailor Springs, Clay County.
Sanicula Springs, Ottawa, Lasalle County.
Tivoli Spring, Chester, Randolph County.

INDIANA.

The list for Indiana shows no change from 1895, and of the 11 springs credited to the State 10 report, as follows:

Emerald Spring, Indiana Mineral Springs, Warren County.
French Lick Springs, French Lick, Orange County.
Greenwood Sanitarium Well, Greenwood, Johnson County.
Indiana Mineral Springs, Indiana Mineral Springs, Warren County.
Kickapoo Magnetic Springs, Kickapoo, Warren County.
King's Mineral Springs, Muddyfork, Clark County.
Lodi Artesian Well, Silverwood, Fountain County.
Magnetic Mineral Springs, Terre Haute, Vigo County.
Magnetic Mineral Well, Fort Wayne, Allen County.
West Baden Springs, West Baden, Orange County.

IOWA.

Two springs have been dropped from Iowa's list and 1 new one added, leaving the total at 5, and all of them report. They are as follows:

Armstrong Medical Springs, Lake View, Sac County.
Colfax Mineral Spring, Colfax, Jasper County.
Mynster Springs, Council Bluffs, Pottawattamie County.
Ottumwa Mineral Springs, Ottumwa, Wapello County.
White Sulphur Spring, White Sulphur, Scott County.

KANSAS.

One spring has been taken from the list for Kansas leaving the total at 6, and of these the following 4 report:

Blazing's Natural Medical Spring, Manhattan, Riley County.
Geuda Mineral Springs, Geuda Springs, Cowley County.
Jewell County Lithium Spring, Montrose, Jewell County.
Topeka Mineral Wells, Topeka, Shawnee County.

KENTUCKY.

One of Kentucky's springs has been taken from the list, and of the 5 still remaining all report, as follows:

Anita Springs, Lagrange, Oldham County.
Bedford Springs, Bedford, Trimble County.
Blue Lick Springs, Blue Lick Springs, Nicholas County.
Crab Orchard Springs, Crab Orchard, Lincoln County.
Hecla Magnetic Spring, Louisville, Jefferson County.

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LOUISIANA.

No reports of sales have been received from any of the springs of Louisiana.

MAINE.

Maine loses 2 springs from the list of 1895 and gains 1, leaving the total at 13. Of these 9 report, as follows:

Blue Hill Mineral Spring, Blue Hill, Hancock County.
Cold Bowling Spring, Steep Falls, Limington, York County.
Crystal Mineral Springs, Auburn, Androscoggin County.
Glenwood Mineral Spring, St. Albans, Somerset County.
Keystone Mineral Spring, East Poland, Androscoggin County.
Paradise Spring, Brunswick, Cumberland County.
Pine Spring, Topsham, Sagadahoc County.
Underwood Spring, Falmouth Foreside, Cumberland County.
Windsor Mineral Spring, Lewiston, Androscoggin County.

MARYLAND.

Maryland has 2 springs added to the list, bringing the total up to 7, and of these 6 report, as follows:

Algonquin Springs, Oxen Hill, Prince George County.
Blackiston Island Diuretic Mineral Spring, Blackiston Island, St. Marys County.
Carroll Springs, Forest Glen, Montgomery County.
Chattolanee Springs, Chattolanee, Baltimore County.
Strontia Mineral Spring, Brooklandville, Baltimore County.
Tacoma Springs, Tacoma, Montgomery County.

MASSACHUSETTS.

Two springs have been added to the list for Massachusetts and 5 have been dropped, leaving the total at 24, and of these all but 1 report. The springs reporting are:

Ballardvale Lithia Spring, Lowell, Middlesex County.
Belmont Hill Spring, Everett, Middlesex County.
Belmont Spring, Belmont, Middlesex County.
Burnham Spring, Methuen, Essex County.
Columbia Lithia Spring, Revere, Suffolk County.
Commonwealth Mineral Spring, Waltham, Middlesex County.
Crystal Mineral Spring, Methuen, Essex County.
Chapman's Crystal Spring, Stoneham, Middlesex County.
Diamond Spring, Lawrence, Essex County.
Electric Spring, Lynn, Essex County.
Everett Crystal Spring, Everett, Middlesex County.
Farrington's Silver Spring, Milton, Norfolk County.
Goulding Spring, Whitman, Plymouth County.
Leland Mineral Spring, Lowell, Middlesex County.
Massasoit Spring, Springfield, Hampden County.
Middlesex Mountain Spring, Malden, Middlesex County.
Moose Hill Spring, Swampscott, Essex County.
Nobscot Mountain Spring, Framingham, Middlesex County.
Robbins Spring, Arlington, Middlesex County.
Sheep Rock Spring, Lowell, Middlesex County.
Simpson Spring, South Easton, Bristol County.
Undine Spring, Brighton, Suffolk County.

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MICHIGAN.

Michigan loses 1 spring from the list, and of the 13 still remaining all report for 1896. They are the following:

Americanus Well, Lansing, Ingham County.
Clarke Red Cross Well, Big Rapids, Mecosta County.
Eastman Springs, Benton Harbor, Berrien County.
Magnetic Mineral Spring, Spring Lake, Ottawa County.
Medea Spring, Mount Clemens, Macomb County.
Midland Mineral Springs, Midland City, Midland County.
Mount Clemens Sprudel Water, Mount Clemens, Macomb County.
No-che-mo Mineral Spring, Reed City, Osceola County.
Pagoda Springs, Mount Clemens, Macomb County.
Plymouth Rock Well, Plymouth, Wayne County.
Salutaris Spring, St. Clair Springs, St. Clair County.
Ypsilanti Mineral Spring, Ypsilanti, Washtenaw County.
Zauber Wasser Springs, Hudson, Lenawee County.

MINNESOTA.

Minnesota gains 2 new spring localities, and the 5 with which the State is now credited all report for 1896. They are as follows:

Indian Medical Spring, Elk River, Sherburn County.
Inglewood and Glenwood Springs, Minneapolis, Hennepin County.
Mankato Mineral Spring, near Mankato, Blue Earth County.
Trio Siloam Springs, Austin, Mower County.
Vitalis Mineral Springs, near Lindstrom, Chicago County.

MISSISSIPPI.

There is no change in the list for Mississippi, and of the 6 springs still credited to the State the following 4 report for 1896:

Brown's Wells, Browns Wells, Copiah County.
Castalian Springs, Durant, Holmes County.
Godbold Mineral Well, Summit, Pike County.
Stafford Mineral Springs, near Vosburg, Jasper County.

MISSOURI.

Two springs have been added to the list for Missouri and 1 taken from it, leaving 9 as the total for 1896. Of these all report, as follows:

Albaqua Mineral Springs, St. Joseph, Buchanan County.
B. B. Mineral Springs, Bowling Green, Pike County.
Blue Lick Springs, Blue Lick, Saline County.
Eldorado Springs, Cedar County.
Excelsior Springs, Excelsior Springs, Clay County.
Lineville Mineral Springs, Mercer County, near Lineville, Iowa.
McAllister Springs, McAllister, Saline County.
Randolph Springs, Randolph Springs, Randolph County.
Sweet Springs, Sweet Springs, Saline County.

MONTANA.

Only 1 of Montana's 2 springs reports sales for 1896, viz:

Lissner's Mineral Springs, Helena, Lewis and Clarke County.

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NEBRASKA.

Nebraska reports 1 spring for 1896, viz:

Victoria Mineral Springs, New Helena, Custer County.

NEW HAMPSHIRE.

One spring is dropped from the list, making the total for the State 3. Of these the following 2 report for 1896:

Londonderry Lithia Spring, Londonderry, Rockingham County.
Pack Monadnock Lithia Spring, Temple, Hillsboro County.

NEW JERSEY.

Both the springs credited to New Jersey report for 1896. They are:

Kalium Springs, Collingswood, Camden County.
Pine Grove Mineral Spring, Woodbury, Gloucester County.

NEW MEXICO.

New Mexico's list remains unchanged for 1896. The total is 3, and of these 2 report as follows:

Harsch's Iron Springs, Coyote Canyon, Bernalillo County.
Ojo Caliente Spring, Ojo Caliente, Taos County.

NEW YORK.

There is no change in the number of springs credited to New York. It still remains at 31, 1 spring being dropped and 1 added to the list of 1895. Of these, 27 report for 1896, as follows:

Artesian Lithia Spring, Ballston Spa, Saratoga County.
Avon Sulphur Spring, Avon, Livingston County.
A. D. Ayer Amherst Mineral Springs, near Williamsville, Erie County.
Boonville Mineral Springs, Boonville, Oneida County.
Cayuga Water, Cayuga, Cayuga County.
Colonial Mineral Springs, West Deer Park, Suffolk County.
Deep Rock Springs, Oswego, Oswego County.
Esperanza Mineral Springs, Lake Keuka, Yates County.
Geneva Lithia Spring, Geneva, Ontario County.
Great Bear Spring, Fulton, Oswego County.
Massena Springs, Massena, St. Lawrence County.
Saratoga Springs, Saratoga County:
- Champion Spring.
- Empire Spring.
- Excelsior Spring.
- Hathorn Spring.
- High Rock Spring.
- Old Putnam Spring.
- Patterson Mineral Spring.
- Royal Spring.
- Saratoga Carlsbad Spring.
- Saratoga Kissingen Spring.
- Saratoga Vichy Spring.
- Saratoga Victoria Spring.
- Union Spring.

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Table Rock Mineral Spring, Honeoye Falls, Monroe County.
White Sulphur Springs, Richfield Springs, Otsego County.
White Sulphur Spring, Sharon Springs, Schoharie County.

NORTH CAROLINA.

There is no change in the list for North Carolina. The 8 springs credited to the State all report for 1896. They are:

Ashley Bromine and Arsenic Spring, Ashe County.
Barium Springs, Barium Springs, Iredell County.
Lemon Springs, Lemon Springs, Moore County.
Park's Spring, Caswell County, near Danville, Va.
Panacea Springs, Warren County.
Seven Springs, Seven Springs, Wayne County.
Shaw's Healing Springs, Littleton, Halifax County.
Thompson's Bromine Arsenic Springs, Crumpler, Ashe County.

OHIO.

From Ohio's list 3 springs have been dropped and 1 added. The total for 1896 is 12, and of these the following 11 report:

Crum Mineral Springs, Austintown, Mahoning County.
Crystal Rock Spring, Erie County.
La Fountaine Mineral Springs, Fountain Park, Champaign County.
Magnetic and Saline Spring, Marysville, Union County.
Mustcash Spring, Erie County.
Puritas Mineral Springs, Rockport, Cuyahoga County.
Purtlebaugh Mineral Spring, Urbana, Champaign County.
Rex Mineral Spring, New Richmond, Clermont County.
Sulphur Lick Springs, Anderson, Ross County.
Talewanda Mineral Springs, near College Corner, Preble County.
Wewoka Spring, near Richards Station, Lucas County.

OREGON.

Oregon's list remains the same as in 1895. Of the 3 springs on the list the 2 following report sales in 1896:

Lehman Springs, Ukiah, Umatilla County.
Wilhoit Springs, Wilhoit, Clackamas County.

PENNSYLVANIA.

Two springs are added to the list for Pennsylvania, and 2 are dropped, so the list remains the same as for 1895. Of the 21 springs included the following 16 report for 1896:

Aquatone Mineral Spring, Aquetong, Bucks County.
Black Barren Mineral Spring, Pleasant Grove, Lancaster County.
Bedford Springs, Bedford, Bedford County.
Charmian Springs, Charmian, Franklin County.
Cloverdale Lithia Springs, Newville, Cumberland County.
Cresson Springs, Cresson, Cambria County.
East Mountain Lithia Well, near Factoryville, Wyoming County.
Gettysburg Katalysine Spring, Gettysburg, Adams County.
Parker Mineral Spring, Gardeau, McKean County.
Pavillion Spring, Wernersville, Berks County.

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Ponce de Leon Spring, Meadville, Crawford County.
Pulaski Natural Mineral Springs, Pulaski, Lawrence County.
Rosscommon Springs, Wind Gap, Monroe County.
Saegertown Mineral Spring, Crawford County.
Sizer Mineral Springs, Sizerville, Cameron County.
Tuscarora Lithia Spring, McClaysville, Juniata County.

RHODE ISLAND.

There is no change in the Rhode Island list for 1895, and the 3 springs report sales. They are:

Gladstone Spring, Narragansett Pier, Washington County.
Holly Spring, Woonsocket, Providence County.
Ochee Mineral and Medical Springs, Johnson, Providence County.

SOUTH CAROLINA.

One new spring is added to South Carolina's list, and 3 of the 5 springs credited to the State report sales for 1896. They are:

Chicks Springs, Chicks Springs, Greenville County.
Edisto Springs, Orangeburg, Orangeburg County.
Harris Lithia Springs, Waterloo, Laurens County.

SOUTH DAKOTA.

The one spring locality credited to South Dakota reports sales in 1896 from 3 of its springs.

Hot Springs of South Dakota, Hot Springs, Fall River County.
Min-ne-kahta Spring.
Lakotah Springs.
Mammoth Springs.

TENNESSEE.

Tennessee loses 1 spring and gains 1, leaving the total number the same as in 1895. All 6 springs credited to the State report for 1896. They are:

Dixie Mineral Spring, Knoxville, Knox County.
Estill Springs, Estill Springs, Franklin County.
Idaho Springs, St. Bethlehem, Montgomery County.
Red Boiling Springs, Red Boiling Springs, Macon County.
Rhea Springs, Rhea Springs, Rhea County.
Tate Epsom Springs, Tate Spring, Grainger County.

TEXAS.

Of the 13 springs credited to Texas 10 report sales in 1896. They are:

Capp's Mineral Wells, Longview, Gregg County.
Dalby Springs, Dalby Springs, Bowie County.
Hynson's Iron Springs, Marshall, Harrison County.
Mineral Wells, Mineral Wells, Palo Pinto County.
Montvale Springs, Marshall, Harrison County.
Overall Mineral Wells, Franklin, Robertson County.

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Rosborough Springs, Marshall, Harrison County.
Sour Mineral Spring, near Luling, Caldwell County.
Tioga Mineral Wells, Grayson County.
Wootan Wells, Wootan Wells, Robertson County.

UTAH.

Only 1 of Utah's 3 springs reports sales for 1896, and it is new to the list. It is:

Deseret Lithia Water Springs, Deseret, Millard County.

VERMONT.

Four of Vermont's springs report sales for 1896. They are:

Clarendon Springs, Clarendon Springs, Rutland County.
Equinox Spring, Manchester, Bennington County.
Missisquoi Mineral Springs, Sheldon, Franklin County.
Vermont Mineral Spring, Brookline, Windham County.

VIRGINIA.

Four new localities are added to the list for Virginia, increasing the 34 of 1895 to 38 for 1896. Of these 28 report their sales in 1896. They are the following:

Beaufont Lithia Springs, Beaufont, Chesterfield County.
Bedford Chalybeate Springs, near Bedford City, Bedford County.
Blue Ridge Springs, Botetourt County.
Buffalo Lithia Springs, Buffalo Lithia Springs, Mecklenburg County.
Chase City Mineral Springs, Chase City, Mecklenburg County.
Colonial Springs, near Claybank Wharf, Gloucester County.
Crockett Arsenic Lithia Spring, Shawsville, Montgomery County.
Farmville Lithia Springs, Cumberland County, near Farmville, Prince Edward County.
Harris Anti-Dyspeptic and Tonic Spring, Burkeville, Nottoway County.
Healing Springs, Healing Springs, Bath County.
Hunter's Pulaski Alum Springs, Walkers Creek, Pulaski County.
Iron Lithia Springs, Tip Top, Tazewell County.
Jordan White Sulphur Spring, Stephenson, Frederick County.
Lake Como Lithia Spring, Henrico County.
Magee's Chlorinated Lithia Spring, Clarksville, Mecklenburg County.
Massanetta Springs, Harrisonburg, Rockingham County.
Nye Lithia Springs, Wytheville, Wythe County.
Otterburn Lithia and Magnesia Springs, Amelia, Amelia County.
Pæonian Springs, Loudoun County.
Powhatan Lithia and Alum Springs, Tobaccoville, Powhatan County.
Pine Mountain Springs, Washington County.
Seawright Magnesian Lithia Spring, Staunton, Augusta County.
Seven Springs, near Glade Spring, Washington County.
Swineford's Arsenic Lithia Springs, Osceola, Washington County.
Virginia Magnesian Alkaline Springs, near Staunton, Augusta County.
Virginia Waukesha Lithia Springs, Staunton, Augusta County.
Wallawhatoola Alum Springs, near Millboro Spring, Bath County.
Wolf Trap Lithia Springs, Wolf Trap, Halifax County.

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WASHINGTON.

Two of the 3 springs credited to the State of Washington report sales for 1896. They are:

Cascade Springs, near Cascades, Skamania County.
Medical Lake, Medical Lake, Spokane County.

WEST VIRGINIA.

Of West Virginia's 6 springs 5 report sales for 1896. These are the following:

Capon Springs, Capon Springs, Hampshire County.
Greenbrier White Sulphur Springs, White Sulphur Station, Greenbrier County.
Irondale Spring, Independence, Preston County.
Salt Sulphur Springs, Salt Sulphur Springs, Monroe County.
Triplet Well, Calf Creek, Grant District, Pleasants County.

WISCONSIN.

The total number of springs credited to Wisconsin is 29, which is a net gain of 1 from 1895. One spring has been dropped from the list and 2 new ones have been added. Reports of sales for 1896 have been received from 26, as follows:

Allouez Mineral Springs, Green Bay, Brown County.
Bay City Spring, Ashland, Ashland County.
Bethania Mineral Spring, Osceola, Polk County.
Chippewa Spring, Chippewa Falls, Chippewa County.
Castalia Springs, Wauwatosa, Milwaukee County.
Darlington Mineral Springs, Darlington, Lafayette County.
Fort Crawford Springs, Prairie du Chien, Crawford County.
Lebens Wasser, Green Bay, Brown County.
Nee-Ska-Ra Mineral Spring, Wauwatosa, Milwaukee County.
Rainbow Mineral Spring, Wautoma, Waushara County.
Salvator Springs, Green Bay, Brown County.
Shealtiel Mineral Springs, Waupaca, Waupaca County.
Sheboygan Mineral Spring, Sheboygan, Sheboygan County.
Silver Sand Spring, Milwaukee, Milwaukee County.
Solon Springs, Upper St. Croix Lake, Douglas County.
Sparkling Spring, Wauwatosa, Milwaukee County.
St. John Mineral Spring, Green Bay, Brown County.
Waukesha Springs, Waukesha County:
- Almanaris Springs.
- Arcadian Spring.
- Bethesda Mineral Spring.
- Fountain Spring.
- Horeb Spring.
- Siloam Spring.
- Waukesha Hygeia Mineral Spring.
- Silurian Mineral Spring.
- White Rock Mineral Spring.

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Summary of reports of mineral springs for 1896.

States and Territories.	Springs reporting.	Springs not reporting.	Total used commercially.
NORTH ATLANTIC STATES.			
Maine	9	4	13
New Hampshire	2	1	3
Vermont	4	1	5
Massachusetts	23	1	24
Rhode Island	3	0	3
Connecticut	4	4	8
New York	27	4	31
New Jersey	2	0	2
Pennsylvania	16	5	21
SOUTH ATLANTIC STATES.			
Delaware	0	0	0
Maryland	6	1	7
District of Columbia	1	0	1
Virginia	28	10	38
West Virginia	5	1	6
North Carolina	8	0	8
South Carolina	3	2	5
Georgia	8	0	8
Florida	1	0	1
SOUTH CENTRAL STATES.			
Kentucky	5	0	5
Tennessee	6	0	6
Alabama	3	1	4
Mississippi	4	2	6
Louisiana	0	1	1
Texas	10	3	13
Indian Territory	0	0	0
Arkansas	6	1	7
Oklahoma	0	0	0
NORTH CENTRAL STATES.			
Ohio	11	1	12
Indiana	10	1	11
Illinois	12	4	16
Michigan	13	0	13
Wisconsin	26	3	29
Minnesota	5	0	5
Iowa	5	0	5
Missouri	9	0	9

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Summary of reports of mineral springs for 1896—Continued.

States and Territories.	Springs reporting.	Springs not reporting.	Total used commercially.
NORTH CENTRAL STATES—continued.			
North Dakota	0	0	0
South Dakota	1	0	1
Nebraska	1	0	1
Kansas	4	2	6
WESTERN STATES AND TERRITORIES.			
Alaska	0	0	0
Wyoming	0	0	0
Montana	1	1	2
Colorado	8	0	8
New Mexico	2	1	3
Arizona	0	0	0
Utah	1	2	3
Nevada	0	0	0
Idaho	1	0	1
Washington	2	1	3
Oregon	2	1	3
California	14	6	20
Total	312	65	377

IMPORTS AND EXPORTS.

Prior to 1884 the Treasury Department did not distinguish natural mineral waters from those that were artificial; since 1883 the distinction has been made, but the artificial waters have not been classified according to the receptacles in which they have been imported. The importation is shown in the two tables following, with a table of exports appended.

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Mineral waters imported and entered for consumption in the United States, 1867 to 1883, inclusive.

Fiscal year ended June 30—	In bottles of 1 quart or less.		In bottles in excess of 1 quart.	
	Quantity.	Value.	Quantity.	Value.
	Bottles.		*Quarts.*	
1867	370,610	$24,913	3,792	$360
1868	241,702	18,438	22,819	2,052
1869	344,691	25,635	9,739	802
1870	433,212	30,680	18,025	1,743
1871	470,947	34,604	2,320	174
1872	892,913	67,951	.....	.....
1873	35,508	2,326	.....	.....
1874	7,238	691	.....	.....
1875	4,174	471	.....	.....
1876	25,758	1,899	.....	.....
1877	12,965	1,328	.....	.....
1878	8,229	815	.....	.....
1879	28,440	2,352	.....	.....
1880	207,554	19,731	.....	.....
1881	150,326	11,850	.....	.....
1882	152,277	17,010	.....	.....
1883	88,497	7,054	.....	.....

Fiscal year ended June 30—	Not in bottles.		All not artificial.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Gallons.		*Gallons.*		
1867	.....	$137	.....	.....	$25,410
1868	554	104	.....	.....	20,594
1869	1,042	245	.....	.....	26,682
1870	2,063	508	.....	.....	32,931
1871	1,336	141	.....	.....	34,919
1872	639	116	.....	.....	68,067
1873	355	75	394,423	$98,151	100,552
1874	95	16	199,035	79,789	80,496
1875	5	2	395,956	101,640	102,113
1876	.....	.....	447,646	134,889	136,788
1877	.....	22	520,751	167,458	168,808
1878	.....	.....	883,674	350,912	351,727
1879	3	4	798,107	282,153	284,509
1880	.....	.....	927,759	285,798	305,529
1881	55	26	1,225,462	383,616	395,492
1882	.....	.....	1,542,905	410,105	427,115
1883	.....	.....	1,714,085	441,439	448,493

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Imports for years 1884 to 1896.

Year ended—	Artificial mineral waters.		Natural mineral waters.	
	Gallons.	Value.	Gallons.	Value.
June 30, 1884	29,366	$4,591	1,505,298	$362,651
1885	7,972	2,157	1,660,072	397,875
Dec. 31, 1886	62,464	16,815	1,618,960	354,242
1887	13,885	4,851	1,915,511	385,906
1888	12,752	4,411	1,716,461	341,695
1889	36,494	8,771	1,558,968	368,661
1890	22,328	7,133	2,322,008	433,281
1891	26,700	8,700	2,019,833	392,894
1892	16,052	9,089	2,266,123	497,660
1893	6,086	2,992	2,321,081	506,866
1894	7,753	3,047	1,891,964	417,500
1895	101,115	19,151	2,104,811	506,384
1896	51,108	11,739	2,273,393	551,097

Exports of natural mineral waters of domestic production from the United States.

Fiscal year ended June 30—	Value.	Fiscal year ended June 30—	Value.
1875	$162	1881	$1,029
1876	80	1882	421
1879	1,529	1883	*a* 459
1880	1,486		

a None reported since 1883.

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INDEX.

Page.

Abrasive materials, by Edward W. Parker 1219–1231
Agate 1207
Alabama, clays 1127
  coke 693
  limestone 1047
  mineral waters 1376
Allegheny Mountain coke district, Pennsylvania 721
Allegheny Valley coke district, Pennsylvania 726
Amber 1212
Amethyst 1204
Analyses, asphalt 926, 932, 937, 939
  asphalt oil 938
  brick (fire) 1120
  brownstone 1029, 1030
  cement material 1174
  clays 1128, 1146, 1147–1168
  feldspar 1366
  fuller's earth 1352, 1355, 1356, 1359
  gilsonite 940
  granite 958, 962, 963, 964, 965, 968, 969, 970, 973, 975
  gypsum 1270
  lime 1066
  limestone 1047, 1048, 1054, 1059, 1060, 1061, 1063, 1065, 1067, 1068
  marble 963, 985–986, 990
  natural gas 912, 915
  petroleum 842
  phosphate rock 1240
  sandstone 1015, 1022, 1023, 1024
  slate 998, 999, 1001, 1004
  turquoise 1211
Appalachian oil field, extension of 764
  prices in 777
  production of 770
  shipments from 774
  stocks in 776
  well records in 782
Arizona, brownstone 1031
  limestone 1048
  marble 987
  sandstone 1015
Arkansas, cement 1174
  limestone 1048
  mineral waters 1376
  natural gas 916
Asbestos, by Edward W. Parker 1323–1331
  Canada 1325
  imports 1324
  Italy 1326
  methods of mining and dressing 1329
  occurrences 1325

Page.

Asbestos, production 1323, 1324
  South Africa 1331
  uses 1326
Asphalt, analyses 926, 932, 937–939, 940
  production from petroleum 922
Asphalt deposits of western Texas, by T. Wayland Vaughan 930–935
Asphalt oil, analyses 938
Asphaltum, by Edward W. Parker 919–948
  California 919, 920, 923, 925
  Colorado 919, 920, 935
  fossils found in 927
  France 945
  Germany 946
  imports 922
  Indian Territory 919
  Kentucky 919, 929
  Oklahoma 929
  production by States 923
  Texas 919, 920, 929
  Trinidad 946
  Utah 919, 920, 935
  varieties produced 921
Austria-Hungary, petroleum 857
Barbadoes, asphalt, analysis 939
Barytes, by Edward W. Parker 1348–1350
Baumé hydrometer scale with corresponding specific gravities 893
Beaver coke district, Pennsylvania 726
Bechelbronn asphalt, analyses 937, 939
Bedford [Indiana] oölitic limestone, by T. C. Hopkins and C. E. Siebenthal 1050
Beryl and emerald 1203
Bituminous rock, California 925
  production 921
  Texas 931
Blossburg coke district, Pennsylvania 729
Brick and tile production, by States 1077
Brick (building), tests 1112–1117
  (common), production and price, by States 1079, 1084, 1094
  (fancy or ornamental), value, by States 1081, 1084
  (fire), analyses, tests, and specific gravities 1119, 1120
  (fire), value, by States 1081, 1084
  (paving), tests 1107–1112, 1117–1119
  (pressed), production and price, by States 1079, 1084, 1094, 1095
  (vitrified paving), production and price, by States 1081, 1084, 1095
Broad Top coke district, Pennsylvania 723
Brownstone, analyses 1027, 1029, 1030
  colors and general properties 1026
  methods of quarrying and handling 1037

www.libtool.com.cn

Page.

Brownstone, mineralogical composition. 1032
occurrence 1037
(Pennsylvania), paper by T. C. Hopkins, on 1025-1043
quarries in the New Red area 1039
structural and textural features 1033
tests 1034-1036
uses 1038
Buhrstones 1219
Burma, ruby 1197
sapphire 1202
Byerley, F. H., quoted on process of obtaining asphalt from petroleum 922
California, asphaltum 919, 925
clays 1130
fossils found in asphaltum of 927
granite 957
limestone 1048
marble 978
mineral waters 1376
natural gas 912
petroleum 841
salt 1309
sandstone 1016
slate 997
Canada, asbestos 1325
grindstones 1225
natural gas 916
petroleum 851
soapstone 1075
C. C. and white granite ware, production by States 1100
Cement, analyses 1174
imports 1171, 1181
Cement, natural rock, by Uriah Cummings 1178-1182
Cement, Portland, by Spencer B. Newberry 1169-1177
Chrysolite 1204
Chrysoprase 1207
Cincinnati coke district, Ohio 709
Clay, analyses 1120, 1128, 1146-1168
active and idle plants, by States 1096
Alabama 1127
California 1130
Colorado 1131
deposits of, by States 1127-1146
imports 1103
imports for use in American pottery 1102
Indiana 1138
Iowa 1139
literature 1146
("mineral soap"), Wyoming 1146
Missouri 1140
New York 1144
Ohio 1145
pottery 1120
Seger's cones for testing firing of 1124
specific gravities of 1120
structural materials made of 1105
tests 1107-1112, 1117-1119, 1122, 1129, 1143, 1144
use for tile making 1106
vitrified wares of 1137
Wyoming 1145
Clay products, brick (common), production and price, by States 1079, 1084, 1094

Page.

Clay products, brick (fancy or ornamental), value, by States 1081, 1084
brick (fire), value, by States 1081, 1084
brick (pressed), prices, by States 1079, 1084, 1095
brick (vitrified paving), prices and production, by States 1081, 1084, 1095
C. C. and white granite ware, production, by States 1100
draintile, value, by States 1081, 1084
earthenware, value, by States 1100
fireproofing, value, by States 1082, 1087
imports 1104
miscellaneous products, value, by States 1082, 1087
porcelain electrical supplies, value by States 1101
porcelain or china, value, by States 1101
pottery, production and value, by States 1099
rank of States in output from 1894 to 1896 1090, 1098
Rockingham ware, value, by States 1100
sanitary ware, value, by States 1101
sewer pipe, value, by States 1082, 1087
stoneware, value, by States 1100
terra cotta, ornamental, value, by States 1082, 1087
tile (not drain), value, by States 1082, 1087
yellow and Rockingham ware, value, by States 1100
Clay-working industry in 1896, by Heinrich Ries 1105-1168
Clay-working industry in the United States in 1896, statistics of, by Jefferson Middleton 1077-1104
Clearfield Center coke district, Pennsylvania 722
Coal, amount and value used in the manufacture of coke 680, 686
amount required to produce a ton of coke 683
amount used in the manufacture of coke 661-663
condition in which charged into ovens in coke manufacture 689
kind used in the manufacture of coke, by States 689
kind used in the manufacture of coke in West Virginia 739
percentage yield of, in the manufacture of coke 684
value of amount displaced by natural gas 903
yield of in coke 661-663
Coal measures, Indiana, section of 1138
Coke, by Edward W. Parker 659-746
Alabama 693
Alleghany Mountain district, Pennsylvania 721
Allegheny Valley district, Pennsylvania 726
amount of coal used in the manufacture of 686
Beaver district, Pennsylvania 726
Blossburg district, Pennsylvania 729

www.libtool.com.cn

	Page.
Coke, Broad Top district, Pennsylvania	723
character of coal used in manufacture of, by States	689
Cincinnati district, Ohio	709
Clearfield Center district	722
coal consumed in manufacture of	680
coal required to produce a ton of	683
Colorado	695
condition in which coal is charged into ovens for making	689
Connellsville district, Pennsylvania	717
establishments for making	661-663
Georgia	697
Greensburg district, Pennsylvania	729
imports	692
Illinois	699
increase and decrease of production	665
Indiana	700
Indian Territory	702
Irwin district, Pennsylvania	730
Kanawha district, West Virginia	741
Kansas	703
Kentucky	704
Missouri	705
Montana	706
New Mexico	707
New River district, West Virginia	741
New York	708
number of ovens built and building	661-663, 669, 671
number of works	667
Ohio	708
Pennsylvania	711
percentage derived from coal	661-663,
percentage yield of coal used in the manufacture of	684
Pittsburg district Pennsylvania	724
Pocahontas-Flat Top district, West Virginia	740
production by States	661-663
production from 1880 to 1886	672
rank of States in production	674
Reynoldsville-Walston district, Pennsylvania	727
Tennessee	731
Texas	732
Upper Connellsville district, Pennsylvania	721
Upper Monongahela district, West Virginia	742
Upper Potomac district, West Virginia	743
Utah	732
value and average selling price of	676
value and prices	661-663
Virginia	733
Washington	734
West Virginia	736
Wisconsin	744
Wyoming	745
Coking industry by States	693
Colorado, asphaltum	919, 920, 935
clays	1131-1138
coke	695
fuller's earth	1353
granite	957
Colorado, limestone	1049
marble	978
mineral waters	1376
natural gas	915
petroleum	840
sandstone	1017
Connecticut, brownstone, analyses	1030
feldspar	1365
granite	957
limestone	1049
mineral waters	1377
sandstone	1017-1021
Connellsville coke district, Pennsylvania	717
Corundum and emery	1227
Cryolite	1316
Cummings, Uriah, on rock cement	1178-1182
Day, William C., on stone	949-1068
Derbyshire, England, petroleum production	871
Delaware, granite	960
Diamond-mining industry in South Africa	1185
Diamonds	1183
artificial	1190
genesis of	1121
New South Wales	1188
outfit for miner or prospector for	1189
South Africa	1185
Wisconsin	1183
District of Columbia, mineral waters	1377
Draintile, value by States	1081, 1084
Earthenware, value, by States	1100
Eastern or southern Ohio petroleum district	818
Ecuador, petroleum	892
Electricity, stone quarrying and working by	957
Emerald	1203
Emery. (*See* Corundum and emery.)	
England, fuller's earth, analyses	1356
Exports, mineral waters	1387
petroleum	756
petroleum, from Russia	890
salt	1285
Feldspar and quartz, by Heinrich Ries	1365-1368
Feldspar, analyses	1366
Connecticut	1365
Maine	1365
Missouri	1365
New York	1366
Pennsylvania	1367
production, by States	1367
used in American pottery	1102
Fibrous talc	1071
Fire clays, analyses	1150-1155
Fireproofing, value, by States	1082, 1087
Flint (quartz) used in American pottery	1102
Florida, fuller's earth	1356
limestone	1049
mineral waters	1377
phosphate rock	1237
Fluorspar and cryolite, by Edward W. Parker	1315-1316
Fossils found in asphaltum in California	927
France, asphaltum	946
pyrites	1259

www.libtool.com.cn

Page.

Franklin Institute (Journal of), quoted on gilsonite 937
Fuller's earth 1351
analyses 1352, 1355, 1356, 1359
Colorado 1353
development and production 1351
Florida 1356
Georgia 1359
Indian Territory 1354
Nebraska 1353
new discoveries 1361
New Mexico 1354
New York 1354
South Dakota 1351
Galicia, ozocerite 946
petroleum 857
Garnet 1204
production for abrasive purposes 1231
Gem literature 1215
Gems, use of 1213
Genesee, New York, salt district 1295
Georgia, coke 697
fuller's earth 1359
granite 960
limestone 1049
marble 980
mineral waters 1377
slate 997
slate, analysis 998
Germany, asphaltum, production 946
petroleum 869
Gilsonite, analyses 940
chemistry of 937
dry distillation of 941
production 935
Granite 951-975
analyses and tests ... 958-965, 968-970, 973-975
California 957
Colorado 957
Connecticut 957
crushing tests 958-961
Delaware 960
electric and pneumatic quarrying and working 957
Georgia 960
Maine 961
Maryland 962
Massachusetts 964
mineral composition 964
Minnesota 966
Missouri 966
Nevada 969
New Hampshire 969
New Jersey 970
New York 970
North Carolina 970
Oregon 971
paving blocks of, value, by States 952
Pennsylvania 973
Rhode Island 974
South Carolina 974
South Dakota 974
value and uses 951, 954, 956
Vermont 974
Virginia 974
Wisconsin 974

Page.

Graphite 1332
Great Britain, petroleum 871, 872
slate 1010
Greensburg coke district, Pennsylvania. 729
Grindstones 1222
Canada 1224
imports 1223
production 1222
Gypsum, by Edward W. Parker 1263-1271
analyses 1270-1271
imports 1268
Kansas 1269
occurrence 1263
production 1265-1267
Hones and whetstones 1224
imports 1227
Hopkins, T. C., on the Bedford (Indiana) oölitic limestone 1050-1057
on Pennsylvania brownstones 1025-1043
Idaho, limestone 1049
marble 980-987
mineral waters 1377
sandstone 1022
Illinois, coke 699
limestone 1049
mineral waters 1377
natural gas 911
petroleum 850
sandstone 1022
Imports, asbestos 1324
asphaltum 922
barytes 1349
buhrstones 1221
cement 1181
clay 1103
clay products 1104
coke 692
cryolite 1316
emery 1228
graphite 1332
grindstones 1223
gypsum 1268
hones and whetstones 1227
lithographic stone 1363
mica 1318
mineral paints 1340
mineral waters 1387
natural gas 918
ocher 1340
petroleum, into Japan 879
phosphate rock 1242
pyrites 1260
salt 1283-1288
soapstone 1074
sulphur 1248
umber 1341
white lead 1346
India, petroleum, production by districts. 876
Indiana, brownstone, analyses 1030-1031
clay deposits 1138
coal measures, section 1138
coke 700
limestone 1049
limestone, analyses 1054
limestone, tests 1053
mineral waters 1378

www.libtool.com.cn

	Page.
Indiana, natural gas	907
petroleum	828
sandstone	1022
Indian Territory, asphaltum	919
coke	702
fuller's earth	1354
petroleum	850
Infusorial earth, occurrence	1229
production	1229
Iowa, clay deposits	1139
limestone	1058
marble	980
mineral waters	1378
sandstone	1023
Irwin coke district, Pennsylvania	730
Italy, asbestos	1326
petroleum	873
Ithaca, New York, or Southern salt district	1295
Jadeite	1211
Japan, petroleum	877
Java, petroleum	879
Kanawha coke district, West Virginia	741
Kansas, coke	703
gypsum	1270
limestone	1058
mineral waters	1378
natural gas	911
petroleum	847
salt	1306
sandstone	1023
Kaolin, analyses	1148–1149
Kentucky, asphaltum	919, 929
coke	704
limestone	1058
mineral waters	1378
natural gas	910
petroleum	767, 838
Killebrew, J. B., quoted on Tennessee phosphates	1238
Kunz, George F., on precious stones	1183–1217
Lead (pig) prices	1347
Lewis, H. Carvill, quoted on the genesis of the diamond	1191
Lima, Indiana, petroleum field, pipe line runs in	809
prices in	812
shipments from	810
Lima, Ohio, petroleum district	807
well records in	813
Lima, Ohio and Indiana, petroleum field	803
Lime, analyses	1066
Limestone	1043
Alabama	1047
analyses and tests	1047, 1048, 1049, 1050, 1053, 1054, 1058, 1059, 1060, 1061, 1063, 1065, 1067, 1068
Arizona	1048
Arkansas	1048
California	1048
Colorado	1049
Connecticut	1049
Florida	1049
Georgia	1049
Idaho	1049
Illinois	1049
Indiana	1049
Limestone, Iowa	1058
Kansas	1058
Kentucky	1058
Maine	1058
Maryland	1058
Massachusetts	1059
Michigan	1059
Minnesota	1060
Missouri	1060
Montana	1061
Nebraska	1061
New Jersey	1061
New York	1061
Ohio	1063
Pennsylvania	1064
Rhode Island	1066
South Carolina	1066
South Dakota	1066
Tennessee	1066
Texas	1066
Utah	1067
value and uses	1044
Vermont	1067
Virginia	1067
Washington	1067
West Virginia	1067
Wisconsin	1068
Lithographic stone	1361
imports	1363
occurrence	1361
prices	1362
Louisiana, mineral waters	1379
salt	1296, 1298
sulphur	1243
Macksburg, Ohio, petroleum district	827
Maine, feldspar	1365
granite	961
limestone	1058
mineral waters	1379
slate	998
Maracaibo asphalt, analysis	939
Marble	975
analyses and tests	981, 982, 983, 985–986, 990
Arizona	991
California	978
Colorado	978
Georgia	980
Idaho	980
Iowa	980
Maryland	980
Massachusetts	980
new discoveries	986–992
New York	981
Pennsylvania	981
Tennessee	981
Utah	991
value by uses and States	975, 977
Vermont	984
West Virginia	992
Maryland, granite	962
limestone	1058
marble	980
mineral waters	1379
sandstone	1023
slate	998

www.libtool.com.cn

	Page.
Massachusetts, brownstone	1030
granite	964
limestone	1059
marble	980
mineral waters	1379
slate	999
Mecca-Belden (Ohio) petroleum district	827
Metallic paint	1341
Mica, by Edward W. Parker	1317–1321
imports	1318
producing States in 1896	1320
production	1317
review of industry	1319
uses	1318
Michigan, brownstone	1031
cement, Portland	1175
limestone	1059
mineral waters	1380
salt	1303
sandstone	1023
Middleton, Jefferson, on the statistics of the clay-working industry in the United States in 1896	1077–1104
Milano petroleum district, Italy, production, refined products	875
Mineral soap clay, Wyoming	1145
analyses	1146
Mineral paints, by Edward W. Parker	1335–1347
imports	1340
metallic paint	1341
ocher, umber, and sienna production, by States	1337
production	1336
slate ground as pigment for	1343
venetian red	1343
white lead	1344
Minerals used as pigments	1335
Mineral waters, by A. C. Peale	1369–1389
Mineral water, Alabama	1376
Arkansas	1376
California	1376
Colorado	1376
commercial springs (list)	1376
Connecticut	1377
District of Columbia	1377
exports	1387
Florida	1377
Georgia	1377
Idaho	1377
imports	1387
Illinois	1377
Indiana	1378
Iowa	1378
Kansas	1378
Kentucky	1378
Louisiana	1379
Maine	1379
Maryland	1379
Massachusetts	1379
Michigan	1380
Minnesota	1380
Mississippi	1380
Missouri	1380
Montana	1380
Nebraska	1381
New Hampshire	1381

	Page.
Mineral water, New Jersey	1381
New Mexico	1381
New York	1381
North Carolina	1382
Ohio	1382
Oregon	1382
Pennsylvania	1382
production, 1883 to 1896, by geographical divisions	1372–1375
production, by States	1369–1371
Rhode Island	1383
South Carolina	1383
South Dakota	1383
springs (list)	1376
summary of reports from springs	1386
Tennessee	1383
Texas	1383
Utah	1384
Vermont	1384
Virginia	1384
Washington	1385
West Virginia	1385
Wisconsin	1385
Minnesota, brownstone	1031
granite	966
limestone	1060
mineral waters	1380
sandstone	1023
slate	999
Mississippi, mineral waters	1380
Missouri, clays	1140
coke	705
feldspar	1365
feldspar, analyses	1366
granite	966
limestone	1060, 1061
mineral waters	1380
natural gas	916
petroleum	849
sandstone	1023
Montana, coke	706
limestone	1061
mineral waters	1380
sandstone	1023
sapphire	1199
National Brick Makers' Association, tests of paving brick made by	1108–1112
Natural gas, by F. H. Oliphant	895–916
analyses	912, 915
Arkansas	916
California	912
Canada	916
Colorado	915
consumption and distribution	901
Illinois	911
imports	918
Indiana	907
Kansas	911
Kentucky	910
Missouri	916
New York	913
Ohio	907
Pennsylvania	905
record, by States	905
record of wells and amount of pipe lines	904

www.libtool.com.cn

	Page.
Natural gas, records in 1895 and 1896	901
rock pressure in Indiana wells	908
tests of	898
Texas	916
uses	904
Utah	915
value of coal and wood displaced by	903
value of amount consumed	900
West Virginia	914
Nebraska, fuller's earth	1353
limestone	1061
mineral waters	1381
Nevada, granite	969
Newberry, J S., quoted on Maine granite	961
New Hampshire, granite	969
mineral waters	1381
New Jersey, brownstone	1030
granite	970
limestone	1061
mineral waters	1381
sandstone	1024
slate	1000
New Mexico, coke	707
fuller's earth	1354
mineral waters	1381
New River coke district, West Virginia	741
New South Wales, diamond fields in	1188
New York, clays	1144
coke	708
feldspar	1366
fuller's earth	1354
granite	970
limestone	1061
marble	981
mineral waters	1381
natural gas	913
petroleum	764
petroleum (*see* Pennsylvania-New York oil field)	790
sandstone	1024
salt	1290
slate	1000
talc	1072
North Carolina, brownstone	1030
granite	970
mineral waters	1382
ruby	1197
sandstone	1024
Ocher	1337
Ohio, cement, Portland	1175
clay	1145
coke	708
limestone	1063
mineral waters	1382
natural gas	907
oilstones	1224
petroleum	803
salt	1361
sandstone	1025
Oklahoma Territory, asphaltum	929
fuller's earth	1355
Oliphant, F. H., on natural gas	895–916
on petroleum	747
Opal	1208
Oregon, granite	971
Oregon, mineral waters	1382
Ozocerite, Galicia	946
Parker, Edward W., on abrasive materials	1219–1231
on asbestos	1323–1331
on asphaltum	919–948
on barytes	1348–1350
on coke	659–746
on fluorspar and cryolite	1315–1316
on gypsum	1263–1271
on mica	1317–1321
on mineral paints	1335–1347
on salt	1273–1313
on soapstone	1069–1075
on sulphur and pyrites	1243–1261
Paving brick clays, analyses	1167–1168
Paving brick tests	1107–1112, 1117–1119
Peale, A. C., on mineral waters	1369–1389
Pennsylvania, brownstones	1025–1043
coke	711
feldspar	1367
granite	973
lime	1066
limestone	1064
marble	981
mineral waters	1382
natural gas	905
sandstone	1025
slate	1000
Pennsylvania-New York oil field, drilling wells in	799
production	790
shipments from	797
Peru, petroleum	891
Petroleum, by F. H. Oliphant	747–893
analyses	842
Appalachian field	764
asphalt from	922
Austria-Hungary	857
Banmé hydrometer scale with corresponding specific gravities for testing	893
California	841
Canada	851
Colorado	840
Ecuador	892
England	871
exports	756
foreign markets	759
Galicia	857
Germany	869
Great Britain	871
Illinois	850
important features, 1896	747
India	876
Indiana	828
Indian Territory	850
Italy	873
Japan	877
Java	879
Kansas	847
Kentucky	767, 838
Lima (Ohio) field	803, 813
Lima-Indiana field	809
Missouri	849
New York	764

www.libtool.com.cn

Page.

Petroleum, Ohio ... 803
Pennsylvania-New York ... 790
Peru ... 891
prices ... 777
production, Appalachian field ... 770-772
production, by countries, States and districts ... 750, 757, 764
production, by fields ... 751
production—increase or decrease—by States ... 751
Roumania ... 865
Russia ... 883
shipments ... 774
stocks ... 776
Sumatra ... 880
Tennessee ... 769, 835
Texas ... 848
total production ... 747
West Virginia ... 765, 799
Wyoming ... 846
Phosphate rock ... 1233-1242
analysis ... 1240
Florida ... 1237
imports ... 1242
South Carolina ... 1234
Tennessee ... 1238
Pigment, minerals used as ... 1335
slate used as ... 1343
Pipe clays, analyses ... 1156
Pittsburg coke district, Pennsylvania ... 724
Pocahontas-Flat Top coke district, West Virginia ... 740
Porcelain or china, value, by States ... 1101
Porcelain electrical supplies, value, by States ... 1101
Portland cement. (*See* Cement.)
Pottery and pottery clays ... 1120
Pottery, chromolithography in ... 1121
materials used in America, by States. 1102
production and value, by States ... 1077, 1099
raw materials ... 1121
Pottery clays, analyses ... 1156-1158
Precious stones, by George F. Kunz ... 1183-1217
literature ... 1215
production ... 1217
use of ... 1213
Pyrites, consumption ... 1261
France ... 1259
imports ... 1260
occurrences ... 1261
production ... 1259
Spain ... 1259
world's product and sulphur displaced ... 1260
Quartz ... 1204, 1367
(flint) used in American pottery ... 1102
Quartz crystal ... 1231
Reynoldsville-Walston coke district, Pennsylvania ... 727
Ries, Heinrich, on the clay-working industry in 1896 ... 1105-1168
on feldspar and quartz ... 1365-1368
Rhode Island, granite ... 974
limestone ... 1066
mineral waters ... 1383
Rockingham ware, value, by States ... 1100

Page.

Roumania, petroleum ... 865
Ruby, North Carolina ... 1197
Russia, petroleum ... 883
Salt, by Edward W. Parker ... 1273-1313
California ... 1309
establishments and processes ... 1276
imports and exports ... 1282, 1288
Kansas ... 1306
Louisiana ... 1296
Michigan ... 1303
New York ... 1290
Ohio ... 1301
production, by States and grades ... 1273, 1374, 1278, 1281
review of the industry ... 1281
supply for domestic consumption ... 1282
Texas ... 1309
Utah ... 1312
West Virginia ... 1298
Salt making in the United States, history of ... 1288-1313
Sandstone ... 1012-1043
analyses and tests ... 1015, 1022, 1023, 1024
Arizona ... 1015
California ... 1016
Colorado ... 1017
Connecticut ... 1017
Idaho ... 1022
Illinois ... 1022
Indiana ... 1022
industry in various States ... 1015
Iowa ... 1023
Kansas ... 1023
Maryland ... 1023
Michigan ... 1023
Minnesota ... 1023
Missouri ... 1023
Montana ... 1023
New Jersey ... 1024
New York ... 1024
North Carolina ... 1025
Ohio ... 1025
Pennsylvania ... 1025
South Dakota ... 1043
Tennessee ... 1043
tests of ... 1017-1023, 1043
Texas ... 1043
Utah ... 1043
value of product, by States ... 1012, 1013-1014
Washington ... 1043
West Virginia ... 1043
Wisconsin ... 1043
Wyoming ... 1043
(*See* Brownstone).
Sanitary ware, value, by States ... 1101
Santa Barbara County, California, bituminous rock deposits ... 925
Sapphire, Burma ... 1202
Montana ... 1199
Seger's cones ... 1124, 1125
Sewer pipe, value, by States ... 1082, 1087
Sicilian sulphur, exports, by countries ... 1255
imports ... 1256, 1257
prices ... 1247
Siebenthal, C. E., on the Bedford [Indiana] limestone ... 1050-1057

www.libtool.com.cn

Page.

Sienna 1337
Slate 992
amount ground for pigment 1343
analyses and tests 998–1001, 1002–1008
California 997
Georgia 997
Great Britain 1010
industry, by States 997
Maine 998
Maryland 998
Massachusetts 999
Minnesota 999
New Jersey 1000
New York 1000
Pennsylvania 1000
roofing, average price per square 993
Tennessee 1001
value of product, by States 993
Vermont 1001
Virginia 1002
Wales 1009
Smithsonite 1212
Smyth, jr., C. H., quoted on talc deposits of St. Lawrence County, N. Y 1072
Soapstone, by Edward W. Parker 1069–1075
annual product since 1880 1071
Canada 1074
imports 1074
occurrence 1069
production 1069
South Africa, asbestos 1331
diamond-mining industry in 1185
South Carolina, granite 974
limestone 1066
mineral waters 1383
phosphate rock 1254
South Dakota, granite 974
fuller's earth 1351
limestone 1066
mineral waters 1383
sandstone 1043
Southern Ohio petroleum district 821
Spain, pyrites, exports 1259
Stone, by William C. Day 949–1068
granite 951–975
limestone 1043–1068
marble 975–992
sandstone 1012–1043
slate 992–1012
use of electricity in quarrying and working 957
use of pneumatic tools and compressed air in quarrying and working 957
value of product, by kinds 949
value of product, by States 950
Stoneware, value, by States 1100
Sulphur and pyrites, by Edward W. Parker 1243–1261
Sulphur, domestic consumption 1244
imports 1248
Louisiana 1243
production 1243
production since 1880 1244
review of the industry 1245
(Sicilian) prices and shipments 1247, 1255, 1256, 1257

Page.

Sulphur, Texas 1243
Utah 1243
Sumatra, petroleum 880
Syria, asphalt, analysis 939
Talc (fibrous) distribution by uses 1071
New York 1072–1074
(*See* Soapstone)
Tennessee, coke 731
limestone 1066
marble 981
mineral waters 1383
petroleum 769, 835
phosphate rock 1238
slate 1001
sandstone 1043
terra cotta (ornamental), value, by States 1082, 1087
Texas, asphaltum 919, 932
bituminous rock, asphaltum content of 934
coke 732
limestone 1066
mineral waters 1383
natural gas 916
petroleum 848
salt 1309
sandstone 1043
sulphur 1243
Tile, drain. (*See* Draintile.)
Tile, not drain, value, by States 1082, 1087
Topaz 1203
Tourmaline 1204
Trinidad asphalt, analysis 939
exports 947
statistics 946
Tripoli 1231
Turquoise 1209
analysis 1211
Umber 1337–1341
Upper Connellsville coke district 721
Upper Monongahela coke district, West Virginia 742
Upper Potomac coke district, West Virginia 743
Utah, asphaltum 919, 920, 935
coke 732
limestone 1067
marble 991
mineral waters 1384
natural gas 915
salt 1312
sandstone 1043
sulphur 1243
Vaughan, T. Wayland, on asphalt deposits of western Texas 930–935
Venetian red, production 1343
Vermont, granite 974
limestone 1067
marble 984
mineral waters 1384
slate 1001
Virginia, coke 733
granite 974
limestone 1067
mineral waters 1384
slate 1002
Wales, slate quarries of 1009

www.libtool.com.cn

	Page.
Wardite	1211
Warsaw, New York, salt district	1294
Washington, coke	734
limestone	1067
mineral waters	1385
sandstone	1043
Welsh slate quarries	1009
West Virginia, coke	736
limestone	1067
marble	992
mineral waters	1385
natural gas	914
petroleum	765, 799
salt	1298
sandstone	1043
Whetstones and oilstones	1224
White lead	1344–1347
Wisconsin, coke	744
diamonds	1183
granite	974
limestone	1068
mineral waters	1385
sandstone	1043
World's product of iron pyrites and amount of sulphur displaced	1260
Wyoming, clays	1145
coke	745
mineral soap clay	1145, 1146
petroleum	846
sandstone	1043
Yellow and Rockingham ware, value, by States	1100

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