PART I. VOL. XXVIII.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

SESSION 1902-1903.

SOLD AT THE ROOMS OF THE SOCIETY,
QUEEN'S CHAMBERS, 5, JOHN DALTON STREET, MANCHESTER.

MDCCCCIII.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL & MINING SOCIETY.

EDITED BY

THE HONORARY SECRETARIES.

VOLUME TWENTY-EIGHTH.

PARTS I.—XXI.

FOR SESSIONS 1902-3, AND 1903-4.

MANCHESTER:
SOLD AT THE ROOMS OF THE SOCIETY,
5, JOHN DALTON STREET, MANCHESTER.
MDCCCCV.

*** The writers of papers alone are responsible for the facts and opinions contained in their respective communications.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART I. VOL. XXVIII. SESSION 1902-1903.

The ANNUAL MEETING of the Members was held on Tuesday, October 14th, 1902, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

MR. JONATHAN BARNES, F.G.S., President,
in the Chair.

NEW MEMBERS.

The following gentlemen were unanimously elected members of the Society, namely :—

Mr. ARTHUR RUSHTON, Manager, Chisnall Hall Colliery, Coppull, near Wigan.

Mr. JAMES EVANS, Britannia Works, Cross Street, Salford.

Mr. RALPH ANDERSON JONES, Colliery Surveyor, 13, Douglas Terrace, Carley Road, Southwick-on-Wear.

THE ANNUAL REPORT OF THE COUNCIL AND TREASURER'S STATEMENT.

Mr. WILLIAM SAINT, one of the Honorary Secretaries, read the Report of the Council, for the Session 1901-1902, as follows :—

REPORT OF THE COUNCIL,

FOR THE SESSION 1901-2.

The Council have pleasure in presenting their Sixty-fourth Annual Report which shows that the Society is maintained in a satisfactory and prosperous condition.

Sixteen new members have been elected during the year.

Twelve members have resigned, and the names of ten have been removed from the list under Rule XII.

Your Council regret to record the loss, by death, of three members, namely: John Ainsworth, David Shaw, and William Turner.

The Society now consists of :—

Honorary Members..	9
Life Members	11
Ordinary Members	206
Total	226

During the past year eight meetings were held in the Society's Rooms, 5, John Dalton Street, Manchester; and one extra Special Meeting was held in January at the Owens College by the kind permission of the Governors of the College, when an interesting and instructive lecture was delivered by Mr. James Stirling on "The Mineral Resources of the State of Victoria, in the Commonwealth of Australia."

Owing to the apparent lack of interest on the part of the members, judged by the few attendances, in the two monthly meetings formerly held in the Mining School, Wigan, it has been considered advisable to hold them in future in the Society's Rooms in Manchester.

Mr. Barnes, the President, instead of giving the usual Presidential Address, has read before the Society during the session no less than three papers on geological subjects, two of which have been illustrated by diagrams.

Papers and short communications on geological subjects have also been contributed by Mr. Joseph Dickinson, Mr. G. H. Kinahan, and Mr. William Pickstone; and on mining and allied subjects by Mr. Thomas Aspinall, Mr. Joseph Dickinson, Mr. John Gerrard, Mr. James Grundy, Mr. J. W. Hutchinson, Mr. William Pickstone, Mr. James Stirling, and Mr. Alfred J. Tonge.

Various fossils and specimens of minerals were exhibited from time to time by Mr. Jonathan Barnes, Mr. John Gerrard, and Mr. William Saint.

A complete list of the papers and short communications read during the session is appended.

Mr. Mark Stirrup, at the request of the Council, very kindly undertook to represent the Society at the meeting of the British Association, held in Belfast.

Two Excursions were made by the members and their friends. One, on July 5th, under the leadership of the President, Mr. Barnes, to examine the strata found between Edale and Castleton, in Derbyshire; the other, on August 2nd, to the Hulton Colliery Company's mines, near Chequerbent, under the leadership of Mr. Alfred J. Tonge. About forty of the members and their friends attended, and they were shown a variety of new steam and electrical plant in motion, on the surface and belowground, including a steam turbine driving a ventilating fan and also generating electricity, modern winding engines, coal-cutting by disc machines, and lighting by electricity; also a series of experiments with an improved hydraulic cartridge, which has been introduced throughout the company's mines for the purpose of bringing down the coal, thus entirely dispensing with the use of explosives for that purpose.

The Council tender the thanks of the Society to the authors of the various papers, and also to the Governors of the Owens College for the use of the Lecture Theatre on the occasion of Mr. Stirling's lecture in January last.

The usual presentations from kindred Societies and others with whom we exchange transactions and periodicals continue to be received, and these, together with the Library, are available for reference by the Members on week days between the hours of 9-30 a.m. and 5-30 p.m., except on Saturday, when the rooms are closed at 1 p.m.

Members are reminded that under the Rules of the Society books may be borrowed from the Library for a month, and that on application to the Honorary Secretaries they may be obtained by parcel post at the risk and expense of the members requiring them.

Your Council have recently appointed a small Library Committee to collect funds and to undertake the work of selecting a list of modern standard books on Mining and Geological Subjects, with a view to purchase, in order to bring the Library up-to-date; also for the purpose of arranging for the binding of a large number of serial publications, such as journals and transactions of various corresponding societies, so as to make them available for easy reference by the members. This work will necessarily entail considerable expense, and with the view of avoiding a heavy drain on the funds of the Society, the Council would be pleased to receive voluntary contributions of suitable books and donations from members and others who desire to aid the Society in these objects.

The Council earnestly invite your individual co-operation in providing papers, and by taking part in the discussion thereon, as a means of advancing the interests of the Society; also in the introduction of new members to take the place of those lost through various causes.

The arrangement by which the subscriptions of the members are now received, on behalf of the Honorary Treasurer, at the Society's Rooms has proved to be entirely satisfactory.

The financial position of the Society continues to be satisfactory, as will be seen by an examination of the Treasurer's balance-sheet hereto appended.

In conclusion, your Council desire to state that they feel that many of those who are interested, both scientifically and practically in mining, and in the geology of the district, do not give such support to the Society, the objects of which are Geology and Mining, as it is entitled to, and they trust that the members generally will endeavour to bring the Society to the notice of their friends, and assist in maintaining it on a firm basis.

MANCHESTER GEOLOGICAL SOCIETY.—ABSTRACT OF ACCOUNTS FOR THE YEAR 1901-2.

Dr. / Cr.

1901. Receipts.	£	s.	d.	£	s.	d.
Sept. 30.—To Balance in Bank				47	6	3
1902.						
Sept. 30.— ,, Balance in hands of Secretaries				1	1	5
,, Members' Subscriptions:—						
Current	160	0	0			
Arrears	40	10	0			
				200	10	0
To Dividends:—						
Birkenhead Railway	22	11	6			
Lancashire & Yorkshire Railway	20	13	8			
				43	5	2
,, Bank Interest				0	9	10
,, Hire of Rooms				4	0	0
,, Sales of Transactions				1	0	6
				£297	13	2

1902. Payments.	£	s.	d.
Sept. 30.—By Rent, Wages, and Expenses of Rooms	90	12	8
,, Printing Transactions	30	8	6
,, Circulars and Stationery	8	12	6
,, Postages, &c.	12	12	5
,, Reporters	10	10	0
,, Library	9	8	5
,, Sundry Expenses, Insurance, &c.	4	0	9½
,, Balance in Bank	130	15	11
,, ,, in Secretary's hands	0	11	11½
	£297	13	2

BALANCE SHEET, 30th September, 1902.

Dr. / Cr.

Liabilities.	£	s.	d.
To Outstanding Accounts:—			
John Roberts & Sons	68	6	9
J. E. Cornish	0	4	6
Manchester Corporation	0	9	2
	£69	0	5
,, Balance in favour of Society	2060	17	5½
	£2129	17	10½

Assets.	£	s.	d.
By £600 Birkenhead Railway Consolidated Preference Stock Guaranteed	783	0	0
,, £733 Lancashire & Yorkshire Railway 3% Consolidated Preference Stock	685	10	0
,, Library and Furniture, say	500	0	0
,, Cash in Bank	130	15	11
,, ,, in hands of Secretaries	0	11	11½
,, Arrears of Subscriptions, £85, say	30	0	0
	£2129	17	10½

The Investments consist of £600 Birkenhead Railway Consolidated Stock (Guaranteed), and £733 Lancashire & Yorkshire Railway 3 per cent. Consolidated Preference Stock. The Certificates for these are deposited at the Williams Deacon and Manchester and Salford Bank, St. Ann's Street Branch, Manchester, and were inspected by us this 13th October, 1902. (Signed) JON. BARNES, GEO. H. WINSTANLEY.

Audited and found correct, October 13th, 1902,

JON. BARNES,
GEO. H. WINSTANLEY, } Auditors.

GEO. H. HOLLINGWORTH,
Honorary Treasurer.

ELECTION OF OFFICERS.

The PRESIDENT said: As usual, the Council have prepared a list of members of the Society whom they recommended for election to fill the various offices, subject to the approval of the Meeting.

The Officers of the Society, for the ensuing year, were appointed as follows:—

Mr. JOSEPH DICKINSON moved, and Professor BOYD DAWKINS seconded, that Mr. Henry Hall, I.S.O., one of H.M. Inspectors of Mines, be appointed President for the Session.

The proposal was unanimously adopted.

On the motion of Mr. JOHN RIDYARD, seconded by Mr. WILLIAM SAINT, the following were unanimously elected to be Vice-Presidents:—

Messrs. John Gerrard, H.M.I.M.: Lionel B. Wells, M.Inst.C.E., G. B. Harrison, H.M.I.M., and John Ashworth, C.E.

Mr. G. H. Hollingworth, F.G.S., was re-elected to the office of Honorary Treasurer.

On the motion of Mr. J. ASHWORTH, seconded by Mr. W. A. RITSON, Messrs. William Saint, H.M.I.M., and James Tonge, junr., F.G.S., were re-appointed to be Honorary Secretaries.

On the motion of Professor BOYD DAWKINS, seconded by Mr. W. SAINT, the following gentlemen were appointed members of the Council in addition to the above-named Officers, namely :—

Messrs. H. S. Atherton, W. F. Holroyd, J. W. Hutchinson, D. H. F. Matthews, A. Miller, W. W. Millington, A. Dury Mitton, W. W. Ollerenshaw, George Peace, W. Pickstone, John Rigby, and A. J. Tonge.

The Past Presidents continue, under the Rules, *ex-officio* members of the Council.

On the proposition of Mr. W. Saint, seconded by Mr. G. B. Harrison, Mr. J. Barnes, F.G.S., and Mr. G. H. Winstanley were re-elected Honorary Auditors.

Mr. Dury Mitton moved a vote of thanks to the retiring President (Mr. J. Barnes) and the officers who had acted during the past year. He was sure the Society had had great help from the President in every possible way. Mr. Barnes had given every attention and encouragement to the Society.

Professor Boyd-Dawkins, in seconding the resolution, said he looked forward to Mr. Barnes taking quite as keen an interest in the work of the Society after he vacated the chair as he had manifested during his occupancy of the presidential office.

The resolution having been heartily adopted,

Mr. Barnes acknowledged the compliment which had been tendered to him and the other officers. As for himself, he would probably go on in the future as he had done in the past. He had a lot of work on hand, and some of it would be brought before the Society during the coming year.

LIST OF PAPERS AND SHORT COMMUNICATIONS

WHICH HAVE BEEN BROUGHT BEFORE THE

SOCIETY DURING THE SESSION 1901-02.

1901.

November. Dickinson, Joseph, F.G.S. "Lead Mining Districts of the North of England and Derbyshire." Reminiscences by.

December. Pickstone, William. "On the Coal Measures in the Parishes of Prestwich and Bury, illustrated by a Cross Station between Ringley and Bury."

1902.

January. Dickinson, Joseph, F.G.S. "On Prevention of Accidents by falls of roof and sides in Coal Mines." A Review.

Kinahan, G. H., M.R.I.A. "On some Irish Laccolithic Hills."

February. Barnes, Jonathan, F.G.S. "On a Metamorphosed Limestone at Peak Forest."

Gerard, John. "A Pagoda Stone from China."

March. Barnes, Jonathan. F.G.S. "On a change in the Mineral deposit in a stream passing through the Yoredale Shales, near Mam Tor."

Grundy, James, H.M.I.M. in India "On Indian Mines and Mining People."

Pickstone, William. "On the National Interest in the future Coal Supply."

April. Barnes, Jonathan, F.G S. "Further observations of the changes brought about by the intrusion of igneous matter into the Limestone at Peak Forest."

Dickinson, Joseph, F.G.S. "Blackpool and the subsoil."

May. Tonge, Alfred J. "On the erection and a few tests of a Steam Turbine, Ventilating Fan, and Generator at Hulton Collieries."

June. Hutchinson, J. W. "On experiments with Duplicate Ventilating Fans at Bamfurlong Colliery."

NEW ORDINARY MEMBERS.

Bouchier, C. F.	Brewerton, J.
Chapman, C. Hughes.	Coleman, W. H.
Cotterill, W. B.	Flatters, A.
Garton, W. E.	Hewitt, J.
Latham, D.	Lea, W.
Matchim, T. H.	Salisbury, S.
Smethurst, W. A.	Stocks, F. W.
Scott, E. Kilburn.	Wall, Capt. A.

MEMBERS DECEASED.

Ainsworth, J.	Shaw, David
Turner, W.	

MEMBERS RESIGNED.

Bancroft, R.	Bennett, S. B.
Cooper, S.	Brooks, The Hon. W.
Grant, F.	Lawson, C. A.
Jobson, H.	Oliver, S. A.
Lindsey, C. R.	Scott, E. Kilburn
Settle, W.	Southworth, T.

MEMBERS REMOVED FROM THE LIST.

Aldred, J.	Bennett, F. F.
Caldwell, J. S.	Hayward, J.
James, Isaac	McCallam, Theo. S.
Orchard, A. J. A.	Scholes, T.
Slee, J.	Woodeson, W.
Thom, J.	

MINERAL PRODUCTION IN INDIA.

Mr. James Grundy, H.M. Inspector of Mines in India, read the following summary of statistics of mineral production in India for the ten years 1892 to 1901, issued by the Director General of Statistics:—

Salt.—The production of salt in India averages about a million tons annually, fluctuating from time to time with the seasons. Last year the production was 1,190,000 tons. In 1900 the production at the Sambhar lake was extremely small, but with a better season manufacture in 1901 was very active. The largest proportion of the salt produced in India is, however, sea salt made on the coast in Sind, Bombay, Madras, Burma, and at Aden. The quantity so made on the Indian coasts in 1901 represented two-thirds of the whole production.

Coal.—This industry is expanding so rapidly from year to year that a statement of the average production over a series of years would not convey a true idea of the conditions. The output has increased from 3,540,000 tons in 1895 to 6,636,000 tons in 1901. Coal is found of varying quality over a very extensive area of the Indian region. At present the principal mines are located in the Ranigunj district in Bengal, at Singareni in the Nizam's territory, in the Lakhimpur district in Upper Assam, at Mohpani and Warora in the Central Provinces, and at Umaria in the Central Indian Agency. Indian coal is now extensively, in some places exclusively, employed for the railways, coasting and river steamers, mills and factories; but, as in the case of salt, the conditions of transport are not yet sufficiently developed, though they are being greatly improved, to permit of the exclusive use of Indian coal for industrial purposes. The quantity of Indian coal used in

India is therefore supplemented by an importation which has averaged 280,000 tons annually in the last five years. Imported coal is mostly landed in Bombay, the mills in that place requiring large quantities of fuel, and being too remote from the Indian sources of supply to find the use of Indian coal economical, having regard to the easy conditions on which steamers carry coal to India as freight. Most of the imported coal is English, a small quantity being received also from Japan.

Gold.—Gold is produced mostly in the mines of the Kolar district in Mysore, where the annual output now exceeds half a million ounces. From the mines in the Nizam's territory only a small quantity has been extracted as yet. No account is taken in these tables of the gold produced in parts of Northern India from the washings of river sands; it is well known that it is entirely insignificant, but there are no means of stating the quantity statistically. The aggregate reported production in 1901 is 531,766 ounces, the value of which may be taken to represent, at £4 an ounce, about two millions sterling. It is all shipped to London.

Petroleum.—The production, which is confined to Burma and Assam, amounted to 50 million gallons in 1901, more than 49 million gallons being of Burman production. Although the production has expanded very largely, it is still insufficient for the requirements of the Indian market, which are met by the importation of some 81 million gallons from the United States and Russia. The exports of Burma petroleum last year were :—

	Gallons.
To foreign countries	37,241
,, Indian ports	18,688,009

It should be borne in mind, however, that the Indian production is stated in terms of crude petroleum, while the imports consist of kerosene and lubricating oil.

Saltpetre.—This article, which is largely produced for export, was in former years of much greater importance than now, the decline in the demand for gunpowder and the preservation of food, with the competition of the nitrates, having operated to prevent an expansion of the exports. It is most largely produced in Bihar, whence the article is sent to Calcutta for export after refinement. The average production is stated to amount to only about 251,000 cwt., of which 209,000 cwt., are reported to have been made in Bengal, that is, in Bihar. But the production is grossly understated, for the average annual exports of refined saltpetre from Calcutta in the last five years have amounted to 370,398 cwt., and this represents a much larger quantity of crude saltpetre.

Iron.—The production of iron is as yet quite in its infancy, the ore being worked for the most part only in the Ranigunj district of Bengal, where it occurs in close proximity to the coalfields. According to the figures which, however, are of doubtful accuracy, the production amounted to only 63,000 tons, of which 57,000 tons were produced in Ranigunj. For the adequate utilisation of the iron ores of Bengal and other parts of India, the application of very large capital is necessary for the manufacture of wrought-iron and steel in the forms in which these metals are mainly used in India, and the prospects of such an enterprise have not hitherto seemed sufficiently decided to induce capitalists to venture on the sinking of the great sums of money required for work on the extensive scale which alone would be remunerative.

Graphite (*Plumbago*).—In the State of Travancore there are four mines from which graphite was extracted in 1901-02 to the amount of 2,490 tons. No information has been given of the quality of the graphite. It is doubtless exported, but no particulars of the trade have been furnished, nor are the capabilities of the mines known.

Other Minerals.—These are relatively of small economic importance, manganese ore, mica, and tin ore alone being of commercial importance. The production of manganese commenced a few years ago, the product being shipped to England. It is all exported, but it does not seem to be a quickly expanding trade: the exports last year were 133,170 tons. The extraction of mica has been an industry in Bengal for a considerable period, and recently this mineral has been worked in Madras in some quantity. This is also mainly exported, the exports last year being 815 tons. Tin mining has been carried on for many years by Chinese in Lower Burma, but their operations have not indicated any tendency to expand, and the trade is trifling. It is practically all used in India.

Mr. Grundy, in replying to a few questions, said he thought nine-tenths of the oil used to light the mines was kerosene oil, and more than that proportion for household purposes. Iron ore was found very near the surface. Limestone was likewise got near the surface.

Mr. Dickinson said he had much pleasure in moving that the thanks of the Society be given to Mr. Grundy for the present contribution, supplementing the paper which he gave on the resources and the mines of India some few months ago. He was pleased to add that he was credibly informed that Mr. Grundy had been before the India Board, and they had pronounced him now thoroughly restored to health, and he would next month set out again for his useful duties in India as H.M. Inspector of Mines.

Professor Boyd-Dawkins said he begged to second the vote of thanks, and to offer his congratulations to Mr. Grundy on his improved health. He hoped Mr. Grundy would be able to send the Society one or two more papers in the future about India.

Mr. Henry Hall said it was satisfactory to know in these days, when one heard so often that we had little coal left, that there was an abundance of the mineral in India. He had learned more about Indian statistics by hearing Mr. Grundy in the few minutes occupied by the reading of the summary than he had learned at any time previously.

The resolution was passed.

Mr. Pickstone asked how it was that so much oil was imported from America, when oil of good quality was obtainable in Burma.

Mr. Grundy replied that some of the native-got oil was refined.

The following is the complete list of the Council for the ensuing year :—

President:

HENRY HALL, I.S.O., H.M.I.M.

Vice-Presidents:

JOHN GERRARD, H.M.I.M. | JOHN ASHWORTH, C.E.
LIONEL B. WELLS, M.Inst.C.E. | GEO. B HARRISON, H.M.I.M.

Ex-Officio Vice-Presidents;

R. CLIFFORD SMITH, F.G.S.
The Right Hon. the EARL OF CRAWFORD & BALCARRES.
LORD SHUTTLEWORTH OF GAWTHORPE.
EDWARD PILKINGTON, J.P.
Professor W. BOYD DAWKINS, M.A., F.R.S., F.G.S.
JOSEPH DICKINSON, F.G.S.
HENRY HALL, H.M.I.M. | JOHN S. BURROWS, F.G.S.
JAMES TONGE, F.G.S., Assoc.M.Inst.C.E.
W. SAINT, H.M.I.M. | MARK STIRRUP, F.G.S.
ROBERT WINSTANLEY, C.E. | JOHN RIDYARD, F.G.S
W. WATTS, F.G.S. | W. S. BARRETT, J.P.
G. C. GREENWELL, M.Inst.C.E., F.G.S.
JONATHAN BARNES, F.G.S.

Hon. Treasurer.

G. H. HOLLINGWORTH, F.G.S.

Hon. Secretaries:

WILLIAM SAINT, H.M.I.M. | JAMES TONGE, Jun., F.G.S.

Other Members of the Council:

H. STANLEY ATHERTON. | D. H. F. MATHEWS, H.M.I.M.
W. F. HOLROYD, F.G.S. | A. MILLER.
J. W. HUTCHINSON. | W. W. MILLINGTON.
A. DURY MITTON, Assoc.M.Inst.C.E.
W. OLLERENSHAW. | WILLIAM PICKSTONE.
GEORGE PEACE. | JOHN RIGBY.
ALFRED J. TONGE.

Library Committee:

JOHN ASHWORTH. | H. STANLEY ATHERTON. | L. B. WELLS.

Hon. Auditors;

J. BARNES, F.G.S. | GEO. H. WINSTANLEY, F.G.S.

Trustees:

JOS. DICKINSON, F.G.S. | LEES KNOWLES, M.A., LL.D., M.P.

PAST PRESIDENTS OF THE SOCIETY.

Year of Election.	
1838-39-40	Egerton, The Rt. Hon. Francis, M.P.
1841-2-3, 49-50-1	Heywood, James, F.R.S., F.G.S.
1843-4-5, 55-6-7	Egerton, Sir Philip de Malpas Grey, Bart, M.P.
1845-46-47	Moseley, Sir Oswald, Bart.
1847-48-49	Thicknesse, Ralph, M.P., Wigan.
1851-52-53	Black, James, M.D., F.G.S.
1853-54-55	Ormerod, G. W., M.A., F.G.S.
1857-8-9, 65-6-7	Binney, E. W., F.R.S., F.G.S.
1859-60-61	Kay-Shuttleworth, Sir, J.P., Bart., M.P.
1861-3, 77-8, 87-8	Dickinson, Joseph, F.G.S.
1863-64-65	Knowles, Andrew.
1867-8-9, 84-5	Greenwell, G. C., F.G.S., M.Inst.C.E.
1869-70-1, 82-3	Aitken, John, F.G.S.
1871-2-3, 88-9	Knowles, John, M.Inst.C.E., J.P.
1873-74	Knowles, Thomas, M.P.
1874-5, 6-7, 86-7	Dawkins, Prof. W. Boyd, M.A., F.R.S., F.G.S.
1875-76	Smith, R. Clifford, F.G.S.
1878-79	Forbes, John Edward, F.G.S.
1879-80	Lindsay, Lord, F.R.S.
1880-81	Shuttleworth, Lord, of Gawthorpe.
1881-82	Gilroy, George, M.Inst.C.E.
1883-84	Pilkington, Edward, J.P.
1885-86	Ormerod, Henry Mere, F.G.S.
1889-90	Hall, Henry, H.M.I.M.
1890-91	Burrows, John S., F.G.S.
1891-92	Tonge, James, F.G.S., Assoc.M.Inst.C.E.
1892-93	Peace, Maskell William, F.G.S.
1893-94	Saint, William, H.M.I.M.
1894-95	Watts, William, F.G.S.
1895-96	Winstanley, Robert, C.E.
1896-97	Stirrup, Mark, F.G.S.
1897-98	Ridyard, John, F.G.S.
1898-99	Livesey, Clegg, J.P.
1899-1900	Barrett, W. S., J.P.
1900-01	Greenwell, G. C., F.G.S., M.Inst.C.E.
1901-02	Barnes, J., F.G.S.

APPENDIX TO THE REPORT.

ADDITIONS TO THE LIBRARY, 1901-1902.

To September 30th, 1902.

Barnsley.—Midland Institute of Mining, Civil, and Mechanical Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Belfast.—Natural History and Philosophical Society. Report and Proceedings for Session 1900-01. *From the Society.*

Birmingham.—South Staffordshire and East Worcestershire Institute of Mining Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Birmingham.—British Geological Photographs (set of twenty-two Platinotypes, mounted). *Purchased.*

Bradford.—Annual Report (31st) of Libraries and Art Museum Committee.

Bristol.—Naturalists' Society. Proceedings. New Series, Part 3, Vol. IX.

Cambridge.—Museum. 36th Annual Report Museums and Lecture Rooms' Syndicate for 1901; also Annual Report of the Library, 1901. *From the Woodwardian Museum.*

Cardiff.—Naturalists' Society. Report and Transactions for 1900-01. Vol. XXXIII. *From the Society.*

Cardiff.—South Wales Institute of Engineers. Proceedings. Nos. 6, 7, 8, Vol. XXII. No. 1, Vol. XXIII. *From the Institute.*

Chester.—31st Annual Report of Chester Society of Natural Science and Literature for 1901. *From the Society.*

Chesterfield and Midland Counties Institute of Engineers.—Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Dublin.—Royal Dublin Society. Proceedings. Parts 3, 4, Vol. IX. Scientific Transactions. Parts 8, 9, 10, 11, 12 and 13, Vol. VII. (2nd Series). *From the Royal Irish Academy.*

Hamilton.—Mining Institute of Scotland. Transactions. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Hanley.—North Staffordshire Institute of Mining and Mechanical Engineers. Proceedings. Parts 6, 7, 8, 9, 10, Vol. XV. *From the Institute.* See also Transactions of the Institution of Mining Engineers.

Hertford.—Hertford Natural History Society and Field Club. Transactions. Part 9, Vol. X. Parts 1, 2, 3, 4, Vol. XI. *From the Society.*

ings. Part 2, Vol. XIV.

Leeds.—Literary and Philosophical Society. Annual Report, 1901.

Leicester.—Literary and Philosophical Society. Transactions. Parts 1, 2, 3, Vol. VI., New Series. *From the Society.*

Liverpool.—Geological Society. Proceedings. Part 1, Vol. IX.

Liverpool.—Public Libraries and Art Galleries. 49th Annual Report, 1901.

London.—British Association for the Advancement of Science. Reports for 1901. Belfast and its Adjacent Counties, Guide to. *From the Association.*

London.—British Museum. Catalogue of Fossil Fishes. Part 4, 1901.

London.—Geological Magazine. (New Series.) Decade IV. Nos. 10, 11, 12, Vol. VIII. Nos. 1-9, Vol. IX. *Purchased.*

London.—Geological Society. Quarterly Journal. No. 228, Vol. LVII. Nos. 229, 230, 231, Vol. LVIII. Geological Literature added to the Geological Society's Library, 1901. *From the Society.*

London.—Geologists' Association. Proceedings. Parts 4, 5, 6, Vol. XVII. Parts 1, 2, 3, Vol. XVIII. List of Members of the Geologists' Association. *From the Association.*

London.—Institution of Mechanical Engineers. Proceedings. Nos. 3, 4, 5, 1901. Nos. 1, 1902, and List of Members. *From the Institution.*

London.—Iron and Coal Trades' Review. Nos. 1753 to 1765, Vol. LXIII. Nos. 1766 to 1791, Vol. LXIV. Nos. 1792 to 1804, Vol. LXV.

London.—Iron and Steel Institute. Journal. Vols. LX. and LXI. Index to Volumes XXXVI. to LVIII. 1890-1900. *From the Institute.*

London.—Palaeontographical Society. Vol. LV., for 1901. *Purchased.*

London.—Royal Society. Proceedings. Nos. 451 to 458, Vol. LXIX. Nos. 459 to 466, Vol. LXX., and the Reports of the Malaria Committee for 1901 and 1902. Report of the Evolution Committee, No. 1. *From the Society.*

London.—Royal Institution of Great Britain. Proceedings. Nos. 2, 3. Vol. XVI.

London.—The Colliery Guardian. Nos. 2127 to 2139. Vol. LXXXII. Nos. 2140 to 2165, Vol. LXXXIII. Nos. 2166 to 2178, Vol. LXXXIV.

London.—The Mining Journal. Nos. 3450 to 3462, Vol. LXXI. Nos. 3463 to 3501, Vol. LXXII.

Manchester.—Literary and Philosophical Society. Memoirs and Proceedings. Parts 1, 2, 3, 4, 5, 6, Vol. XLVI. *From the Society.*

Manchester. Geographical Society. Journal. Nos. 7 to 9, Vol. XVII., and Supplement. Nos. 1 to 3, Vol. XVIII. *From the Society.*

Manchester.—Field Naturalists Society. Report and Proceedings for the year 1901.

Manchester.—The Owens College Museum. Report for the year 1900 and 1901. Publication. Nos. 34, 36, 37, 38. *From the College.*

Newcastle-upon-Tyne.—Institution of Mining Engineers. Transactions. Nos. 5, 6, Vol. XX. Nos. 4, 6, Vol. XXI. Nos. 1, 2, 3, 4, Vol. XXII. Parts 1, 2, 3, 4, 5, Vol. XXIII. Mechanical Ventilators. By M. Walton Brown. *From the Institution.*

Newcastle-upon-Tyne.—North of England Innstitute of Mining and Mechanical Engineers. Transactions. Included in the Transactions of the Institution of Mining Engineers; Annual Report, 1900-01; also Subject Matter, Index of Mining, Mechanical and Metallurgical Literature for the year 1900. *From the Institute.*

Penzance.—Royal Geological Society of Cornwall. Transactions. Part 7, Vol. XII.

Rochdale.—Literary and Scientific Society. Twenty-third Annual Report, 1901. *From the Society.*

Salford.—The Fifty-third Annual Report of Libraries, Museum, and Parks Committee for the Borough of Salford, 1900-1901.

Stafford.—North-Staffordshire Field Club. Transactions, Vol. XXXVI. *From the Club.*

Truro.—Royal Institution of Cornwall. Journal. No. 1, Vol. XV. 1902.

Wigan.—Science and Art of Mining. Nos. 4 to 26, Vol. XII. Nos. 1 to 3, Vol. XIII.

BOOKS, PAMPHLETS, AND REPORTS.—ENGLISH AND FOREIGN.

Mines and Quarries. Part 4, 1900; Part 1, 1901; also H.M. Inspector's Report of Mines and Quarries for the S. W. District for 1901. London. *Presented by Mr. Joseph S. Martin.*

H.M. Inspector's Report of Mines and Quarries for the Liverpool and North Wales District (No. 7). *Presented by Mr. Henry Hall.*

The Fish River Bush, South Africa, by Mr. T. Black, F.R.C.S. (Ed.), F.G.S. (Ed.) *Presented by the Author.*

Twelve Papers by Prof. J. Branner, Stanford University, California.

Glacial and Post-Glacial Features of the Lower Valley of the Lune and its Estuary, by T. Mellard Read, C.E., F.G.S., F.R.I.B.A.; with list of Foraminifera, by J. Wright, F.G.S. *Presented by Mr. T. Mellard Reade.*

Papers. *Presented by W. Whittaker, B.A., F.R.S., F.G.S., &c.* On Earthquake-Sounds, by C. Davidson, D.Sc., F.G.S. A White-Hot Liquid Earth and Geological Lime, by Prof. James Geikie, D.C.L., LL.D., F.R.S. Manifestation en L'Honneur De M. G. Dewalque, Secretaire General Honarairi, La Société Geologique Belgique. Le Science Minérales devant les jurys des prix quinquennaux des Science Naturelles, par G. Dewalque. Rapport du jury chargé de décerner, en 1897 le prix décennal des Sciences Minérales (période de 1892-1897).

Oxford Historical Map of Modern Europe, No. 30. *From the Delegate of the Press.*

Cape of Good Hope.—Annual Report of the Geological Commission, 1898 and 1899. *From the Commissioners.*

Coal-Cutting by Machinery in Great Britain. *Colliery Guardian* series of Handbooks, No. 15. *From the Colliery Guardian.*

Edinburgh.—Field Naturalists Quarterly. No. 1, Vol. I. *From the Publisher.*

Adelaide.—Record of the Mines, South Australia.

Mines of South Australia, Tarcoola, North Western District, with Plans.

Queensland Government Mining Journal. The Year Book of Queensland. *Presented by the Agent-General for Queensland.*

Review of Reviews for Queensland. Part 18, Vol. II., and Handbook of Tasmania. *Presented by the Agent-General for Tasmania.*

Mineral Resources of New South Wales. *Presented by the Agent-General for New South Wales.*

India.

Calcutta.—Memoirs of the Geological Survey of India. Nos. 3, 4, Vol. XXX.; Nos. 1, 2, 3, Vol. XXXI.; Nos. 1, 2, Vol. XXXII.; No. 2, Vol. XXXIII.; No. 1, Vol. XXXIV.; and General Report of Geological Survey, April 1st, 1900, to March 31st, 1901. *From the Director of the Survey.*

Australia.

Adelaide.—Royal Society of South Australia. Transactions. Parts 1, 2, Vol. XXV. *From the Society.*

Brisbane.—Annual Report of the Under Secretary for Mines. Queensland, 1901.

Melbourne.—The Australian Mining Standard. Nos. 667 to 685, Vol. XX.; Nos. 686 to 711, Vol. XXI.; No. 712 to 718, Vol. XXVIII. *From the Editor.*

Sydney.—Australasian Association for the Advancement of Science. Vol. VIII., 1901.

Sydney.—Geological Survey of New South Wales: Department of Mines. Records. Part 2, Vol. VII. Mineral Resources, Nos. 9, 10. *From the Hon. the Minister of Mines.*

Sydney.—Royal Society of New South Wales. Journal and Proceedings. Vol. XXXIV.

Sydney.—Mineral Resources of New South Wales, and Annual Report of the Department of Mines and Agriculture for the year 1900. Handbook to the Mining and Geological Museum, Sydney. *From the Hon. the Minister of Mines.*

Canada.

Hamilton.—Hamilton Association. Journal and Proceedings for 1899-1900. No. 17. *From the Association.*

Houghton, Michigan.—Michigan College of Mines. Year-Book, 1901-1902.

Ottawa.—Canadian Mining Institute. Journal. Vol. IV.

Ottawa.—Geological Survey of Canada. Annual Report, 1898. Vol. XI. Index to Reports, 1863-1884. Catalogue of Canadian Birds, Part 1. Catalogue of the Marine Invertibrata of Eastern Canada. Contributions to Canadian Palæontology. Part 2, Vol. II.; Part 2, Vol. IV.

St. John, New Brunswick.—Natural History of New Brunswick. Part 5, Vol. IV. *From the Society.*

Toronto.—Canadian Institute. Proceedings. Part 13, Vol. VII., and Vol. VII. *From the Institute.*

Toronto.—Bureau of Mines. Report for 1902.

U. S. AMERICA.

Cambridge.—Harvard College. Bulletin of the Museum of Comparative Zoology. No. 3, Vol. XXXVII.; No. 6; Vol. XXXVIII.; Nos. 1, 3, Vol. XXXIX.; Nos. 1, 2, Vol. XL. Annual Report of the Museum of Comparative Zoology for 1900-1901. Memoirs, No. 1. Vol. XXV. *From Alex. Agassiz.*

Cambridge.—Harvard College. Geological Series. No. 6. Vol. 5.

Chicago.—Field Columbian Museum. Geological Series, Nos. 9, 10. Vol. I. Report Series, No. 1, Vol. II. Zoological Series, No. 2, Vol. II.; Nos. 4, 5, Vol. III. *From the Museum.*

Iowa.—Geological Survey of. Vol. XI. *From the Director of the Survey.*

Madison.—Wisconsin Geological and Natural History Survey. Bulletin. No. 7; No. 4 Economic Series.

Minneapolis—The American Geologist. Nos. 4, 5, 6, Vol. XXVIII., Nos. 2, 3, 4, 6, Vol. XXIX., and Nos. 1, Vol. XXX. *Purchased.*

New York.—The American Museum of Natural History. Bulletin No. 4, Vol. XI.; Vol. XIX.; No. 1, Vol. XV.; No. 2, Vol. XVII.; also Annual Report for 1901. *From the Museum.*

New York.—American Institute of Mining Engineers. Pamphlets. List of Members, Officers, Rules, &c., 1902.

New York.—Stone.—Nos. 2, 3, 4, 5, 6, Vol. XXIII; Nos 1, 2, 3, 4, 5, Vol. XXIV. *Presented by the Publisher.*

Philadelphia.—Franklin Institute. Journal. Nos. 4, 5, 6, Vol. CLII.; Nos. 1, 2, 3, 4, 5, 6, Vol. CLIII.; Nos. 1, 2, 3, Vol. CLIV. *From the Institute.*

Philadelphia.—Academy of Natural Sciences. Proceedings. Parts 2, 3, 1901; Part 1, 1902. *From the Academy.*

Philadelphia.—American Philosophical Society. Proceedings. Nos. 166, 167, 168, Vol. XL.; No. 169, Vol. XLI., and Memorial Volume I.

Scranton, Pa.—"Mines and Minerals." Nos. 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, Vol. XXII.; Nos. 1, 2, Vol. XXIII. *From the Editor.*

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FOREIGN.

Basil.—Naturforschenden Gesellschaft: Verhandlungen. No. 2, Vol. XIII.

Berlin.—Gesellschaft für Erdkunde: Zeitschrift, Nos. 3, 4, 5, 6, Vol. XXXVI., Verhandlugen, Nos. 7, 8, and 9, Vol. XXVIII; Nos. 1, 2, 3, 4, 5, 6, 1902. *From the Society.*

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft, Nos. 2, 3, 4, Vol. LIII; No. 1, Vol. LIV. Zeitschrift der Deutschen Geologischen Gesellschaft in den Jahrin 1884-1898 mit eimim Lebensabriss Von Ernst Beyrick. *From the Society.*

Buenos Ayres.—Demografic Argentine. Bulletin. Part 7.

Buenos Ayres.—Comunicaciones del Museo Nacional de Buenos Ayres. Part 10, Vol. I.

Caen.—Sociétè Linnéenne de Normandie (5th Series), Vol. IV. *From the Society.*

Copenhagen.—Dansk Geologisk Forening. Meddelelser. Nos. 7, 8.

Dresden.—" 8 Isis," January—June, 1901. *Presented by Naturwissenschaftliche Gesellschaft Isis.*

Freiburg.—Naturforschenden Gesellchaft, Berichte. Vol. XII.

Iglo.—Jahrbuch des Ungarischen Karpathen-Vereines. No. XXIX.

Halle A/S.—Mittelungen der Vereins für Erdkunde zu Halle A/S. 1901.

Halle A/S.—Kaiser. Leopold Carol, Akademie der Naturforscher. Monograph. Nos. 35, 36, 37.

Helsingfors.—Commision Gëologique de Finlande. Bulletins, Nos. 12, 13.

Kazan.—La Societe des Naturalistes de l'University de Kazan. Nos. 1-5. Vol. XXXV., Vol. XXXVI., Nos. 5, 6, Vol. XXXVIII.

Keiff (Russia).—La Société des Naturalistes. Memoirs. No. 2, Vol. XVI.

Lausanne.—Société Vaudoise. Bulletins, Nos. 141, 142, Vol. XXXVII.

Lille.—Société Géologique du Nord. Annales, Vol. XXIX., 1900.

Mexico.—Sociedad Científica "Antonio Alzate." Memorias Y. Revista. Nos. 1, 2, Vol. XIII. Nos. 7, 8, 9, 10, 11, 12, Vol. XV. Nos. 1, 2, 3, 4, 5, 6, Vol. XVI.

Mexico.—Institute Geologies des Mexico Boletins. No. 15.

Montevideo.—Annales del Museo Nacional. Nos. 21, 22, Vol. III.

Naples.—Rendiconti dell' Accademia della Scienze Fisiche e Mathematiche. Parts 8, 9, 10, 11, 12, Vol. VII. Parts 1, 2, 3, 4, 5, 6, 7, Vol. VIII. *From the Academy.*

Paris.—Société Gèologique de France. Bulletin. No. 6, Vol. XXVI. Nos. 1, 2, 3, 4, Vol. I. (4th Series). No. I, Vol. II. *From the Society.*

Pisa.—Atti della Societa Toscana. Bulletin. Vol. XVIII.

Pisa.—Societa Toscana de Scienze Naturale. Vols. XIII., XIV.

Rome.—Atti della Reale Accademia dei Lincei. Rendiconti. Nos. 6, 7, 8, 9, 10, 11, 12, 2nd Series, Vol. X. Nos. 1, 2, 3, 4, 5, 6, 7, 8, 8, 10, 11, 12, 1st Series, Vol. XI. Nos. 1, 2, 3, 4, 5, 2nd Series, Vol. XI. Rendiconto.—Dell' Adunanza Del, 1 Geugno, 1901-1902. *From the Academy.*

St. Petersburg.—Comité Geologique. Bulletin. Nos. 7-10, Vol. XIX. Nos. 1-5, Vol. XX. Memoirs. Nos. 1, 2, Vol. XVIII. Bebliothique Geologique de la Russia, 1897. *From the Society.*

St. Petersburg.—Russ. Kaiser Mineralog. Gesellschaft. Verhandlungen. Vol. XXXIX. *From the Society.*

St. Petersburg.—Geologique Du Cabinet De Sa Majésté Travaux de la Section. No. 2, Vol. III. Vol. IV.

Stockholm.—Académie Royale Suédoise des Sciences. Bulletin. Nos. 1, 2, 5, 9. Memoirs 32, 34. *From the Academy.*

Stockholm.—Bihang Fill Krongl Svenska Velenskaps Akademiens Handlingar. No. 1, Vol. XVI. *From the Academy.*

Tōkyō (Japan).—Imperial University. Journal of the College of Science. Nos. 1, 6, Vol. XVI. *From the University.*

Societies with which the Society exchanges its Transactions, and Institutions and Journals to which a copy is sent free.

I.—England.

London ....British Association for the Advancement of Science, Burlington House, London.

British Museum, The Superintendent, Copyright Office.

British Museum Library, Natural History Department, Cromwell Road, Kensington.

Geological Society, Burlington House, W.

Geological Survey, Jermyn Street, S.W.

Geologists' Association, University College, Gower Street, W.C.

Institution of Mechanical Engineers, Storey's Gate, St. James' Park, Westminster, S.W.

Iron and Steel Institute, 28, Victoria Street, S.W.

Royal Institution of Great Britain, Albemarle Street.

Royal Society, Burlington House, W.

Public Library, Kensington, High Street, W.

Manchester ..... The Manchester Association of Engineers, Grand Hotel, Aytoun Street.

Field Naturalists' Society.

Free Library, King Street.

Literary and Philosophical Society, 36, George Street.

Manchester Geographical Society, 16, St. Mary's Parsonage.

The Owens College.

Barnsley........Midland Institute of Mining Engineers.

Birmingham ....Free Library and Museum.

South Staffordshire and East Worcestershire Institute of Mining Engineers, Colmore Chambers, 3, Newhall Street.

Bradford .....Public Free Library, Bradford, Yorkshire.

Bristol ....Naturalists' Society, Clifton.

Cambridge ......Geological Museum, University.

University Library.

Cardiff ... .Cardiff Naturalists' Society, 44, Londoun Square.

South Wales Institute of Mining and Mechanical Engineers, Park Place, Cardiff.

Chester ....Society of Natural Science, Grosvenor Museum.

Chesterfield......Chesterfield and Midland Counties Institution of Engineers (G. A. Lewis, Secretary, Albert Street, Derby).

Cornwall ......Royal Geological Society, Penzance.

Royal Institution, Truro.

Mining Association and Institute of Cornwall, Tuckingmill, Camborne.

Essex ....Essex Field Club, Passmore-Edwards Museum, Romford Road, Stratford, Essex.

Exeter ....Albert Memorial Museum.

Hanley ....North Staffordshire Institute of Mining and Mechanical Engineers.

Leeds ....Philosophical and Literary Society.

Yorkshire Naturalists' Union (W. D. Roebuck, Esq., Hon. Librarian, 259, Hyde Park Road, Leeds).

Geological Association, Mechanics' Institution, Cookridge Street.

Yorkshire Geological and Polytechnic Society, the Museum, Leeds.

Leicester........Literary and Philosophical Society.

Liverpool ....Free Library and Museum.

Geological Association, Free Library, William Brown Street.

Geological Society, Royal Institution.

Science Students' Association, Royal Institution, Colquitt Street.

Newcastle-on-Tyne Institution of Mining Engineers.

North of England Institute of Mining and Mechanical Engineers.

Newcastle-under-Lyme ...... North Staffordshire Naturalists Field Club (Secretary, W. Wells Bladen, Esq., Stone, Staffordshire).

Norwich........Norfolk and Norwich Naturalists' Society.

Oxford ....Bodleian Library.

Radcliffe Library.

North Shields....Public Free Library.

Rochdale........Literary and Scientific Society, 105, Freehold Street.

Salford ....Royal Museum and Library.

Southampton ....Hampshire Field Club, Harley Institution.

Warwick ......Natural History Society.

Watford, Herts..Herefordshire Natural History Society and Field Club (Daniel Hill, Esq., Hon. Librarian, Herga, Watford, Herts).

Wigan ....Free Library.

Mining School.

II.—Scotland.

Dundee ....Free Library and Museum.

Edinburgh ......Advocates' Library.

Edinburgh Geological Society.

Royal Society.

Royal Physical Society.

Glasgow ....Geological Society.
Natural History Society.

Hamilton ......Mining Institute of Scotland.

III.—Ireland.

Dublin ....Royal Dublin Society.
The Library, Trinity College.

Belfast ....Natural History Society, the Museum.

IV.—Australia.

Adelaide........Royal Society of South Australia (W. C. Rigby, 74, King William Street, Adelaide).

Melbourne ......Geological Society of Australasia, Colonial Mutual Chambers.
Public Library of Victoria.
Australian Mining Standard.

Sydney ....Free Public Library.
Australasian Association for the Advancement of Science, the University.
Royal Society of New South Wales, 37, Elizabeth Street.
Department of Mines. — The Government Geologist.

V.—Canada.

Halifax, Nova Scotia..... } Nova Scotian Institute of Science.

Hamilton, Ont. ..Hamilton Association.

Montreal........Library of Canadian Mining Institute, Room 4, Windsor Hotel, Montreal.
M'Gill University (The Principal).

Ottawa ....Geological Survey of Canada (Director, Museum, Sussex Street, Ottawa).

St. John, N.B. ..Natural History Society of New Brunswick.

Toronto ....Canadian Institute, 58, Richmond Street, E.

VI.—India.

Calcutta........Geological Survey of India.

VII.—United States.

Baltimore ......The Maryland Geological Survey (The State Geologist, John Hopkins University).

Boston ....Free Library.

Cambridge, Massachusetts...... Museum of Comparative Zoology, Harvard College.

Chapel Hill, North Carolina...... The Elisha Mitchell Scientific Society.

Chicago ....The Chicago Academy of Science.
Field Columbian Museum, Zoological Series.

Columbus ......Ohio, Geological Survey of. (The State Geologist.)

Denver ....Colorado Scientific Society, Denver, Colorado.

Indiana ....Department of Geology and Natural Resources (W. S. Blatchley, Esq., State Geologist).

Illinois ....Illinois Mining Institute, Springfield, Ill.
Field Columbian Museum, Chicago.

Michigan ......Michigan Mining School, Houghton.

Minneapolis ....Geological and Natural History Survey of Minnesota.

Jefferson City, Missouri.... Missouri Geological Survey.

New York ......American Institute of Mining Engineers (Secretary, R. W. Raymond, 99, John Street, New York City).

American Museum of Natural History, Central Park.

Philadelphia ....Academy of Natural Sciences.
Franklin Institute.
Pennsylvania Geological Survey.
American Philosophical Society, 104, S. Fifth Street.

Scranton, Pa.....Editor of "Mines and Minerals."

Washington ....Library of the U.S. Geological Survey.
Smithsonian Institute.

Wisconsin ......Wisconsin Academy of Science, Arts, and Letters, Madison.

Wyoming ......Historical and Geological Society.

VII.—Foreign Societies.

Berlin ....Deutsche Geologische Gesellschaft.
Gesellschaft für Erdkunde. Wilhelmstrasse, 23, S.W.

Brussels........Société Royale Malacologique de Belgique.

Buenos Ayres ..Officiana Nacional de Commercie.

Caen ....La Société Linnéenne de Normandie.

Christiania ....Royal University of Norway.

Dresden ....Naturwissenschaftliche Gesellschaft Isis.

Halle, A/S ...Verein für Erdkunde.
Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.

Helsingfors......La Commission Gèologique de la Finlande. (Secretary, Dr. J. J. Sederholm, Boulevardsgatan 29.)

Iglo, Hungary ..Societé Hongroise de Carpathe.

Kazan, Russia ..La Société des Naturalistes de l'Université de Kazan.

Kieff, Russia ....La Société des Naturalistes.

Lousanne (*Suisse*).Société Vaudoise des Sciences Naturelles.

Lille ....Société Geologique du Nord.

Mexico ....Sociedad Cientifica "Antonio Alzate."

Naples ....Accademia della Scienza Fisiche e Mathematiche.

Paris ....La Société Gèologique de France.
La Société de Spéléologie. 7, Rue des Grands Augustins.

Pisa ....Società Toscana di Scienze Naturali, Museo di Storia-Naturale.

Rio de Janeiro ..Museo Nacional.

Rome ....Reale Academia dei Lincei.

St. Petersburg ..Académie Impériale des Sciences.
Comité Géologique. Institut des Mines.

Stockholm ......Académie Royale Suedoise des Sciences.

Turin..........Acadêmie Royale des Sciences.

IX.—Scientific Journals, &c.

Iron and Coal Trades Review, 165, Strand, W.C.

Mining Journal, 46, Queen Victoria Street, London.

Colliery Guardian, 49, Essex Street, Strand, London.

Science and Art of Mining, 27, Wallgate, Wigan.

Stone, F. W. Hoyt, 45, Broadway, New York.

LIST OF MEMBERS.

OCTOBER, 1902.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	Names and Addresses.
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.A.
1897	Allen, Edward, M.E., Willow Bank, Hale, Bowdon, Cheshire.
1898	Allen, Robert, River Cottage, Lower Broughton, Manchester.
1893	Ashworth, John, C.E., 8, King Street, Manchester. *Vice-President.*
1878	Ashworth, Thomas, 42, Deansgate, Manchester.
1877	Atherton, James, 13, Mawdsley Street, Bolton.
1895	Atherton, H. Stanley, 7, Brazennose Street, City. *Member of Council.*
1878	Atkinson, W. N., H.M. Inspector of Mines, Barlaston, Stoke-on-Trent.
1897	Baker, Godfrey, Pendlebury, Manchester.
1901	Baldwin, Walter, Hall Bank, Rochdale.
1900	Banks, Thomas, 60, King Street, Manchester.
1895	Barnes, J., F.G.S., South Cliff House, 301, Great Clowes Street, Higher Broughton. *Past President. Hon. Auditor.*
1875	Barrett, W. S., J.P., 64, The Albany, Old Hall Street, Liverpool. *Past-President.*
1891	*Bell, Thomas*, J.P., 15, The Valley, Scarborough.
1881	Black, W. G., F.R.C.S. Ed., F.G.S. Ed., 2, George's Square, Edinburgh.

Year of Election.	Names and Addresses.
1898	Boden, Peter, Butterworth Hall Colliery, Milnrow, Rochdale.
1889	Bolton, Edgar O., Burnley Collieries, Burnley.
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., The Collieries, Accrington.
1902	Bouchier, C. F., Strangeways House, Platt Bridge, near Wigan.
1886	Bramall, Henry, M.Inst.C.E., Pendlebury Collieries, Pendlebury, Manchester.
1900	Brancker, Richard, 11, Old Hall Street, Liverpool.
1902	Brewerton, Joseph, Civil and Mining Engineer, 97, Bridge Street, Manchester.
1877	*Broeck, Ernest Von den*, 32, Place de l'Industrie, Brussels.
1900	Burke, Harry, 47, Albion Street, Brooks' Bar, Manchester.
1878	Burrows, John S., F.G.S., Green Hall, Atherton, Manchester. *Past-President.*
1887	Campbell, W. M., Sutton Heath Collieries, St. Helens, Lancashire.
1901	Champ, Henry, c/o Messrs. S. & J. Watts & Co,, Portland Street, City.
1901	Chapman, C. H., 293, Liverpool Road, Salford.
1882	Clark, George, Mining Engineer, Newton-le-Willows.
1898	Clark, Robert F., Bickershaw Collieries, Leigh, Lancashire.
1894	Clarke, Robert, 42, Deansgate, Manchester.
1894	Cole, Robert H., Endon, Stoke-on-Trent.
1901	Coleman, W. H., 4, Sunnyside Terrace, North Road, Clayton, Manchester.
1901	Cotterill, W. B., Hazlehead, near Sheffield.
1878	Cowburn, Henry, 253, Westleigh Lane, Westleigh, near Manchester.
1883	Crankshaw, Joseph, F.G.S., 11, Ironmonger Lane, London.
1879	Crawford and Balcarres, The Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*

Year of Election.	Names and Addresses.
1900	Davidson, Robert, 2, Park Lane West, Pendlebury, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., D.Sc., F.R.S., F.G.S., F.S.A., A.M.I.C.E., The Owens College, Manchester. *Past-President.*
1900	Deane, Adam, Stopes Colliery, Little Lever, Bolton.
1877	*De Rance*, C.E., F.G.S., 32, Carshalton Road, Blackpool.
1898	Dickinson, Archibald, 13, St. Matthew's Street, Burnley.
1856	Dickinson, Joseph, F.G.S., Hon.M.I.M.E., South Bank, Sandy Lane, Pendleton. *Past-President. Trustee.*
1889	Dobbs, Joseph, Coolbawn House, Castlecomer, Co. Kilkenny.
1898	Douglas, Ernest, Pemberton Collieries, Wigan.
1898	*Eagle, George, Westminster Buildings, 37, Brown Street, Manchester.
1878	Ellesmere, the Right Hon. the Earl of, Worsley.
1895	Ellis, Thomas Ratcliffe, Solicitor, King Street, Wigan.
1897	Ellis, W. T. Wood, M.Inst.M.E., M.S.A., 29, Blackfriars Street, Manchester.
1900	Elce, Abraham, jun., Colliery Manager, 78, Church Street, Dukinfield.
1884	Elce, George, Altham Colliery, Whalley Road, Accrington.
1895	Evans, Robert, Mining Engineer, Olive Bank, Royton, Oldham.
1897	Evans, Walter, J.P., M.E., Royton, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1891	Finch, John, 4, Wellington Terrace, Lichfield Road, Sutton Coldfield.
1891	Fletcher, Arthur, 8, St. Andrews, Ainsworth Road, Radcliffe.

Year of Election.	Names and Addresses.
1896	Fletcher, Leonard R., Atherton Collieries, Atherton, Manchester.
1868	Fletcher, Thomas, Wheatfield, Bolton.
1873	Garforth, W.E., F.G.S., Snydale Hall, near Pontefract.
1893	Garside, Edward, B.Sc., Town Hall Chambers, Ashton-under-Lyne.
1902	Garton, Walter, Worsley House, Worsley Mesnes, Pemberton, Wigan.
1874	*Geikie, Sir Archibald*, D.Sc., LL.D., F.R.S., 10, Chester Terrace, Regent's Park, London, W.
1892	Gerrard, John, H.M. Inspector of Mines, Worsley, Manchester. *Vice-President.*
1882	Glover, B. B., 41A, Victoria Buildings, Manchester.
1898	Glover, J. W., M.E., 41A, Victoria Buildings, Manchester.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1874	Greenwell, G.C., M.Inst.C.E., F.G.S., Beechfield, Poynton, Cheshire. *Past-President.*
1879	Greenwood, John, c/o The Globe Spinning Company, 1, Marsden Street, Manchester.
1892	Gregson, G. Ernest, 11, Chapel Street, Preston.
1890	Gresley, W. S., F.G.S., F.G.S.A., 16, Radburn Street, Derby.
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.
1888	Grundy, James, Inspector of Mines in India, F.G.S , 27, Chowringhee Road, Calcutta, India.
1897	Guy, J. G.
1881	Hall, Henry, I.S.O., H.M. Inspector of Mines, Rainhill, Prescot, Lancashire. *President.*
1898	*Hall, Levi J., Morland House, Birch Vale, near Stockport, (Furness Vale Collieries, Stockport.)
1877	Handsley, Robert, Burnley Colliery Office, Burnley.

Year of Election.	Names and Addresses.
1877	Harris, George E.. M.E., Assam Railway and Trading Co., Limited, Margerita, Assam, India.
1894	Harrison, George B., H.M. Inspector of Mines, 278, Worsley Road, Swinton, Manchester. *Vice-President.*
1892	*Haworth, Denis, Oswaldtwistle Collieries, Accrington.
1897	Heather, Frank, 47, Mosley Street, Manchester.
1900	Henshaw, A. M., Talk-o'th'-Hill Collieries, Staffordshire.
1902	Hewitt, J., 114, Bell Green Lane, Ince, Wigan.
1889	Higson, Charles H., 106, Eccles Old Road, Pendleton, Manchester.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1900	Hinnell, Leonard H., Civil Engineer, 26, Corporation Street, Manchester.
1897	Hobson, Bernard, M.Sc., F.G.S., The Owens College, Manchester.
1877	Holding, William, Cossall Colliery, near Nottingham.
1878	Hollingworth, George H., F.G.S., 37, Cross Street, Manchester. *Hon. Treasurer.*
1899	Hollingworth, David, Chemist, Gas Works, Stretford, Manchester.
1895	Holroyd, W. F., F.G.S., 31, Barrfield Road, Pendleton. *Member of Council.*
1897	Howsin, Evelin G., Huntroyd Estate Office, Padiham.
1894	Hughes, Owen, Rose Hill House, Hindley, near Wigan.
1874	*Hull, Professor Edward,* M.A., F.R.S., 20, Arundel Gardens, Notting Hill, London, W.
1895	Hutchinson, John William, Bamfurlong Collieries, Wigan. *Member of Council.*
1887	Jackson, Andrew, Craven Lodge, Rainhill, S.O., Lancashire.
1878	Jackson, Charles G., Rookwood, near Chorley.
1883	Jobling, Albert, 91, Rectory Road, Burnley.
1883	Jobling, Henry, 91, Rectory Road, Burnley.

Year of Election.	Names and Addresses.
1884	Jobling, John, Manager, Cliviger Colliery, Burnley.
1882	Johnson, William, Abram Colliery, Wigan.
1897	Keen, James, Hindley Green, Wigan.
1893	Kenrick, James P., 8, St. James's Square, Manchester.
1879	*Kinahan, G. H.*, M.R.I.A., Woodlands, Fairview, Co. Dublin.
1901	Knight, Henry, Manager, Rose Bridge Ince Hall Collieries, Wigan.
1889	Knowles, John, Brynn Mount, Westwood, Lower Ince, Wigan.
1887	*Knowles, Lees, M.A., LL.D., F.G.S., M.P., Westwood, Pendlebury. *Trustee.*
1898	Krauss, John Samuel, B.A., Hodnet, Shropshire.
1898	Landless, Richard, Bank Hall Colliery, Burnley.
1902	Latham, Daniel, Surveyor, Rose Bridge and Ince Hall Collieries, Wigan.
1898	Laverick, John H. W., Pye Hill, Jacksdale, near Nottingham.
1890	Law, J. Illingworth, Waterfoot, Manchester.
1912	Lea, Walter, Collins Green Colliery, Earlstown.
1899	Leah, Richard, Smedley Road, Cheetham, Manchester.
1884	Leech, A. H., Brinsop Hall Colliery, Wigan.
1897	Lees, Frederick, The Rookery, Ashford, Bakewell.
1899	Leigh, Oswald B., The Towers, Didsbury.
1898	Livesey, John, Rose Hill Colliery, Bolton.
1898	Lomax, James, 65, Starcliffe Street, Moses Gate, Bolton.
1887	Lord, James, Hill House, Rochdale.
1898	Lowe, Henry, Moss Colliery, Ince, near Wigan.
1881	Macalpine, G. W., Parkside, Accrington.
1902	Machin, Thomas H., Hyde Lane Colliery, Hyde, Cheshire.
1901	McKay, William, Carlton Villa, Park Road, Hindley, Wigan.

Year of Election.	Names and Addresses.
1897	Makepeace, H. R., H.M. Inspector of Mines, Trentham, Stoke-on-Trent.
1891	Marshall, Herbert S., Arnoldsmere, Freshfield.
1892	Mathews, D. H. F., H.M. Inspector of Mines, Hoole, Chester. *Member of Council.*
1893	Matthews, E. L., Belvedere Street, Withington Street, Pendleton, Manchester.
1896	Matthews, Thomas, Imperial Iron Works, Belvedere Street, Withington Street, Pendleton, Manchester.
1873	*Martin, Joseph S.*, H.M. Inspector of Mines, the Vikings, 16, Durdham Park, Clifton, Bristol.
1900	Maxwell, Frank, Architect, 41, Corporation Street, City.
1892	Miller, Arthur, Broad Oak, Hurst, Ashton-under-Lyne. *Member of Council.*
1892	Millington, W. W., Hardman House, Hollinwood, Oldham. *Member of Council.*
1892	Mills, David, Bradford Street, Farnworth.
1895	Mitton, A. Dury, Assoc.M.Inst.C.E., Oakwood, Walkden, Bolton. *Member of Council.*
1895	Mort, Arthur, B.Sc., Sharigh, Baluchistan.
1878	Nall, Simon, Newbold, Rochdale.
1898	Naylor, Alfred, Shirebrook Colliery, Mansfield.
1897	Nelson, William, jun., Clifton and Kearsley Collieries, Clifton, Manchester.
1897	Noar, L. Lamb, The Grove, Lymm.
1900	Ollerenshaw, W., Manager, Denton Colliery, Denton, Manchester. *Member of Council.*
1876	Peace, George, Monton Green, Eccles. *Member of Council.*
1883	Peace, George Henry, M.Inst C.E., Monton Grange, Eccles.

Year of Election.	Names and Addresses.
1897	*Pickup, P. W. D., Rishton Colliery, Rishton, near Blackburn.
1900	Pickstone, William, 11, Brighton Grove, Rusholme. *Member of Council.*
1879	Pilkington, Charles, The Headlands, Prestwich, Manchester.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*
1899	Pilkington, Lawrence, South Garth, Eccles Old Road, Pendleton.
1377	Place, W. H., Hoddleston Collieries, Darwen.
1887	Platt, Samuel Sydney, M.Inst.C.E., F.G.S., Moss House, King's Road, Rochdale.
1891	Prestwich, Joseph, Elm Bank, 72, Eccles Old Road, Pendleton, Manchester.
1897	Reid, Alexander, Pekin Syndicate Limited, Shanghai, China.
1900	Rhodes, John R., Gorphwysfa, Prestwich.
1897	Richardson, Isaiah, Blainscough Collieries, Coppull, near Chorley.
1860	Ridyard, John, F.G.S., Hilton Bank, Little Hulton, Bolton. *Past-President.*
1900	Ridyard, George, M.E., Bruntscar, Westhoughton.
1893	Rigby, John, Highfield, Winsford, Cheshire. *Member of Council.*
1897	Ritson, W. A., 44, Woodlands Street, Cheetham, Manchester.
1889	Robinson, John, Haydock Collieries, St. Helens.
1892	Roscoe, George, Peel Hall Collieries, Little Hulton, Bolton.
1898	Roscoe, Thomas, Peel Hall Collieries, Little Hulton, Bolton.
1895	Rothwell, Samuel, 21, Chorley New Road, Bolton.
1895	Ryans, Joseph, Colliery Manager, Arigna Mines, Carrick-on-Shannon.

Year of Election.	Names and Addresses.
1887	Saint, William, H.M. Inspector of Mines, Kersal Bank, Higher Broughton, Manchester. *Past-President. Hon. Secretary.*
1902	Salisbury, S., 60, Ayres Road, Brooks' Bar, Manchester.
1888	Scarborough, George Edward, Colliery Manager, Newton and Meadows Collieries, Wigan.
1887	Scott, Frederick W., Atlas Works, Reddish, near Stockport.
1889	Scott, William B., Eversley Cottage, Middleton.
1891	Scowcroft, Thomas, J.P., Redthorpe, Bromley Cross, near Bolton.
1899	Selby, John B., Atherton House, Leigh, Lancashire.
1882	Settle, Joel, The Hill, Alsager, Stoke-on-Trent.
1878	Settle, Miles, Rosslymn, Lytham Road, Blackpool.
1899	Shaw, Alfred, Bersham Colliery, Wrexham.
1887	Shuttleworth, Lord, of Gawthorpe, Burnley.
1884	*Simpson, W. W., Winkley, near Whalley, Blackburn.
1864	*Smethurst, William, F.G.S., Brynmair, Dolgelly, North Wales.
1902	Smethurst, W. A., Garswood Hall Collieries, Brynn, Wigan.
1881	Smith, John, Bickershaw Collieries, Westleigh, near Manchester.
1873	*Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell. *Past-President.*
1888	Smith, Sydney Arthur, 1, Princess Street, Albert Square, Manchester.
1886	Speakman, Harry, Bedford Collieries, Leigh, Lancashire.
1881	Squire, J. B., Assoc.Inst.C.E., F.G.S., M.I.M.E., 20, Victoria Street, Westminster, London, S.W.
1880	Stirrup, Mark, F.G.S., High Thorn, Stamford Road, Bowdon. *Past-President.*
1902	Stocks, F. W., F.S.I., The Hermitage, Middlewich.
1882	Stopford, T. R., Ashton's Green Collieries, St. Helens, Lancashire.
1891	Sutcliffe, Richard, Horbury, near Wakefield.

Year of Election.	Names and Addresses.
1899	Tansley, A. E., Springfield House, Coppull, Chorley.
1899	Tatham, Roger.
1901	Taylor, John, 51, Park Road, Darwen.
1889	Taylor, William, 51, Park Road, Darwen.
1893	Thompson, F. W., 18, Wood Street, Bolton.
1892	Thompson, James, 248, Chorley Road, Westhoughton, Bolton.
1897	Tickle, James.
1893	Timmins, Arthur, A.M.I.C.E., F.G.S., Argyll Lodge, Higher Runcorn.
1891	Tonge, Alfred J., Hulton Colliery, near Bolton. *Member of Council.*
1875	Tonge, James, F.G.S., Assoc.M.Inst.C.E., Albany Chambers, Mawdsley Street, Bolton. *Past-President.*
1898	Tonge, James, Jun., F.G.S., Westhoughton, near Bolton, *Hon. Secretary.*
1886	*Trafford, Sir Humphrey Francis de, Bart., 18, Arlington Street, London, W.
1895	Travers, T. W., Mining Engineer, Spring Bank, Broad Oak Park, Worsley.
1896	Turner, Robert, Jesmond House, St. Helens.
1876	Unsworth, John, Scot Lane Collieries, Wigan.
1887	Walkden, Richard, Colliery Manager, 26, Watery Lane Terrace, Springvale, Darwen.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1902	Wall, Captain Arthur, Coed Mawr Hall, Tal-y-Cafn, Wales.
1882	Wall, Henry, Rowbottom Square, Wallgate, Wigan.
1893	Wallwork, Jesse, Shakerley Collieries, Tyldesley, near Manchester.
1888	*Walmsley, Oswald, 2, Stone Buildings, Lincoln's Inn, London.
1879	Walshaw, John, Astley and Tyldesley Collieries, Tyldesley.

Year of Election.	Names and Addresses.
1897	Walton, Thomas, Habergham Colliery, Burnley.
1892	Ward, Alexander Haustonne, Ranigunj, Bengal, India.
1885	Ward, Thomas, J.P., F.G.S., Wadebrook House, Northwich.
1880	Watts, William, F.G.S., Underbank Hall, Deepcar, near Sheffield. *Past-President.*
1897	Wells, Lionel B., M.Inst.C.E., 5, John Dalton Street, Manchester. *Vice-President.*
1890	*Whittaker, William*, B.A., F.R.S., F.G.S., Freda, Campden Road, Croydon.
1891	Whitehead, J. J.
1898	Widdowson, J. H., 19, Brazennose Street, Manchester.
1867	*Wild, George*, Albert Street, Bardsley, Ashton-under-Lyne.
1880	Williams, Sir E. Leader, M.Inst.C.E., Manchester Ship Canal Company, Spring Gardens, Manchester.
1897	Winstanley, George H., F.G.S., 42, Deansgate, Manchester. *Hon. Auditor.*
1876	Winstanley, Robert, C.E., 42, Deansgate, Manchester. *Past-President.*
1886	*Wood, Guy.
1897	Wood, John, M.E., Barley Brook Foundry, Wigan.
1897	Wood, Percy Lee, Clifton and Kersley Coal Co., Ltd., Clifton, Manchester.
1895	Wordsworth, T. H., New Moss Colliery, Audenshaw, near Manchester.

SUBSCRIBERS.

Stechert & Co., 2, Star Yard, Carey Street, London, W.C.
Eyre & Spottiswoode, 5, Middle New Street, London, E.C.

Members are requested to communicate to the Hon. Secretaries all changes of address, also any omissions, or corrections required in the list.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART II. VOL. XXVIII. SESSION 1902-1903.

The ORDINARY MEETING of the Members was held on Tuesday, November 11th, 1902, in the Society's Rooms, 5, John Dalton Street, Manchester.

Mr. HENRY HALL, I.S.O., one of H.M. Inspectors of Mines, President, in the Chair.

The PRESIDENT, at the outset of the proceedings, spoke as follows: My first duty is to thank you for the honour that you have done me in electing me President of the Society for this session. I shall do my utmost to make the session a success, and I hope that members will aid me in that direction. I hope they will attend the meetings, and that we shall have good meetings. When attending these meetings in the past I have sometimes felt that the discussions were a little bit too prolonged—that the meetings in fact were too long. Now I think, that a meeting is best ended when it is as it were in its full energy, and not after the members are tired. I am looking forward to many more of the members taking an active part in the discussions than has hitherto been the case. This Society, like others, seems to get into a groove. There are certain members who having the gift of eloquence, perhaps take up more of the time of the meeting than they ought, though, of course, the meeting must be kept going. I am anxious that every one should have an opportunity of speaking and that the discussions should be shared in by a larger number. It is not always the man who has the most to say whose observations are of the most value. Personally, I cannot add much to the interest of the meetings from a geological point of view. But I am an excellent listener, and am always delighted to listen to geologists building up a world for themselves, deftly piling one stone upon another. A geologist has the advantage of most people, for in whatever country he finds himself there is always something to attract and interest him. His enthusiasm is kindled by innumerable things which the ordinary observer would pass by as commonplace, whilst his delight in beautiful scenery is twofold, he loves and revels in his favourite science and becomes a more devoted disciple day by day.

The President read his Inaugural Address on "Industrial Education" as follows:—

INDUSTRIAL EDUCATION.

By Mr. Henry Hall, I.S.O.,

One of H.M. Inspectors of Mines, President.

I purposely use the word "industrial" in preference to technical education, because the observations I have to make are intended to apply more especially to that section of society who are mainly dependent on their own efforts for their living and advancement in life, a class which can only devote a limited time to education, and whose education must be strictly utilitarian.

The subject of industrial education occupies a good deal of public attention just now, and advice comes from all sides as to what this education ought to be, and the best methods of imparting it. We are warned that unless we make haste and educate, British industries and commerce will soon be extinct.

As is always the case when there is popular clamour for a change, the existing system is depreciated far beyond its deserts, and the merits of the new are exaggerated far beyond the possibility of achievement.

It is taken for granted, and the public appear to have accepted it as true, that any decadence from our position as the leading industrial nation of the world is due to the lack of method and practical utility in our educational system. Most likely the public is right, though in this matter it is not quite the *vox populi* we hear, but probably only that of the somewhat large class who presume to manage other people's business.

There are undoubtedly other influences and factors to be reckoned with. It will suffice for the moment to mention one or two; for instance, there are the huge joint stock companies, which lack the vital energy of business conducted by individuals on their own behalf; the interests of shareholders do not supply the same stimulus for strenuous effort and attention as when direct personal advantage is involved. And we know that these great limited companies have been very much on the increase of recent years, and some of them have proved striking examples of ill success.

Again, our railway system heavily handicaps trade by excessive railway charges; it seems hardly credible that traction on land should cost so much more than traction on water, and yet we know that the rates from an inland works to the coast are often far in excess of the freight charges over thousands of miles on water. It is, of course, true that in the latter case the track has not to be maintained, but, even granting this, it cannot account for or explain a difference in cost twenty times greater in the one case than the other.

I am told that the rate for a ton of steel from Sheffield to Aberdeen is 38s. 10d. per ton, whilst from Sheffield to New York the rate is only 23s. 9d. per ton.

A box of oranges, sent from Florida to friends of mine, cost more for the 100 miles they travelled over English railways than from Florida to London, a distance of 3000 miles.

Similar instances might be multiplied indefinitely. Nor is it to the credit of our railway system that packages sent by ordinary goods train are longer in arriving at their destination than if they had been sent by road; indeed, the most primitive method of transporting goods practised by the Kaffirs in South Africa is as expeditious as we are able to achieve by our elaborate railway system. In Africa the Kaffir boy carries a 40lbs. package on his head and covers from 25 to 35 miles a day; now if we hand a similar package to an English railway company to be forwarded by goods train, we will find that in nine cases out of ten this rate of speed is not attained.

I admit that the engineering part of our railways has been, and is, well done; the speed and comfort of through trains is all that can be desired, and the immunity from accident is a great achievement; but I think it is indisputable that the system, or want of system, in handling the goods traffic, both as regards time and cost, is a failure, and seriously handicaps trade and commerce.

Our railways are no doubt handicapped by the fact that they are of spasmodic growth, which has resulted in an intricate system ill-adapted to the needs of the country, and perhaps impossible of reorganisation; but I am satisfied that if the existing railway system could be swept away bodily some much more economical and expeditious method of transporting merchandise would quickly be devised to take its place.

Mr. Carnegie, in his address to the students of St. Andrew's University, a few days ago, made some interesting remarks *apropos* of these subjects. He said: "Britain, 40 years ago, made more iron and steel, manufactured more machinery, mined more coal, wove more cloth, than all the rest of the world; that now capital, management, and skilled labour have become mobile in the extreme, so that the seat of manufacturing is, and will continue to be, more and more simply a question of where the requisite raw materials are found under suitable conditions. Capital and labour have lost the power they once had to attract raw materials; these now attract labour and capital."

In speaking of the immense home demand and consumption in America, he remarks: "With British home commerce both are Britons; with foreign commerce only one is a Briton and the other a foreigner, hence home commerce is doubly profitable; and that is not all, when the article exported, such as machinery or coal, for instance, is used for developing the resources of manufactures of the importing country, and enables these to compete with those of the exporting country, the disadvantage of this foreign commerce to the seller, except the profit upon the sale, is obvious."

This expression of opinion by Mr. Carnegie, on the exportation of raw material, must strike us as being a weighty argument against the exportation of our own coal to foreign countries, and most disinterested persons will agree with Mr. Carnegie.

We are witnesses to the anomaly of a Royal Commission sitting to inquire as to the probable duration of our coal fields, whilst 50 million tons per annum are being exported to foreign countries to help the foreigner, as Mr. Carnegie reminds us, to compete with us in various industries.

Fifty million tons per annum represents about 23 per cent. of our total output, and is a serious addition to the already rapid rate of exhaustion of our coal supplies. Surely if the position is so serious as to call for the appointment of a Commission of Inquiry it must be patent to everyone what the first step should be.

The growth of this foreign export has been very rapid, and in a very few years time, if no steps are taken, it will probably reach 100 million tons per annum, but I believe our coal masters are sufficiently patriotic to draw the line at 50 millions, and say so far but no further. They are well aware that England without coal spells the end of most things.

I have spoken of the decadence of our industrial position; this must be understood in a qualified sense. We probably employ more hands in Britain to-day, and turn out more work than ever was the case before. The trouble is that notably America and Germany have developed as competitors so rapidly that we have taken fright, and, looking about for the cause, have decided that it is chiefly due to a better and more thoroughly practical system of education in those two countries. America, we know, has so many natural advantages and immense reserves of raw material, that she could hardly have failed to become one of the greatest industrial nations of the world; but Germany is by no means so favourably circumstanced, and her position is undoubtedly due to the character and training of her people.

The German Government has always cared for and enforced education, and the fact that the attainment of a certain standard by the youth of Germany exempts them from a substantial part of their compulsory service in the army is a great incentive to effort and application.

There is no doubt that the average German schoolboy is far ahead of the average British schoolboy of the same age in respect of those subjects likely to be useful to him in after-life, while the cost of a thoroughly good education in Germany is so extremely moderate as to be within the reach of all.

In England we are now making strenuous efforts by establishing technical and secondary schools to remove this inequality. We are no longer content with academical instruction; indeed, there is quite a revolt against teaching of this kind, on the grounds of inelasticity, and a complete blindness to the national educational needs of this industrial age.

Professor Armstrong, in his address to the British Association, spoke of our educational system as being too rigid to adjust itself to its environment, "that our system of edu-
" cation had no theoretical basis. Educators had ceased to
" be practical because they have failed to keep pace with the
" march of discovery; the theoretical basis underlying their
" profession having been enlarged so rapidly that it was

"beyond their power to grasp its problems. The priesthood "of the craft were, in fact, possessed by the spirit of narrow "parochialism and upholders of an all too rigid creed, being "descendants of a privileged class—'the knowledge caste,' "to use Thrings's expression—whose functions were far "more limited than were those which must now be discharged "by teachers if teaching was to be given, which would serve "as an efficient preparation for life under modern con- "ditions."

Professor John Perry, before the same Association, "said: The average boy leaves an English school, with "no power to think for himself, with a hatred for books, "with less than none of the knowledge which might help "him to understand what he sees."

"That our school system resembles the ordinary type of "old-fashioned works, where gradual accretion has produced "a higgledy-piggledy set of shops, which one looks at with "stupefaction, for it is impossible to get business done in "them well and promptly, and yet it seems impossible to "start a reform anywhere. What is wanted is an earth- "quake or a fire—a good fire—to destroy the whole works, "and enable the business to be reconstructed on a consistent "and simple plan. And for much the same reason our "whole public school system ought to be scrapped."

Whether or no these censures are deserved is not material to my purpose to-day. The Universities and public schools teach a class who can afford to pursue learning for its own sake, and have both time and means to remedy any short-comings of the system, and they could probably give a very good account of themselves.

What we are concerned with is the education of that large class whose opportunities are distinctly limited by the necessity of living. This class must be taught with a book in one hand and a tool in the other. Our technical schools are being established to fulfil this function.

The school buildings are generally of a costly and magnificent character, and, up to the present, are the outcome of private beneficence, and are a practical refutation of the assertion so often made that we English people take little interest in education, and that we are content to rely on what we choose to designate "good common sense." The annual support of the schools comes from three sources, viz., grants from the Board of Education on pass results, grants from County and County Borough Councils, and from voluntary subscriptions and fees.

Taking the school at Wigan as an example, the sums forthcoming from these different sources are as follows:—

	£
Board of Education	700
County and Borough Councils	1,500
Fees	200
Voluntary Subscriptions	400

You will notice that the amount charged for fees is quite small as compared with the receipts from the other sources.

The curriculum of these schools is generally somewhat ambitious, the most important place being given to such teaching as bears directly on the special industries of the town and neighbourhood where the school is situated. I have a sample - syllabus before me, which embraces—mining, geology, steam engine, theoretical and applied mechanics, geometry, machine construction, building construction, carpentry, mathematics, chemistry, electricity, iron and steel manufacture, metallurgy, cotton spinning and weaving, wood carving, manual instruction, artistic and practical drawing, shorthand, typewriting, hygiene nursing, laundry, cookery, and ambulance.

The subjects are taught by means of lectures, illustrations and experiments—for instance—the lectures on chemistry and electricity are interspersed with experiments, in mining, metallurgy, engineering, building, and cotton spinning models and illustrations are used to elucidate and give interest to the lectures—but most important of all are the workshops and laboratories where the students practice actual handicrafts and become adepts in the use of tools for working both wood and metal and where they engage in practical chemistry, analysis, assaying, wood carving, modelling, plumbing, &c.

The value of the work done depends chiefly on the extent and character of the equipment of the various workrooms, laboratories, &c.—because it is here the students can give practical effect to their teaching and attain a knowledge and skill which will bring within their reach positions to which otherwise they could not have aspired.

In some of the larger schools the facilities for manual training and expert operations are most complete, neither money nor thought having been spared to supply up-to-date machine tools, electrical appliances and other apparatus. Too much cannot be done in this direction, principles and theories are easily forgotten and in the absence of practice are quite valueless to the class in whose interests technical schools are being established.

The examinations are conducted in the elementary stages by the school authorities themselves, in advanced subjects by the Board of Education who make money grants on pass results. The City and Guilds of London, the Lancashire and Cheshire Institutes, the St. John's Ambulance, give certificates of merit but no money. The schools are inspected from time to time by H.M. Inspectors.

It is absolutely essential that the examinations should be adapted to, and a test of the practical work done in the schools, and it is the business of the Board of Education to take care that the examinations are in accordance with the needs of the special industries of the district, because if this is not so the teaching will inevitably run into grooves which are likely to earn the pass grants to the disadvantage of the best objects of the schools.

Government passes and certificates ought to be reliable credentials for an employer; but it is often said that this is by no means the case. To give an instance, the students who come to the college to study mining naturally and properly expect to be taught in such a way that they will have little difficulty at a later stage in obtaining a manager or under-manager's certificate, and the school authorities endeavour to fit the teaching to the attainment of this object; but the teaching staff are in a serious dilemma when the examination questions in mining sent down from South Kensington deal almost solely with principles and leave out entirely such practical matters as timbering, lighting, ventilation, mine gases, explosives, coal dust, haulage, pumping, electrical appliances, coal cutting machines, &c. If an influential representation were made to the Board of Education on this subject, I have no doubt that they would see that this defect was remedied.

The utility and success of technical instruction depend entirely on the two conditions being fulfilled which I have referred to, namely, that the teaching is appropriate to the needs and interests of the class for whom it is intended, and that the examinations are carefully directed to promote and encourage such teaching.

The chief difficulty which confronts the managers of technical schools is the fact that many of the young persons coming direct from primary schools are very poorly equipped to take advantage of technical instruction. It is hard to say how this difficulty can best be met, but to attempt, as some people suggest, to supply and support three classes of schools, namely, primary, secondary, and technical, is out of the question. I think the best plan would be to fuse the secondary and technical instruction into one. The greater part of technical instruction is given in the evening, thus leaving the school buildings very much at liberty during the day. Advantage could be taken of this to have preliminary or secondary courses in subjects in which the primary scholars were found to be most deficient. If such a fusion was effected it would not be unreasonable to require every town having a population of 40,000 and upwards to establish and support a thoroughly efficient technical school, with, of course, the aid of the Government and technical grants.

Such a scheme would give opportunity to all the more intelligent of the industrial classes to struggle upwards, and, by means of scholarships, the pick of these might rise to the highest positions. To attempt to give technical instruction to all alike is Utopian; we are bound to recognise that there must always be a multitude of simple workers acting under the direction of others.

Having succeeded in establishing our schools, how are they to be made attractive to those whom we hope to benefit by them. The attraction held out must be something substantial—something to make it worth the student's while. In France and Germany, there is the incentive already mentioned, namely, the escape from a large part of the compulsory service in the army; in England, this incentive is not available, and we must rely, I think, chiefly on the heads of the great manufactories, some of whom are already in favour of the movement, and do their best to encourage their apprentices and others to attend the schools. In evidence of this I quote the following letter :—

AMERICAN *VERSUS* ENGLISH METHODS OF BUSINESS.

To the Editor of the Times.

Sir,—In regard to your articles on American *versus* English methods, it may be interesting to you to know that we have now made arrangements for a number of our apprentices to attend classes at the Derby Technical College, and in order to encourage those apprentices we are paying half of the fees and purchasing the necessary instruments and books for each apprentice for a term of three years.

Apprentices who pass the prescribed examinations at the end of each year will receive increased wages, and will be allowed to retain the instruments purchased for them.

I have every reason to believe that this is in advance of anything at present being done in this country, or in most up-to-date American practice in this respect. I am hoping, if this idea is followed by employers, even in some degree, it will help to solve the question of technical education.

Yours faithfully,

ANDREW HANDYSIDE AND CO. (Limited).

Edward E. Mattheson, Works Manager.

Britannia Iron Works, Derby,
October 21st.

If the attitude of employers generally is favourable to scientifically trained officials and skilled workmen, then the acquisition of technical certificates will have a direct money value, and that will of itself be sufficient attraction. But it is by no means certain that as yet the great bulk of English employers regard favourably or value highly knowledge gained in the lecture rooms of colleges, and for this reason I have laid stress on the great importance of providing workshops where the principles taught by lecturers can be applied to actual work. An applicant for a position who can show that his scientific training has made him a more capable and intelligent workman than his fellows is certain to succeed whatever the standpoint of his would-be employer may be.

But the time is rapidly passing away when scholarly attainment is looked at askance by employers who boast that they are "practical men," because these employers are themselves being pushed into the background.

If we look round we cannot fail to note that the directors of our great industries, the directors of our huge manufacturing establishments which lead the van in the commerce of the country, are often men who take a high place in the scientific world.

With workmen willing to give a fair day's work for a fair day's pay, officered and directed by foremen having a thorough technical training, and the whole governed by men to "the manner born," and not necessarily the product of any special system of education, Britain need not fear for the continuance and welfare of her industries.

Mr. W. S. Barrett: I beg to move a vote of thanks to the President for his address. He has touched upon many important points. I was particularly struck with the observations on the new methods. The object of the address, it seemed to me, was to show how we may assimilate the best of the old with the new, and that strikes me as very useful. There are many matters I might refer to, but I have a wholesome fear after what the President said at the opening of the meeting, of talking too much. I highly appreciate the address and feel obliged to the President for the trouble he has taken in preparing and delivering it.

Mr. J. S. Burrows: I have much pleasure in seconding the resolution. As an employer it has often puzzled me—and I don't see the end of it yet—why the mine owners, or many of them, have not pushed technical education more among their workpeople. But I see the difficulty very plainly, that in Lancashire, at any rate up to now, the great bulk of work in the pit has been laborious and the greatest qualifications a man could have were a pair of strong arms and a good constitution to stand the work he had to do. I believe, however, the day is not far distant when we shall have to take off a lot of our heavy labour. We shall have to adopt more machinery. Then it will be more to the interest of employers to have a highly-trained set of men to take charge of the machinery. I would rather have a man who had been trained in a technical school, who had had all the points explained and knew the mechanism of the machine so that he would know when something was wrong and whether it was within his power to repair the defect—I would rather, I say, have such a man in charge of a machine, a cutter, than one who had not had any training of that sort. Then the use of mechanical cutters will lead to a more systematic plan of timbering. When we have to keep four feet clear for the coal cutter we shall have to pay more attention to regularity and system in the work of timbering, the faces will also have to be kept straighter. In that way I look forward to the time when we shall have something better to offer a well-trained workman than we have now. I often wonder what inducement I have to offer our young people to attend technical schools. If they say: "Can you promote me if I do this?" I have to answer "No." We have only so many firemen and the positions are all filled, and it is so with other owners. I think that will account in a large measure for the apparent apathy with which the coal owners as a class have regarded technical education in their workpeople. But we see things moving, and in a few years probably we shall be seeking men to take charge of machines. The machines will do the heavy work but you must have the brains to direct them.

Mr. MARK STIRRUP, F.G.S.: Before the resolution is put I should like to say a word or two. Probably many of you have not seen a list of those distinguished gentlemen who have had the Imperial Service Order conferred upon them, which was published yesterday. I think you will find Mr. Hall's name there. I really think the Society ought to congratulate him upon the high honour he has received in being numbered among those who have received this new Order founded by the King.

The resolution was then put by Mr. BARRETT, and carried.

The PRESIDENT: I thank you very much for your kind vote of thanks. I think some kind of apology is due to the meeting for the selection of this particular subject, which seems to be a little apart from the objects of the Society. It is one, however, which is a good deal to the front just at present, and I selected it on that account. The kind of education I have spoken of is so thoroughly utilitarian, whilst geology is pursued for its own sake and not for any expected monetary advantage. I am very glad if I have interested you with the few remarks I have made. I thank Mr. Stirrup very much for his remarks on the other matter. Of course I naturally feel very much honoured that His Majesty has been graciously pleased to confer this decoration upon me, but I am equally appreciative of friends' and neighbours' kindness in trying to persuade me that it was deserved. I have been a good long time in Lancashire, a good many years. During that time I have always endeavoured to do my work impartially and fearlessly. I have always tried, as far as I could, to look after the safety of the workers and, if possible, to lessen their dangers, and I do not think I have been slow to recognise the practical difficulties of the managers and the employers. I thank you very much, gentlemen.

Mr. Mark Stirrup, F.G.S., presented the following report of the meeting of the British Association at Belfast, which he attended as the Society's delegate :—

REPORT OF THE DELEGATE (Mr. MARK STIRRUP, F.G.S.), TO THE MEETING OF THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION AT BELFAST, 10th SEPTEMBER, 1902.

The Manchester Geological Society, as its members are aware, has the honour of being one of the corresponding societies of the British Association. For many years past the Society has been represented at the annual meetings of this Parliament of Science, but last year, at Glasgow, no delegate was present on its behalf.

Nominated by your Council to represent the Society at the recent meeting of the Association at Belfast, I had at first some hesitation in accepting the post of delegate, an office which I have filled on several previous occasions, but of which I desired to be relieved this year by some younger member; no aspirant, it would appear, presented himself. However, I was able to attend the meeting, and was also present at the two conferences of the delegates, the attendance at the latter meetings being strongly urged upon the delegates, so that they may individually be able to report the proceedings to their respective societies, the neglect to do which on the part of a few at the Glasgow Meeting called forth severe remarks from the Secretary of the Corresponding Societies Committee.

I now proceed to report the proceedings as succinctly as possible, so that I may not be charged with dereliction of my duty.

The first meeting was opened by a short address from Professor Watts, of the Mason College, Birmingham, who remarked on the importance of local societies, such as field clubs, and urged the desirability of these and similar organisations keeping in touch with one another, so that united work might be the result. Research work, he said, should be the great aim of each Society.

The Professor also adverted to the importance of local societies preserving their publications, and observed that those having the charge of local museums should exercise great care in handing over to town or county councils collections which were often of much local interest and value.

Then followed Dr. Garson, Assistant General Secretary to the Association, who presented the Report of the Corresponding Societies Committee of last year's meeting at Glasgow. He complained of the great remissness on the part of the secretaries of local societies in making the requisite reports to the Association, thus causing needless correspondence, and further he charged the delegates with neglect in not adequately bringing before their societies the result of the work done by the Association. This was a fact, Dr. Garson said, which could not be disguised. Last year there were seven delegates who had made no reports at all to their societies, a serious matter, he confessed, requiring the attention of the societies implicated.

As some of the members of the Society may not be fully cognisant of the purpose for which the appointment of Corresponding Societies is made, I may briefly explain, viz., to aid, whenever possible, the Committees of the British Association, which are annually appointed for carrying out scientific research in all those departments of knowledge covered by the sections of the Association. Further information as to the character of the work desiderated may be gleaned from a study of the Committee's circular before mentioned, a copy of which I now lay on the table.

If time permitted I might refer to one or two paragraphs of this document as explanatory of this point.

After some discussion on the part of the delegates as to how better results might be obtained from the corresponding societies, the Conference was closed.

The second Conference of the Delegates took place on the 16th September, under the presidency of Professor Watts, when representatives of the sections were heard on behalf of any special work recommended by them. Dr. Mill and others attended on behalf of their respective sections, and urged certain subjects for consideration.

The larger part of the time of the meeting was, however, devoted to the reading of a paper by Mr. G. F. Tocher, on the "Pigmentation Survey of Scottish School Children"—an endeavour to trace the origin of their ancestors by physical characteristics—a subject promoted by the Anthropological Section.

It will thus be recognised that these scientific investigations embrace a wide and various field, many of which lie quite outside our line of operations. There are others, however, such as Coast Erosion, the Distribution of Erratic Blocks, the Course of Underground Waters, and the Geological Photographs Committee (a series of whose prints have been purchased by the Society, and are now lying on the table for inspection), which may claim our help.

If any of these investigations, or others of like import, can be promoted by the members, individually or collectively, it is evidently our duty to help. Further information on these matters may be obtained from a study of the Corresponding Societies' Annual Reports, which are bound up with the Association volume.

The names of 58 Societies were published as sending Delegates to Belfast, but of these scarcely one-fourth was represented at the two Conferences.

These Societies represent, in a great measure, the activity of lovers of natural science and of workers in applied science distributed throughout various and distant parts of Great Britain; the only part of the United Kingdom apparently unrepresented by any scientific association is Wales.

The number of members in attendance at the meeting was given as 1,620.

Following the custom of previous years, I will bring my Report to a close by a review of some of the salient features of the Association meeting, which seem to me to have distinguished it; personal impressions being well aided by the agency of the local Press, thus enabling one to form an opinion of what was doing in other sections than the one which had special claims on one's presence.

The attendance of members at Belfast was rather below the average, probably because there was no special attraction announced of a great leader among men, such as Tyndall or Huxley, as at the last Belfast meeting, no geographical explorer from ice-bound seas or desert lands was available; indeed, as the years pass, it would seem that in the near future there will be few tracts on the globe able to be cited as unknown or unexplored, after the Antarctic and Arctic regions have yielded up their secrets.

Deprived of any adventitious influence or attraction, the meeting was allowed to be a good average one, with many special points of interest, the Presidents of the Sections being, in many cases, men of great power and individuality.

The Local Committee and inhabitants of Belfast deserve the highest praise for their commendable efforts to honour their visitors. Private hospitality, official receptions by the Mayor and Corporation of Belfast, garden parties and excursions, formed an acceptable relief to attendance on the sections.

The Belfast Tram Company presented free tickets throughout their service to visitors—a boon which was much appreciated.

Speaking first of Section C (Geology), the address of the President (Colonel MacMahon) was on Rock Metamorphism, an important though somewhat technical subject. The other papers read were principally concerned with Irish Geology. Among others of interest, Prof. Cole gave an admirable *resumé* of the geological structure of Ireland, illustrated by lantern views. Mr. J. Wright, an eminent local microscopist, maintained his well-known views on the *marine* origin of the boulder clay, as proved by its marine organisms. A discussion on this paper brought up supporters of the conflicting views which are held on the origin of glacial deposits. An address by Mr. John Milne, F.R.S., on "World-Shaking Earthquakes," before the Geographical Section, drew a large audience, influenced probably by the great interest excited by the recent extraordinary exhibitions of volcanic energy in the Antilles. In describing the regions whence these earthquake shocks proceeded, Mr. Milne said they were situated on the flanks or near the base of the steepest flexures on the earth's surface.

With the exception of the Caucasian and Himalayan regions, they were all sub-marine, and their boundary ridges were, for the most part, lined with volcanic peaks. Mr. Milne gave instances of many world-shaking earthquakes, resulting in subsidences and elevations of land. When the origins had been sub-oceanic, as many of them were, soundings had shown that vast depressions had been formed, while coast lines had been raised or lowered.

Such like observations, he said, indicated that large earthquakes originated in vast earth movements, deepening the depressions already existing on the ocean floor and elevating the ridges. This elevation might relieve constraint at volcanic foci, with the result that volcanos, particularly those which had been sealed for many years, might suddenly burst into activity, like those in the Antilles. Thus it would appear that great earthquakes were due to adjustments of the earth's crust, and volcanic activity, as a rule, the result of these dislocations.

It follows, that the popular idea of earthquakes being due to volcanic eruptions is not correct, a statement greatly supported by earthquake recording instruments, which inform us that the 10,000 small earthquakes which occur in the world annually have no sensible relationship to volcanos whatever.

In the Geographical Section, addresses, on the present Antarctic Expeditions and their object, were given by Dr. Hill and Mr. Bruce, the latter speaking specially on the organisation of the Scottish Expedition.

The other sections, which I had little opportunity of visiting, were, I believe, all amply supplied with their special scientific pabulum.

One of the most striking features of the meeting was the interest, oft-times bordering on excitement, aroused by the discussions in the recently established Educational Science Section.

Professor Armstrong (the President) delivered a stimulating and important address on "Education in the United Kingdom," in which he vigorously denounced existing systems and suggested radical reforms in the methods of teaching. The old idea of the value of Latin as an educational subject, he said, has been grossly exaggerated, and the study of Mathematics greatly over-valued. There was, Professor Armstrong remarked, a want of plasticity of mind in the English methods of instruction, the lack of power of adaptation of new conditions.

An equally fervent and impressive address on a similar educational topic was given to the Engineering Section by its President (Professor John Perry, D.Sc., F.R.S.), in which Classics and the study of Euclid were again described as impediments in the education of the young engineer, Professor Perry advocating a greater attention to English, Applied Mathematics, and the Natural Sciences.

A joint meeting of the Engineering and Education Sections was arranged, a sort of Educational Field Day, when eminent educationists discussed with vigour the various views put forward.

Such are a few of the points of interest which engaged my attention, a summary of which falls far short of embracing a full outline of the scientific work of the Association.

To anyone wishing to gain an intelligent insight into the value of the work promoted by the agency of the British Association, I would earnestly recommend to their perusal the joint addresses of the President of the meeting and the Presidents of the sections, wherein will be found an invaluable record of the present position of science in our midst, and suggestions of better methods for its promotion and teaching in the future.

A vote of thanks was accorded Mr. Stirrup for his Report.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART III. VOL. XXVIII. SESSION 1902-1903.

The ORDINARY MEETING of the Members was held on Tuesday, December 9th, 1902, in the Society's Rooms, 5, John Dalton Street, Manchester.

Mr. HENRY HALL, I.S.O., H.M.I.M., President, in the Chair.

The following paper by Mr. JOSEPH DICKINSON, F.G.S., on "Heaton Park Borehole, near Manchester, with Notes on the surroundings," was read:—

HEATON PARK BOREHOLE, NEAR MANCHESTER, WITH NOTES ON THE SURROUNDINGS.

By Mr. JOSEPH DICKINSON, F.G.S.

This borehole, called No. 1, was bored for the Right Honourable the Earl of Wilton. It was commenced August 26th, 1895, and ceased February 26th, 1897, by the Vivian's Boring and Exploration Company, Limited, Whitehaven.

Heaton Park in which it is situated has now been purchased by the Manchester Corporation. The copy of the

Section of strata bored through with plan showing the position of the borehole has been given to the writer by the Parks Committee through the courtesy of Mr. William Henry Talbot, the Town Clerk, and it is signed by Mr. T. de Courcy Meade (M.Inst.C.E., F.G.S.), the City Surveyor, and initialled as examined by R. G., and sent September 24th, 1902. The accuracy of the copy now exhibited is therefore adequately vouched.

It is a deep exploration in a part of the Lancashire coalfield hitherto but little known, and being very important general information, a few observations on the surroundings seem desirable.

These are divided into:—

I. The Lancashire coalfield.
II. Surroundings of the borehole.
III. Summary of the results.
IV. Conclusion.
V. Details of the Strata bored through.

I. The Lancashire Coalfield.

The main Lancashire coalfield in which the borehole is situate is in the form of an amphitheatre, having in the interior seams of coal cropping out underneath each other instead of seats, and faults intervening instead of gangways.

The outline of the coalfield, beginning at Huyton and going north about, passes near Prescot, St. Helens, Bickerstaffe, Wrightington, Euxton, Chorley, Blackburn, Great Harwood, Colne, Burnley, Cliviger, Todmorden, Littleborough, Mossley, Stalybridge, and thence into Cheshire. The dip throughout this range is mainly from the outskirts towards the centre of the chord, or a little south of the centre.

On the south side of the chord the coalfield is covered with other formations; and occasionally these formations jut into the interior and also occur isolated.

These overlying formations are chiefly of reddish colour, from which and the divisions not being well known in former times they were often grouped as "Red rock." The divisions are now fairly well known to ordinary mining men as the Upper new red sandstone, Permian marls, and Permian or Lower new red sandstone. In the vicinity of Manchester they lie conformably with each other like ordinary strata but unconformable with the coalfield, sometimes one and sometimes another of the members being in juxtaposition, the lower member being occasionally broken up into sand. Having to be often mentioned in this paper they will for brevity where separation is unessential be termed Red rock.

Although the Red rock and this coalfield are unconformable each formation is similarly dislocated by the same main faults. As an instance of the unconformability it may be mentioned that at Patricroft old colliery west of Manchester the Red rock is about 385 yards above the Worsley four foot coal, whilst at Tyldesley about six miles further west the Red rock lies immediately upon the outcrop of the same coal—the approach of the Red rock to the coal in this distance averaging about 65 feet per mile. Further west than Tyldesley the approach of the Red rock to lower members of the coal measures is similar; and if needed other instances could be given. Juxtaposition of the formations does not therefore afford any clue to the identity of underlying coal measures unless accompanied by other proof.

A common section of the Red rock about Manchester at the places where all the three members are fully represented is:—

Upper new red or Bunter sandstone.	Mottled U.N.R. Pebble beds.	about 300 yards or so.
Permian marls.	The lower part especially containing gypsum, thin beds and lumps of limestone, with fossil shells, the bottom stratum being conglomerate.	about 65 yards or so.
Lower new red or Permian sandstone.	Soft (suitable for moulding), sometimes variegated.	about 250 yards or so.

For the sake of distinction it may be stated here that the beds of limestone worked at Ardwick, Manchester, are entirely distinct from the Permian limestones. The Ardwick limestones lie in from 30 to 40 yards of ground, sometimes with a thin coal, and are classed with the upper coalfield.

II. Surroundings of the Borehole.

The borehole is near the north side of Heaton park, about half a mile north of Heaton house; other distances being 217 yards south of Bridle road and 295 yards east of Keepers house or Dog Kennel cottages, the exact point being 26 yards east of the Fish pond, and 43 yards south east of the plantation abutment on the north arm of the pond.

It is surrounded by the Lancashire coalfield, but is within an area including the park and vicinity about four miles square or 16 square miles without any colliery working.

The top of the borehole is about 300 ft. above Ordnance datum or mean water tide at Liverpool.

The coal workings surrounding the area in which the borehole is situated are:—

Pendleton, Pendlebury, Clifton, &c.; in the upper and middle coalfield, on the upthrow or S.W. side of the Great Irwell valley fault, 3 miles from the borehole.

Ringley buildings, Outwood, on the downthrow side of the Irwell valley fault; in the Worsley 4 ft. coal which divides the upper from the lower coalfield, 3 m. S.W. by W. from the borehole.

Park road exploration, Hughes Wood, Outwood; 2 m. S.W.

Outwood; middle coalfield, 2¾ m. W.

Stand lane; Worsley 4 ft. and middle coalfield, 3 m. N.W.W.

Radcliffe and Bank top; middle coalfield, 3 m. N.W.

Bury; Dogshaw seam, bottom of middle coalfield, 3½ m. N.W.

Pilsworth; Three-quarter seam, lower coalfield, 2 m. direct N.

Hopwood; Royley seam, bottom of middle coalfield, 3 m. N.E.

Middleton and Tonge; middle coalfield, 2½ to 3 m. N.E.E.

Alkrington; middle coalfield, 2 m. E.

Moston; middle coalfield, 3 m. S.E.

Manchester: St. George's, Bradford, and Clayton; upper coalfield, 3½ m. S.S.E. from the borehole.

The Faults adjacent to the area in which the borehole is situated, and their approximate throws, are:—

Great Irwell valley fault; down N.E. 1,000 yards, bringing in the Red rock, from beyond which the coalfield again emerges.

Knob end fault; down S.W. 50 yards, decreasing E. to 35 yards.

Ringley road fault; very flat, down N.E. 500 yards.

Higher barn fault; down S.W. 130 yards.

Radcliffe Bridge, Stand lane, and Radcliffe faults; various throws, ultimately bringing in the outcrop of the Red rock which extends along the S. side of the River Irwell to the confluence of the River Roch.

Hinds mill fault with junctions, turning E. and N.E.E. at N.W. of Blackford bridge.

Bury faults; a pair of small faults with belt of Dogshaw coal between, and a large fault not yet fully proved.

Pilsworth fault, on the dip of the Three quarter coal.

Alkrington great fault; E. of Alkrington wood.

Moston faults; various, with Red rock on the dip.

Manchester faults: Clayton fault, down E. 600 yards, throwing in the Red rock; St. George's fault, down N.W. 400 yards bringing in the Red rock; Ardwick faults, down N.E. 90 yards with a continuing main fault down S.W. bringing in the Red rock.

At the downthrown side of the great faults are seams of coal and other strata which are not in at the immediately opposite up side. These up parts from which the strata has been denuded or removed vary in size according to the amount of throw and rate of dip. The denuded part of the Worsley 4 ft. seam at the up side of the Irwell valley fault is about six miles in length, and the greatest width about four miles.

The drift covering most of the area surrounding the borehole is deep, varying from 40 to 60 yards. In forming the Lancashire and Yorkshire Railway through Heaton Park some of the ground met with was quicksand, requiring timber, bent iron rails, and grouting to form a foundation. The cutting was first made opencast, and then encased with brickwork in tunnel form.

This deep drift has been a main cause in delaying the proving of the area. Notwithstanding the want of proof, however, the six-inch to the mile geological survey maps had to be filled in. The filling has been done as ably as possible, without proof of the subsoil; but it is now apparent, from the information afforded by this borehole, that some parts would have been shown differently had the information been available. The Red rock also, along the south side of the River Irwell, from near Radcliffe Bridge to the River Roch, would not have been termed "banks of sand and boulder clays, and sands resting on boulder clay," had the publicly reported finding of gypsum in the marls, when cutting the foundation of the since constructed railway bridge, been then known.

Unproved areas are best left blank, and the old rule of never drawing a fault beyond its proof is commendable.

III. Summary of the Boring.

The borehole was believed to be more or less in faulty ground, and the coal met with was considerably squeezed.

Tubing was inserted from the surface, decreasing in diameter at the following depths:—

		Yds.	ft.	in.
12 inch. tubes	to	6	1	6
10 ditto	„	51	1	1
$8\frac{3}{8}$ ditto	„	192	2	7
$7\frac{1}{8}$, $6\frac{1}{8}$, $5\frac{1}{4}$, $4\frac{1}{4}$ inch.	„	497	2	9
$3\frac{1}{2}$ inch.	„	542	2	0
3 ditto	„	684	0	8
$2\frac{1}{2}$ ditto		?		
Total depth		790	2	2

Abstract of the Strata Bored through.

					Thickness.			Total Depth.		
		Yds.	ft.	in.	Yds.	ft.	in.	Yds.	ft.	in.
Red rock.	Soil, sand, clay, gravel, fragment of coal and other Drift	....			47	1	11	47	1	11
	Upper New Red or Bunter Sandstone.. { Mottled	79	1	5	117	2	4	165	1	3
	Upper New Red or Bunter Sandstone.. { Pebble beds	38	0	11						
	Permian Marls, with grey sandstone containing lime, anhydrite, gypsum, limestone beds, sandstone, and at bottom 5 ft. of conglomerate	....			86	2	11	252	1	2
	Permian, or Lower New Red sandstone—soft..	....			277	2	4	530	0	6
Coal Measures.	Grey sandstone, shale and sandstone chiefly red with iron ore in the upper parts	86	1	4	260	1	8	616	1	10
	Black shale containing Gas Coal	1	0	2				617	2	0
	Shale, sandstone, shale with ironstones	66	2	8				684	1	8
	Coal	0	0	11				684	2	7
	Fireclay, shale, sandstone, ironstones	41	1	1				726	0	8
	Bastard grey sandstone containing Lime	1	0	7				727	1	3
	Shale with ironstones	63	0	11				790	2	2

IV. Conclusion.

The main practical views to be drawn from the account of this boring are the help it affords in solving the problem of the richness or poorness of the large area surrounded by coalfield, and what portion of the coal measures have been struck into below the Red rock. Preliminary, the depth of 530 yards to the bottom of the Red rock, and the absence of proved workable coal, precludes sinking shafts, but the information may help further investigation, and lead to useful results.

In some aspects the information is less than the opportunity afforded. It does not specify the rates of dip and fossils shown by the cores obtained from the borehole, nor whether water was met with during the boring, nor whether the minerals met with were analysed or only judged by eyesight.

Some of this information is still available. The cores may yet be tested, and it appears that an expert mining engineer who viewed the operations from time to time, still survives.

On one of the occasions when Heaton Park was open to the public after the boring had ceased, the writer of this paper visited the site of the borehole, and saw the numerous spare cores then lying about, but now he is informed that the site has since been cultivated. He has also recently (December 1, 1902) seen the specimen cores which are preserved in the clock tower loft near the Heaton house residence.

The cores in the loft are arranged in rows on the floor, those from the lower or coal measure portion of the boring being in boxes. All are dusty. Many have mouldered and laminated with age, but the substance is intact. Some have labels, others none. The rows are numerous and long, some of the boxes containing half a dozen rows side by side. To inspect all carefully would occupy a long time, but it could be done.

From the writer's brief viewing and few measurements taken, the cores vary in diameter from 6½ inches at the upper part of the borehole to a little more than one inch at the lower part; and the rate of dip shown by some of them is 3 to 4 degrees from the horizontal, the dip of those from the Red rock being less and those from the coal measures more, one small exceptional core of tough clay resembling the substance commonly met with in fault veins, being about 45°, indicating faulty ground.

Some fossil shells would most likely be met with in the lower portion of the Permian marls, and had the absence of water in the borehole been mentioned an inference might be drawn either that water was barred off by a fault or was being pumped from some of the deep wells at works on the dip.

The Red rock cores do not show any sign of fault. The Upper new red sandstone is only about half on at the site, but the Permian marls and the Permian sandstone are each more than the average thickness, which shows that not any part of them has been missed by fault.

The tough clay, like that in fault-veins mentioned above, was a coal measure core. It was labelled 2053-7, which, if feet, indicate about 684 to 686 yards, in which is the eleven-inch coal, where passing through a large fault would miss many strata and show an incorrect succession in the section.

The core of the 3 ft. 2 in. bed of black shale, containing gas coal at 617 yards and of the 11 in. bed at 684 yards, were looked for but not found.

The core of the 3 ft. 7 in. bed of sandstone containing lime at 727 yards, was also looked for, hoping that if other beds of like kind had been missed by a fault the bed left might indicate whether it belonged to the series of Ardwick limestones, but it was not found.

Here it may be interpolated that in hurried boring seams of coal have been passed through without being recorded, and that cores insufficiently tested have been wrongly named; it must, however, be added that as regards the present boring there is not any supposition of such an occurrence.

Taking the section as it is, and without further proof of a fault having been passed through than that mentioned, the three distances in the coal measures—86 yards next below the Red rock to the shale containing gas coal, next 66 yards to the eleven-inch coal, but especially the 105 yards lower without any coal, are distances without coal seldom, if ever, met with in the middle series of the Lancashire coalfield. Such distances are, however, to be found in the upper and in the lower series, especially in the upper; it is therefore likely that it is into either the upper or the lower series that the borehole penetrated.

The Red rock and the coalfield being unconformable affords no clue to the particular portion of the coal measures struck into in an isolated area. And as to the iron ore met with immediately below the Red rock that is too common to help correlation.

The surroundings of the area in which the borehole is situated show, as described, that one of the three series has been worked. Also that numerous faults course, in various directions, the throw of the largest being more than the thickness of strata in any one of the three series.

Issues of water in the park indicate that either fault or barrier of some kind traverses the area.

Arbitrary decision of the exact portion of the coal measures penetrated by the borehole may therefore await further evidence.

The following section in Part V. gives the details of the strata bored through, as furnished, except that the writer has distinguished the respective formations.

V. Details of the Strata bored through in No. 1 Borehole, Heaton Park.

Begun August 26th, 1895.

Drift 47 1 11.

	Thickness. Yds.	Ft.	In.	Total Depth. Yds.	Ft.	In.
Soil .. .. *12 in. tubes*	0	1	0	0	1	0
Sand	1	0	0	1	1	0
Loamy sand	1	1	0	2	2	0
Brown sandy clay with small stones	0	1	9	3	0	9
Sand (wet)	2	1	3	5	2	0
Loamy sand .. .. *10 in. tubes*	0	2	6	6	1	6
Brown sandy clay	0	2	0	7	0	6
Dark brown pinnel with stones	0	1	6	7	2	0
Brown sandy clay	0	1	6	8	0	6
Sand and fine gravel	0	1	0	8	1	6
Loamy sand	0	2	0	9	0	6
Sand and small stones	1	2	3	10	2	9
Hard bound fine gravel (red)	0	2	3	11	2	0
Hard red sand and small stones	4	0	0	15	2	0
Red sandstone	0	0	9	15	2	9
Brown sandy clay and cobbles	0	2	6	16	2	3
Fine gravel (hard)	0	2	0	17	1	3
Sand (dry)	1	0	0	18	1	3
Red sand and gravel	1	1	0	19	2	3
Running sand	1	0	0	20	2	3
Foul coal (drift)	0	0	3	20	2	6
Running sand	4	0	9	25	0	3
Red sand (firm)	4	1	5	29	1	8
Brown sandy clay	0	1	0	29	2	8
Stiff brown clay and gravel	0	2	8	30	2	4
Red sandstone (soft) and pebbles	2	2	5	33	1	9
Reddish dry sand and gravel	1	2	4	35	1	1
Brown clay and gravel	5	0	7	40	1	8
Reddish clay and stones	2	1	0	42	2	8
Stiff brown clay and stones	3	2	3	46	1	11
Yellow sand and gravel	1	0	0	47	1	11

			Thickness.			Total Depth.		
			Yds.	Ft.	In.	Yds.	Ft.	In.
Upper new red sandstone 117 2 4.	Mottled Sandstone 79 1 5.	Red sandstone (soft)	1	0	1	48	2	0
		Red sandstone (hard)	0	1	6	49	0	6
		Red sandstone (hard, soft joint) *8⅝ in. tubes.*	2	0	7	51	1	1
		Red sandstone	47	0	1	98	1	2
		Grey sandstone	0	1	0	98	2	2
		Red marl	0	1	4	99	0	6
		Grey sandstone	0	0	10	99	1	4
		Red sandstone	3	2	2	103	0	6
		Grey sandstone	0	1	0	103	1	6
		Red Marl	0	0	10	103	2	4
		Red sandstone	23	1	0	127	0	4
	Pebble Beds 38 0 11	Red sandstone with pebbles ..	10	1	3	137	1	7
		Red sandstone	13	2	10	151	1	5
		Red sandstone with pebbles ..	7	0	4	158	1	9
		Red sandstone	6	2	6	165	1	3
Permian.	Marls 86 2 11.	Grey sandstone containing lime.. ..	0	0	6	165	1	9
		Red marl..	1	0	0	166	1	9
		Red marl mixed with grey sandstone..	0	1	9	167	0	6
		Red marl	6	1	6	173	2	0
		Strong red marl mixed with gypsum..	1	0	6	174	2	6
		Reddish grey Anhydrite	1	1	0	176	0	6
		Strong red marl mixed with gypsum..	15	2	7	192	0	1
		Red marl and limestone	0	1	9	192	1	10
		Red marl.. .. .. .. *7½ in. tubes*	0	0	9	192	2	7
		Red marl with gypsum	14	0	4	206	2	11
		Red and blue marl with gypsum ..	1	0	0	207	2	11
		Grey limestone	0	0	5	208	0	4
		Red marl	11	2	3	219	2	7
		Grey sandstone	0	0	6	220	0	1
		Red marl	1	2	0	221	2	1
		Red marl with beds of grey marl....	4	0	8	225	2	9
		Red marl with beds of blue marl ..	11	1	3	237	1	0
		Red marl with blue beds and gypsum balls..	1	1	0	238	2	0

			Thickness.			Total Depth.		
			Yds.	Ft.	In.	Yds.	Ft.	In.
Permian.	Marls 86 2 11.	Red marl with blue beds	5	2	5	244	1	5
		Red marl..	1	2	0	246	0	5
		Grey sandstone	0	1	4	246	1	9
		Red sandstone	4	0	5	250	2	2
		Red sandstone mixed with pebbles, conglomerate	1	2	0	252	1	2
	Lower new red sandstone 277 2 4	Red sandstone (soft)	47	1	10	300	0	0
		Red sandstone (very soft)..*6½, 5½, and 4½in. tubes*	143	2	4	443	2	4
		Red sandstone mixed with grey ..	3	1	3	447	0	7
		Red sandstone (hard)	2	2	5	450	0	0
		Red sandstone .. .. *3½in. tubes*	47	2	9	497	2	9
		Red and grey sandstone..	1	2	9	499	2	6
		Red sandstone	30	1	0	530	0	6
Coal Measures 260 1 8.		Grey sandstone	0	0	6	530	1	0
		Red marl mixed with iron ore	1	0	4	531	1	4
		Red shale with iron ore joints	3	1	0	534	2	4
		Red and grey shale mixed with iron ore ..	4	2	5	539	1	9
		Red and grey shale (sandy) .. *3in. tubes*	3	0	3	542	2	0
		Reddish grey sandstone..	2	0	0	544	2	0
		Reddish grey sandstone with iron ore joints	5	2	9	550	1	9
		Dark red shale with iron ore joints	7	0	9	557	2	6
		Red shale with ore joints..	2	1	5	560	0	11
		Reddish grey shaley sandstone	2	1	0	562	1	11
		Red shale with ore joints	5	1	1	568	0	0
		Red and grey sandy shale with iron ore joints	3	1	2	571	1	2
		Red shale	4	2	8	576	0	10
		Red shale with iron ore joints	3	1	2	579	2	0
		Reddish grey sandstone	1	2	0	581	1	0
		Reddish grey sandy shale with ore joints..	0	2	0	582	0	0
		Red shale	12	1	6	594	1	6
		Grey sandstone with spar joints	0	0	2	594	1	8
		Red shale with iron ore joints	15	1	9	610	0	5

Coal Measures 260 1 8.

	Thickness. Yds.	Ft.	In.		Total Depth. Yds.	Ft.	In.
Reddish grey sandstone..	0	0	3	..	610	0	8
Dark blue shale with iron ore joints.. ..	3	2	9	..	614	0	5
Dark red shale with iron ore joints	1	2	8	..	616	0	1
Dark red shale	0	1	0	..	616	1	1
Black shale	0	0	9	..	616	1	10
Black shale containing Gas Coal	1	0	2	..	617	2	0
Blue shale	0	1	6	..	618	0	6
Blue shale with grey sandstone..	2	1	0	..	620	1	6
Grey sandstone with iron ore and spar....	2	0	0	..	622	1	6
Blue sandy shale	2	2	4	..	625	0	10
Blue shale with ironstone bands	6	1	0	..	631	1	10
Dark blue shale	1	0	10	..	632	2	8
Yellow sandstone (hard)..	0	1	3	..	633	0	11
Blue shale with ironstone balls..	1	1	6	..	634	2	5
Grey sandy shale	0	0	9	..	635	0	2
Blue shale with ironstone bands	1	1	0	..	636	1	2
Grey shaley sandstone	2	0	0	..	638	1	2
Dark grey shaley sandstone with ironstone bands	3	2	2	..	642	0	4
Yellowish grey sandstone	2	1	3	..	644	1	7
Blue shale with ironstone bands	12	1	3	..	656	2	10
Grey fireclay parting (soft)	0	0	2	..	657	0	0
Blue fireclay (hard) with ironstone balls..	2	2	5	..	659	2	5
Blue shale	6	0	9	..	666	0	2
Blue shale with ironstone balls..	9	1	4	..	675	1	6
Bluish grey sandy shale with ironstone bands	1	1	4	..	676	2	10
Bluish grey sandstone (hard)	0	2	0	..	677	1	10
Blue shale with ironstone balls	6	1	10	..	684	0	8
Dark fireclay (hard) .. .. *2½ in tubes*	0	1	0	..	684	1	8
Coal	0	0	11	..	684	2	7
Grey fireclay (soft)	1	0	0	..	685	2	7
Blue shale with ironstone balls	2	2	0	..	688	1	7
Bastard grey sandstone	1	0	0	..	689	1	7
Dark fireclay (rotten)	3	2	8	..	693	1	3

Coal Measures 260 1 8.

	Thickness. Yds.	Ft.	In.		Total Depth. Yds.	Ft.	In.
Dark sandy shale	1	2	0	..	695	0	3
Yellowish grey sandstone	0	1	0	..	695	1	3
Blue shale with ironstone bands	2	2	8	..	698	0	11
Grey sandy shale	0	0	4	..	698	1	3
Black sandy shale	1	1	9	..	700	0	0
Black sandy shale with ironstone bands ..	11	1	8	..	711	1	8
Grey bastard sandstone..	0	1	0	..	711	2	8
Blue sandy shale	6	1	7	..	718	1	3
Blue and grey sandy shale	7	2	5	..	726	0	8
Bastard grey sandstone containing lime ..	1	0	7	..	727	1	3
Blue and grey sandy shale	15	2	9	..	743	1	0
Blue shale	8	1	7	..	751	2	7
Blue shale with ironstone balls	4	0	0	..	755	2	7
Rusty blue shale with spar joints	0	1	0	..	756	0	7
Blue shale	3	0	4	..	759	0	11
Blue sandy shale	28	2	3	..	788	0	2
Blue shale .. *Ceased Feb. 26th, 1897* ..	2	2	0	..	790	2	2

Mr. W. S. Barrett: I beg to move a vote of thanks to Mr. Dickinson for his very interesting paper. It shows a great deal of research, care, and labour on his part, and it is specially interesting to us, because of the light which it throws on the position of the coal in this part of Lancashire. I am not prepared to criticise it at all, but I thank him for the paper he has given us.

Mr. John Gerrard: I have the greatest possible pleasure in seconding the motion. Mr Dickinson has secured many valuable records, and this, in my judgment, is valuable. First, because it is a section in a district hitherto unproved; second, it will prevent large sums of money being spent in that locality to win coal, until further information be obtained. I would like to suggest that a committee of the Society examine the cores, for one thing to ascertain what fossils are therein.

The resolution was adopted.

The PRESIDENT invited discussion on the paper.

Mr. LIONEL B. WELLS: I did not hear Mr. Dickinson fix the centre of the amphitheatre into which the surrounding coal strata dipped.

Mr. DICKINSON: The deepest part of the coalfield is near Manchester, and south of the amphitheatre.

Mr. GERRARD: Can Mr. Dickinson tell us if the gas coal mentioned in the section is cannel coal?

Mr. DICKINSON: I searched to find the shale containing gas coal, and I searched to find the eleven-inch coal, but unsuccessfully. We did find near to that faulted piece of ground I mentioned a small piece of core as big as your thumb-nail, with some shale attached to it, but without any number. I can give you no further account beyond what I have mentioned in the paper. I was told that both coal seams were met with in a crushed state.

Mr. ROBERT WINSTANLEY, C.E.: No doubt the paper read by Mr. Dickinson is very valuable, so far as information goes, but I must confess, as one interested in the neighbourhood, that the section and information obtained is, so far as leading to any results, not very encouraging. What we have heard to-day will not induce anyone to spend £100,000 in sinking for coal there. A depth of 800 yards is a serious thing to contemplate. I had hoped to find the coal measures nearer to the surface. The information Mr. Dickinson has given us will be of great value if anyone thinks of making further borings in that district.

The PRESIDENT: What strikes me, knowing nothing about this district, is that Mr. Dickinson seems to have read the paper as a kind of warning. I do not think anybody is likely to spend money there, but possibly Mr. Dickinson's paper may prevent an attempt of that kind.

The following notes "On Coal-Cutting by Machinery" were read by Mr. A. DURY MITTON, Assoc.M.Inst.C.E.:—

NOTES ON COAL-CUTTING BY MACHINERY.

By Mr. A. Dury Mitton, Assoc.M.Inst.C.E.

I was asked to read a paper before your Society some short time ago, but pressure of work combined with a certain amount of diffidence prevented my performing such a task, especially knowing the excellent papers upon geological and mining subjects that have appeared in the Transactions; I therefore suggested to your Secretary that I would prefer to give some notes upon the very important subject of Coal-Cutting by Machinery that has come under my immediate notice; with a view to open a discussion upon the subject. I am sure there are several mining gentlemen in Lancashire who are present, who, if they are willing to contribute towards the discussion, will add considerable interest to the subject that it will form, in itself, an interesting and instructive paper; as it is a subject that specially interests mining men at the present time, not only in this county of Lancashire, but in every mining county in England, Wales, and Scotland, where coal cutting by machinery can be adopted. Why? Simply because we are labouring under peculiar conditions, viz.:—First, a very high rate of wages for the labour producing cost of the coal at the working face, by reason in late years of increased combination and unionism: Second, as years go on, *the supply* is gradually overtaking *the demand*, by reason of scientific engineering skill, hence increased competition is reducing the cost of the merchantable article upon the market, and Third, in the last few years the coal owner, and rightly too, has been compelled to pay more attention to the ventilation and safety of the collier; hence the casting round for cheaper methods of producing the coal from beneath the surface.

Now I propose to take the following three heads as a basis of argument :—

1. What coal-cutting machine and motive power is the best to adopt?

2. Under what circumstances can coal-cutting machines be adopted?

3. What is the benefit derived by the coal owners?

First of all taking the question of motive power for driving coal-cutters, I cannot bring myself yet into that state of mind to approve of applying an electrical current through the coal faces, however much I am aware of the great gain in its efficiency over compressed air as a power for driving coal-cutters. I do not say this antipathy to electric power extends to its application to haulage and pumping under certain conditions; some here may not agree with me; no doubt it is open to argument, but in my case in this particular occasion of my starting coal-cutters at the Bridgewater Trustees' Collieries, compressed air plants were adopted for haulage and pumping, hence electric coal-cutters had to give way to the compressed air power already provided at considerable outlay. Now in considering the question of a suitable coal-cutter for long-wall faces, I had under consideration the Bar machine, one of which machines is patented by Mr. Hurd; I have witnessed its work driven by electricity, in Lancashire, and I like its principle of construction very much. The advantages are, in my opinion, that it can cut thin mines on the top as well as underneath by the elevation of the Bar; a deep cutting can be obtained, and less frictional disturbance made to the roof than by a Rotary machine; but when I found that the price was much more than for a Rotary machine and no delivery could be made under six months and nothing less could be taken for a machine of this type to be worked by compressed air I could not entertain it, but I may say that if the Bar machine could be made to work by compressed air upon equal terms with a Rotary machine, I consider there will be a great future for it. The Rotary machines were my next consideration, and I made enquiries about the "Gillott," the "Clark & Steavenson," the "Yorkshire Engineering Company," and the "Jeffrey."

The prices quoted were from £160 to £200 for compressed air power machines for a 3 ft. 6 in. holing, which I consider most suitable for the seams that I had to work them in, after taking into account the nature of the roofs. If there is a very strong, close coal, and good roof, a depth of cut up to 5 ft. can be worked with advantage.

No doubt, the difference in prices referred to above may be to some extent according to the strength of the material in the machine, but I decided in favour of Gillott's machine, because of its lightness, and because it could be worked backwards and forwards by simply reversing the teeth—two points I consider most important, especially in steep mines, which, if not adopted, necessitate a great amount of extra work in conveying a coal-cutting machine round the gate roads after each cut along the working face.

Now, under my second head, I have had a somewhat varied experience, and have both failed and succeeded. I think it well to mention failures, as the object of remarks of this kind is to assist others who may entertain the question of trying mechanical coal-cutters in the future.

I had a seam of coal 5 ft. thick, which had a fireclay floor. In this fireclay the colliers would not hole, as they considered it was against their interest to do so, although it was of a soft nature. I found that by not holing in the fireclay the coal was hard and "winded," and the collier was only earning about 4s. 6d. per day, which was a low average wage when the wages were 30 per cent. above the 1888 standard. As they declined to do this, I put in a coal-cutter to hole in the fireclay, and having compressed air quite close to, it cost very little. When this was done and the machine had worked some weeks, the coal began to completely change its character, and being a thick seam with sooty partings, it fell upon the machine to such an extent that it blocked it considerably, and impeded its work; in fact, it would have been impossible to continue, and as the colliers disliked the "iron man"—for what reason, goodness knows!—they willingly said they would continue holing in the fireclay if I would take it away; and after the machine was withdrawn the men increased their wages up to 6s. 6d. per day.

In another mine I tried a machine with the following section:—

METAL ROOF—SOFT.

	ft.	in.	ft.	in.	
Roof Coal	3	0			
Top Coal	1	4	1	0	Coal worked.
Dirt	0	11	1	4	
Good Coal..	0	9	0	9	
Band	0	1	2	9	
Bottom Coal	2	9	5	10	
	8	10			

This seam was very hard, and the cost was very high. It was usually worked in bays of from 15 to 20 yards wide, on account of a bad metal roof, there being no strata for seven yards worth relying on. I opened a face of 60 yards long, and the cutter did its work very well indeed, and plenty of coal was obtained, but the great drawback was the insufficient support behind, and with this great weight of rotten metal roof, carried by only 2 ft. of strong roof coal, made the work of coal-cutting dangerous unless the face was chocked the whole length, the cost of which swallowed up any saving that might be made.

In another mine, where cutting has proved more favourable, the section being:—

	ft.	in.
Roof Coal	0	6
Good Coal..	2	10
Fireclay Floor	—	

A machine, cutting in the fireclay floor, can cut an average of 70 lineal yards in 9½ hours, which would yield say 53 tons; this would give an approximate cost:—

	Per Ton. s.	d.
Labour, for cutting..	0	5
„ Collier, for filling..	1	10
„ Extras for holing out, &c.	0	0·35
Repairs to machine and sharpening	0	1·38
Compressed air, including coal and labour ..	0	0·64

	£		s.	d.
Pipes	300	Depreciation of air-compressing Plant.. Pipes and Coal-Cutter	0	1·25
Compressing Plant	700			
Cutter	200			
	£1,200	£70 on 13,780 tons per year..	2	6·62

Gain	3·13d. per ton.
	£
Depreciation.—£200 at 10 per cent... ..	20
£1000 at 5 per cent.	50
	£70

There is then the question of yield of round coal, a most important element, as by hand labour a large amount of slack is made, which only brings to the coal owners a low value. I have tested this in a mine of the above thickness, and find that it shows:—

	Per Cent.
By hand labour—Round	48·0
Slack	52·0
	100·0
By Machine—Round..	54·55
Slack	45·45
	100·00

Gain of Round Coal = 6·55 per cent.

Hence, if we assume selling prices of coal at say 10s. for round at the pit, and 3s. for slack at the pit, we get:—

	s.	d.
Average selling price of coal got by machine labour	6	9·82
Average selling price of coal got by hand labour ..	6	4·32
Per Ton	0	5·50

In another mine, where the coal is 3 ft. 8in. thick, I find the average cutting price is higher by 1d. per ton, but this is owing to fewer yards being cut. By a test made in it, 4 per cent. more round coal was obtained.

I have tried a Sullivan Patent Pick for driving narrow work, and have seen it at work in fairly soft coal successfully, but in the hard coal the cost of working it is greater than for hand labour. I have inspected the working of the Jeffrey Header, and am trying one. It costs about £300, and is capable of cutting 5 ft. 6 in. under, and 9 ft. wide in three cuts of 3 ft. each. I have seen these machines do excellent work in a seam 3 ft. thick of exceedingly hard coal. They can cut across a 9 ft. place in 1½ hours holing 5 ft. 6 in. deep, thereby saving yard work and getting work out quickly. In my opinion these headers for hard coal in narrow work are a great saving of labour, and do produce a very much greater increased quantity of round coal, the saving being largely made in the price paid for yard work.

I may say, in conclusion, that having gone through the early stages of coal-cutting five years ago, when the prejudice of the collier was greater than it is now, I am sure that when the conditions of the mine prove favourable to machine cutting, advantages can be obtained for the coal owner: 1st. By working hard coal which cannot be worked by hand at a profit. 2nd. By increasing the yield of round coal. 3rd. By having a smaller area of workings open at one time, thereby saving cost of maintaining roads, and ensuring greater safety to the collier, as less face has to be examined in a given time. The one very great object to be obtained in successful coal-cutting is to have a thoroughly organised staff of men, who are engaged by the piece;

officials to take a keen interest in the work to make it a success, as the cutting depends on the filling, and *vice versa.* The colliers being on the tonnage must not be tied to one place, a number joining together is much the best arrangement, so that they can follow the machine along the faces. The old prejudice of the collier against coal-cutters still exists with some of the men; but the more they work with them the less they fear that worn-out cry about the "iron man" superseding the collier. I have not found that I require fewer colliers by the introduction of coal-cutters; but I have seen vanish that hard part of a collier's duty, viz., "holing."

There are other coal-cutters in the market that I have not mentioned, amongst which is one recently introduced, viz., "The Champion," but I have desired to only refer to those I have actually used. I have not enlarged upon these notes to go into the details of the construction of these cutters, as they are so well known by most of the members, but I can strongly recommend any person considering the subject to carefully study a book on "Coal-Cutting by Machinery," by Sydney F. Walker, published by *The Colliery Guardian Company,* where they can get the fullest description in detail of all the principal mechanical coal cutters now upon the market.

Mr. G. B. HARRISON proposed a vote of thanks to Mr. Dury Mitton for his notes, and said, coal-cutting by machinery was a very important subject, and he was very glad it had been introduced by a gentleman who had had actual experience of the work.

Mr. H. STANLEY ATHERTON seconded the proposal, which was adopted.

Mr. DURY MITTON said: I am very much obliged to you for kindly passing a vote of thanks, although I have done no more than open the matter for discussion. I have been looking forward to learning a good deal more from members who can give information on this subject. There are a great many points which might be taken up, and on which I should like to get information.

The PRESIDENT: I think we might go on for half an hour or so, and then you may think it necessary to adjourn the discussion.

Mr. JAMES TONGE, F.G.S., said: I should like to add my thanks to Mr. Mitton for bringing this subject before us. It is, in my opinion, most interesting and important. Holing is the most unhealthy part of the collier's occupation, if indeed it is not also the most dangerous, and I for one should be very glad indeed to see coal-cutters being put in rapidly. One reason why, I think, coal-cutting machines have not been more generally adopted has been because we have had no truly economical, safe, and convenient motive power. I hardly agree with Mr. Dury Mitton as to the power that is the most to be preferred. I have thought ever since we began to use electricity for other purposes—haulage, pumping, and lighting—it would be extensively applied to coal-cutting machinery, and I think so still. I think that the dangers attendant upon other powers are quite as great as those arising from electricity. Then, of course, we have not yet arrived at anything like perfection in our electrical appliances underground. I have very little doubt that soon we shall have reached a state of greater perfection in regard to electrical appliances for coal-getting, and that such machinery will do its work more safely and rapidly than it does at present.

Mr. GEORGE PEACE said an element of danger in the use of electricity as a power underground was in the emission of sparks or the fusing of the wires. To his thinking, coal-cutting by machinery worked by compressed air was much superior in point of safety to that which was worked by electricity. We are quite aware it is a more expensive process, but I think it is very much safer than electricity in mines where any large quantity of gas is given out. In all such cases there must be constant fear of sparks and the fusing of the cables. I have had pleasure in hearing the paper, and I think it is a step in the right direction.

Mr. DICKINSON said: Mr. Mitton had named the machines which he had tried himself, but there are several others that have been tried, and I hope that when we have this discussion revived, with ample time before the meeting, that the merits or demerits of the whole of those machines that have been tried will be brought forward. It is many years ago since an old friend of mine, and a member of this Society—the late Mr. William Peace—had a patent coal-cutting machine. He worked it for a time, but it came to naught, and I think the next great effort was made by Mr. Frith, of a Leeds firm. It was a pick machine, and was at work. I, with a colleague of mine—Mr. J. J. Atkinson—tested the working power. He took the power of the steam engine on the surface, and I, simultaneously, took the power of the machine worked by compressed air, about 900 yards from the steam engine. The actual horse-power exercised by the steam engine was 15; that given out by the coal-cutting machine was 1·9, showing very little power utilised. No doubt later coal-cutters give out much more power than that. They are successfully worked in some coal mines, and in the salt mines they are a notable success. I hope when the discussion is resumed we shall have not only a description of the machines, but some account of the power taken to work them.

Mr. WORDSWORTH said he would like to ask how the use of the machines affected the percentage of round coal; and what did Mr. Mitton regard as "round coal"? Did he include "house nuts" in that description? In speaking of the failure or success of a machine a good many things had to be taken into consideration. There was the inclination of the seam and also the angle of the working face in its relation to the lines of clevage in the coal. He had seen cutters working on various degrees of inclination, and knew that these points had to be taken into account in determining whether the work was suitable for a machine. He had known one kind of machine to be an utter failure under certain conditions and a great success when the conditions of work were suited to it. A machine was sometimes condemned, not because it was faulty, but because it was applied to cut coal in an unfavourable position.

Mr. DURY MITTON, replying on the debate, said the gain in the matter of round coal by the use of the coal-cutter was 6·55 per cent. That was in one mine, but in another mine 69 per cent. of round coal was yielded, as against 50 per cent. by hand. As to the question of inclination, he agreed that it made a difference in the effectiveness of a machine. In a steep mine he had generally worked a machine along the level. But in one particular mine to which he had referred the coal would fall back two feet, and come right over upon the machine. If he worked it on the face, it would be too soft, and by working it on end they got a larger percentage yield of round coal.

Mr. GERRARD said he hoped the discussion would be continued at another meeting.

The PRESIDENT: I think the best plan would be to adjourn the discussion to the next meeting, or to the following one. I am not so sanguine about these machines as a great many people seem to be, and I shall be very glad if, in the discussion, you will be careful to give us facts, and not so much what are theories. Anybody who has had experience should be careful to give us the precise facts. For instance, with regard to the cost of the power. It has been thrown in our face often enough that the Americans did so much more coal-cutting than we did. Slack in America is 2s. a ton. I believe it is put in the works for about 2s. a ton. Here it is worth 6s. a ton. You have the power then three times dearer in Lancashire. I notice when gentlemen are speaking about coal-cutting machines they have missed out the cost of the power, or put it at some very low item. Mr. Mitton, I think, mentioned 3s. a ton as the price of slack.

Mr. MITTON: No, I did not mention that as the cost of power; it was simply mentioned in working out an assumed selling price.

The PRESIDENT: It amused me at the time, for yesterday I wanted some slack for my greenhouse, and I called at the colliery and asked the price for delivery at a distance of a mile, and I was quoted a very much higher price.

The discussion was adjourned to the February meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART IV. VOL. XXVIII. SESSION 1902-1903.

The ORDINARY MEETING of the Members was held on Tuesday, 13th January, 1903, in the Society's Rooms, 5, John Dalton Street, Manchester.

Professor BOYD DAWKINS, F.R.S., &c. (in the absence of the President), in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society:—

Mr. WILLIAM ROGERS, 311, Wigan Road, Bolton.

Mr. WILLIAM HENRY SUTCLIFFE, Shore Cottage, Littleborough.

Mr. LIONEL PILKINGTON, Haydock Colliery, St. Helens.

The following paper "On a Calcareous Sandstone" was read by Mr. J. BARNES, F.G.S.:—

ON A CALCAREOUS SANDSTONE FROM BAMBERG, BAVARIA, GERMANY.

By Mr. J. Barnes, F.G.S.

(Illustrated with specimens and micro-sections.)

Geologists divide the rocks that form the solid portion of the crust of the earth into two grand classes, viz.: the igneous rocks, or those formed by the action of heat, and of such we have, as typical examples, the lava from volcanoes, the various kinds of granites, basalts, &c. The other great class consists of rocks laid down in water and known as the aqueous sedimentary rocks; this class being sub-divided into minor divisions, which may be mechanical, as are rocks such as sandstones and shales, or they may be chemically precipitated from solution, as salt, gypsum, and even limestone.

The igneous rocks must, of course, have preceded the fragmental aqueous rocks, and it is by the breaking down of the igneous rocks by the action of water and air, either in motion or at rest, heat and cold. All these agencies assist in their disintegration. Following on this disintegration flowing waters carry off the *débris*, which in its passage, the particles being in constant contact with each other, causes the sharp angles to become worn away, giving rise to the rounded grains such as are seen in sandstones.

Sandstones were orginally derived mainly from the breaking up of granites or quartz rock. Granites (which consist of quartz, one of the felspars, and mica), when acted upon by rain water containing carbonic acid, are attacked; the potash, soda, lime, and magnesia being removed, whilst the alumina remains behind in combination with the silica, as kaolin or china clay.

The mica also undergoes decomposition, whilst the quartz is mechanically liberated and undergoes no chemical change. When removed by the running waters of rivers and carried seawards the sand grains are first deposited in the delta of the river, forming sand banks, which may and often do remain as masses of loose sand, whilst the kaolin and mica are carried further into the sea. But conditions may be set up in which the particles or grains of quartz may become cemented or united together to form one mass of solid rock, such as are the sandstones.

How is this change brought about? It may be brought about by the solution of a small amount of the quartz itself and a subsequent deposition, assisted by heat and pressure; the grains being thus permanently attached to each other, and what was originally a mass of loose sand is now a compact sandstone.

Besides this mode of cementing together particles of sand there is another method, and that is by means of carbonate of lime, carbonate of magnesia, and carbonate of iron.

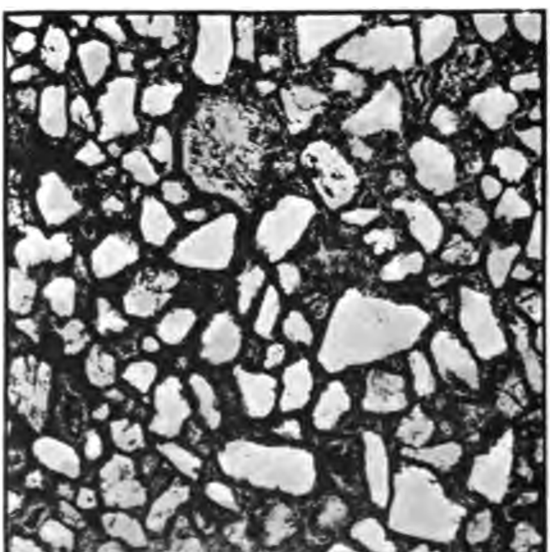
The subject of the present short communication is upon a rock of this kind.

Having recently had occasion to spend some time in Bavaria, I naturally was desirous of studying, as far as time and opportunity would allow, the geology of the country. One of the most interesting things that I came across was this calcareous sandstone. At first sight I took it to be a pure limestone; but, upon examination with a hand lens, I took it for a sandstone pure and simple, because it shows the usual granular sandstone-like appearance. On chemically examining the stone, however, I found that it was not wholly sandstone, but that it partook of the character of both; in fact it is, after all, more of a limestone than a sandstone. Its composition is as follows:—

	Per cent.
Insoluble matter, silica, and felspar	25·855
Organic matter	·688
Water	·965
Ferric oxide (Fe_2O_3)	·166
Alumina (Al_2O_3)	·802
Carbonate of iron ($FeCO_3$)	·454
Silicate of lime ($CaSiO_3$)	5·233
Carbonate of lime ($CaCO_3$)	34 648
Carbonate of magnesia ($MgCO_3$)	30·883
Total	99·694

The specific gravity is 2·719.

It will be seen that a little more than one-fourth of the rock is sand, whilst the bulk of it is made up of the cementing material, which is certainly a very large amount. *(See Diagram.)*



Dark portion *limestone*; clear portion *quartz*; light portion, streaked, *felspar*.

Now, if the carbonates of lime and magnesia hold the mass together, it follows that if these be removed, and it can easily be done, the rock should fall to pieces; and this is what actually does happen, for here you see some of the rock from which I have removed, by means of acid, the lime, magnesia, and iron, with the result that the quartz and felspar are, with a pocket lens, easily recognisable.

The rock, when seen *in situ*, is stratified, which shows that it has been laid down in running waters which were fluviatile. Then how did the limy matter get there? There appears to have been a change from a purely fluviatile state of affairs to one of marine conditions; for, lying above the calcareous sandstone, is to be found a bed of limestone with a large amount of magnesia in it, just as is found in the matrix of the rock in question. The calcareous material, finding its way from above, has filled in the interspaces of the sandy material and so solidified, giving rise to this rock as it is at the present time.

The following is the composition of the limestone:—

	Per cent.
Insoluble matter (Kaolin)	11·017
Ferric oxide (Fe_2O_3)	0·712
Ferrous carbonate ($FeCO_3$)	0·291
Alumnia (Al_2O_3)	1·023
Manganous carbonate ($MnCO_3$)	0·804
Calcium carbonate ($CaCO_3$)	47·146
Magnesium carbonate	36·898
Water	2·050
	99·941

On the motion of Mr. J. DICKINSON, F.G.S., seconded by Mr. MARK STIRRUP, F.G.S., a vote of thanks was passed to Mr. Barnes for his communication.

The CHAIRMAN said he was sure the Society was much indebted to Mr. Barnes for the trouble he took in these matters. Mr. Barnes was certainly one of the most active and energetic members of the Society. In this particular communication Mr. Barnes had brought before them an exceedingly interesting point which was very generally ignored in reference to the cement which inclosed the grains of sand in the sandstone. He did not propose to add much to the debate, but, no doubt, some members would like to ask Mr. Barnes questions or discuss some points which had been raised.

Mr. DICKINSON asked if the sand had been subjected to some petrifying water similar to that at the petrifying wells in this country.

Another member asked whether the organic matter in the composition of the stone was vegetable or animal.

Mr. BARNES: I could not tell you that. It is derived from the decomposition of either plants or animals. The amount of organic matter is very small.

The CHAIRMAN: I should like to know on what basis Mr. Barnes puts the organic matter. Is it nitrogenous?

Mr. BARNES: I don't know what it is exactly.

A MEMBER: Of what formation is the stone?

Mr. BARNES: I don't know. They were paving the streets in Bamberg with this rock, and it looked such a very peculiar stone that I decided to bring some home and examine it. With regard to Mr. Dickinson's question, as to whether the sand had been subject to the action of petrifying water, the cementing, I take it, has been brought about in the same way as the formation of the tufa, except that in the case of tufa the sand has been laid down and there has been a solution of carbonate of lime which has infiltrated. It makes a good and very durable wearing rock.

The CHAIRMAN: It is a stratified rock. All these sand stones are stratified, and the composition of this is very clear as far as the sand grains go in this bottle. There is an unusual number of round grains of sand, and a great many which have the pitted structure which is characteristic of the quartz when it is in the rock from which it has been derived. The structure of the quartz derived from a rock is this: The grains are shaped like potatoes, very irregularly, and in consequence of that a very curious result occurs. All the grains of sand which have been embedded in the red sandstone are coated with ferric oxide, coloured red. In other words, there is a layer of red over the grains, and the little hollows retain a bit of the red coating of the original red sandstone. You can in this way tell which grains have, and which have not, been derived from the red sandstone, and this irregular surface is one which is characteristic of the particles of quartz in the igneous crystalline rock, and is not quite obliterated by the action of the waters of the sea.

The following paper on "Some Prehistoric Finds from Ashworth Moor and Neighbourhood" was read by Mr. WALTER BALDWIN, F.G.S.:—

SOME PREHISTORIC FINDS FROM ASHWORTH MOOR AND NEIGHBOURHOOD.

By Mr. Walter Baldwin, F.G.S.

The paper which I am about to read may perhaps be of more interest to an Archæological than to a Geological Society. Having shewn some of the specimens to one of the members of this society I was persuaded to bring them before your notice and to prepare a short paper dealing with them. The ground run over in this paper is common to the archæologist and to the geologist, and I have therefore no hesitation in bringing the matter before your notice. The neighbourhood to which your attention is directed is Ashworth Moor, lying about five miles to the north-west of Rochdale.

It is a rough, barren, and treeless district, exhibiting the characteristic features of the millstone grit formation, for it embraces the first, second, and third grits of this series. In the spring time the body is exhilarated by the sharp, fresh air, and the ear is charmed by the notes of the skylark and pewit which are to be seen on the moor. Of course the grouse and snipe are there in large numbers. But let us take our eyes off the birds and fix them upon the trees,—alas we cannot, for they are no more, but we know that they did exist here as is evidenced by the deposits of peat which are met with, varying in thickness from a few inches to ten feet or more.

Let us examine these peat deposits: there one sees the remains of the Scotch fir, oak, birch, hazel, ash, willow and Scotch elm, together with a mass of peaty fibre representing the undergrowth which was probably composed of the sloe, holly, blackberry bush, &c.

The Scotch fir and oak were perhaps the most plentiful trees of those ancient forests, for they are most commonly met with in the peat. Acorns, the fruit of the oak, are found preserved; rolled up sheets of the silvery bark of the birch also occur, and the hazel is represented by its fruit, the hazel nut. But more interesting still, the hazel nuts record their own story, as they often bear the teeth marks of the squirrels, which played about among the branches of the trees and hoarded up their stores of nuts for the coming winter's supply.

The specimens before you have been obtained from the site of the Ashworth Moor Reservoir, which is now being constructed to supply the boroughs of Heywood and Middleton with an additional supply of water.

The site chosen for the reservoir is undoubtedly that of an old lake which gradually became choked up with vegetation. Among the denizens of the forest surrounding this lake the squirrel has already been mentioned. The Celtic shorthorn (*Bos longifrons*) probably roamed about there too, as the writer has found portions of their bones at Cowpe not very far away. The teeth of a young ox and the other bones which you see lying on the table have been extracted from under the peat on the reservoir site. Perhaps the most interesting fact we have set before us is, that man himself was in the neighbourhood at this period of the world's history and has left his traces behind him in the shape of flint and chert implements, cores, chippings, &c.

He probably wandered about the forests, clothed in the skins of animals his prey, or dressed in roughly spun woollen garments, following the chase, grubbing in the ground for roots, or gathering for his food fruit, which grew on the bushes. It is possible, that as a rule, towards dusk he would leave the forest for the hill-tops where he would be safer from wild beasts or perhaps from the spirits which he supposed haunted the trees. The evidence for this, lies in the fact, that it is on the summits of the hills where the majority of flints are found: one of these Knowl Hill, part of the gathering ground, seems to have been a veritable workshop for the user of flint, for great quantities of chippings and cores are found, together with most beautiful arrow heads, thumb-stones and flakes. A beautiful specimen found by Mr. W. A. Parker and now in the possession of Messrs. W. H. Sutcliffe and Parker* shows the flakes to have been manufactured on the ground, for the flake was found lying about five yards from the core off which it had been struck.

Only a few flints have been found on the reservoir site, one of which is one of those pigmy flints, that are awakening so much interest at present; another is a very beautifully worked scraper, used in the preparation of skins of animals, found broken in two pieces, which were eventually found to be part of the same implement. It shows evidence of having been chipped by frost fracture, presenting an appearance very similar to those seen in the so called Eoliths from the Kentish plateau.

Another testimony to man's existence here, is charred wood-pine needles with which he used to keep his fire blazing. The fire was probably started by striking flint against iron pyrites, the spark being directed in the first place on to dry grass, or it may have been produced by the friction of wood against wood as do some modern savages.

It has been suggested that these pieces of wood which have charred points may not be portions of fires but merely wood with the ends pointed and hardened by fire for the purpose of digging up roots. But this view does not seem likely to be correct as some of the specimens are pine knots, besides they seem too short to have been used for digging.

Prehistoric man of this period beautified (?) himself by colouring his skin with ruddle (red hematite).

On the table before you is an assortment of implements and ornaments from the neighbourhood, which were used by "prehistoric man" of this age. There are beautifully

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*Since writing the above, this and other specimens have been removed to the Rochdale Museum.

formed arrow tips of flint, which vary in design; some of them were leaf-shaped, lozenge-shaped, stemmed, stemmed and barbed, and single barbed. Some of these may have been used for various purposes, or some may have been earlier types than others. They would be mounted in wooden shafts, tied on to these by thongs cut from the skins of animals caught in the chase.

The very fine combination implement came from Higher Hill, a portion of the gathering ground. Of thumbstones there are many sizes, some are so small that it has been suggested that they might have been used as charms. Of personal ornaments, necklaces of shale beads were worn, either by the most important ladies of the tribes or by the chiefs. The little bead,* rectangular in shape, measuring $\frac{3}{8}$in. by $\frac{3}{8}$in. by $\frac{1}{16}$in., was found on Knowl Hill, and was a portion of one of these necklaces. It is fashioned out of the black shale of the neighbourhood, is polished, and has a circular perforation $\frac{1}{12}$in. in diameter, which has been bored from both sides, very likely by means of a flint drill, used with a little sand and water, for flint drills have been found on the hills around.

Another ornament was the jet button.

Numerous flakes or flint knives have also been found on the hills, presenting distinct cutting edges.

Of burial places or barrows very few have been found in the district, but those which have are of the "round" type.

The Hades Hill Barrow† is worthy of note. It is a round barrow, "its present dimensions being 52 ft. north and south, 45 ft. east and west, and 3 ft. above the surrounding ground." It contained an urn of the two-tier variety, hand made, of coarse local material, and imperfectly baked. The urn is

* This specimen is in the Rochdale Museum.

† Hades Hill Barrow, by W. H. Sutcliffe. Trans. Rochdale Lit. and Sci. Socy. Vol. VI., 1898-1900. Contents of the Hades Hill Barrow are in the Rochdale Museum.

ornamented by impressions of some vegetable fibre, placed chevronwise. It contained calcined bones of almost all the parts of a female human skeleton except the teeth; fragments of burnt flakes, and a burnt fragment of a well-worked implement. There were also found in the barrow the burnt tooth of a domesticated ox, animal bones, charcoal, numerous flint flakes and implements, pieces of coal, and quartz pebbles. The burnt bones of the ox would appear as if it had been sacrificed at the grave, and afterwards probably formed part of the funeral feast. The quartz pebbles were probably used as lucky stones, as we find the superstition of rounded and various coloured stones still being considered lucky surviving in some parts of the country.

Mr. W. G. Wood-Martin, in his "Traces of the Elder Faiths of Ireland" (p. 331), says: "In the present day, if a person in the Orkney or Shetland Islands is supposed to have been affected by the "Evil Eye," he is cured by having administered to him water, both externally and internally, into which have been dropped charms supposed to possess magical power. As a rule these are pebbles of different colours." The scarcity of barrows in the district would suggest that only the most important people were buried in barrows, and that the common people were interred without barrows. Perhaps cremation was not practised in their case.

The reference to the Hades Hill Barrow and to some other matters may have appeared foreign to the title of this paper, but it was necessary when we come to ask ourselves the question: To what age do the people who used the flint and chert implements in this district belong? From the evidence we have before us it would appear that these people belonged to the Bronze Age, although there might be very little bronze in the neighbourhood, as it would only be used by perhaps the wealthiest chiefs, or it might not have penetrated into these districts at that time.

Sir John Evans, referring to personal ornaments—buttons, necklaces, &c., of jet, shale, or stone—says: "Nearly all, however, appear to be characteristic of the time when stone was already being superseded by bronze for cutting purposes." * In the Crania Brit. we read that a ring of Kimmeridge shale, 1⅜ in. diameter, was found with a penannular ring of bronze, flint flakes, and arrow heads, a perforated whetstone, a bead of glass, and one bone, in examining a series of barrows at Affington, Dorset.† The round barrow, the two-tier urn, the burnt tooth of ox, shale buttons and beads, all seem to fix the age as that of Bronze, and it is most probable that the people who lived on these hills and fashioned the flint implements found on the Rochdale neolithic floor belonged to the early Celtic race, for Mr. Bateman, referring to the bones of the ox, remarks: "They are uniformly found with the more ancient interments," that is with the early Celtic.‡

In conclusion, let me express my thanks to Messrs. Sutcliffe and Parker for the loan of a portion of their magnificent collection.

On the motion of Mr. Barnes, seconded by Mr. Stirrup, the thanks of the meeting were given to Mr. Baldwin for his communication.

The Chairman said he thought Mr. Baldwin had laid before them very clearly the facts he had discovered, and had expressed a very accurate view in regard to the age question. While he was making his remarks I wondered whether he would fall into the usual blunder which is made in the case of these discoveries. As a rule rude implements made of stone, when not found in association with bronze or iron, are looked upon as belonging to the stone age; but I

*Ancient stone implements of Great Britain, p. 452.—Evans.

† Cran. Brit., Vol. II., pl. 45, 3.

‡ Ten Years' Diggings, page 132.—Bateman.

am very pleased to see that Mr. Baldwin has grouped the whole together, and has assigned them to the Bronze Age.

Mr. STIRRUP: This is not the first time we have heard of a find of similar things on this moor, accounts of which have been previously brought before the Society. The curious thing to my mind is the question as to where the flint came from. The flint does not occur naturally on these hill tops, and the problem is how it got there. It is supposed that some of these flint implements have been obtained from silicious boulders in the *drift*, but, as these are rare, I do not think that the theory explains all the difficulties of the case.

Mr. BARNES said he had picked up lots of flint pebbles in the drift sand on a certain moor.

Mr. PICKSTONE said he had also found flint pebbles in the drift in the neighbourhood of Prestwich. In the Whitefield district, where the gravel has been mixed with the clay, there were numerous flints.

The CHAIRMAN: Very few large implements have been made out of the flint. In this case they are very small, such as might be made out of the flint in the drift.

Mr. BALDWIN, in replying, said that some of the flint tools had undoubtedly been formed out of the pebbles found in the drift. Some of the tools had apparently been formed in that way, and others had probably been bartered.

NOTE.—A beautifully worked scraper from Higher Hill has been fashioned from a split flint pebble picked out of the drift, whilst a flint from Cupwith Hill is certainly one of the chalk flints and must have been bartered. Mr. Parker has found flint with the chalk still adherent.—W. B., April, 1903.

The following paper on "Recent Geological Changes in the Peninsula of Wirral, Cheshire," was read by Mr. WILLIAM PICKSTONE:—

RECENT GEOLOGICAL CHANGES IN THE PENINSULA OF WIRRAL, CHESHIRE.

By Mr. WILLIAM PICKSTONE.

It has been more or less a fad of mine for years to observe the changes that have been taking place on the sea front and Dee estuary of the part of Cheshire to which my paper refers. I suggested to Mr. Saint that if in his opinion a paper on the subject would be likely to interest the members of our society I would write one. By all means do so, was his reply. I had then to consider how I should deal with it and came to the conclusion that I had best go back to the time when the land of the Peninsula emerged from the glacial sea and gave to us the conditions that present themselves to the observer in our own time, namely, the New red sandstone base covered by a blanket of boulder clay. The sandstone base is a definite and well known formation, and so is the boulder clay; but it is quite possible that other deposits of clay besides the lower one that is here *in situ* may have covered it, but with this question and with the question of the great depth of sand and sand and gravel cover that is found to overlie the boulder clays in many parts of the country, I do not purpose to deal; but of the sands that are moved by wind and water of our own time, I must say something, as they are so plentiful on the sea front between New Brighton, Hoylake, and West Kirby.

When the land of the Peninsula came up out of the sea there was very much more of it than there is now. The sea has taken much of it up, and the two rivers Mersey and Dee have helped it in the work. The hills of red sandstone that skirt the Mersey from New Brighton and Wallasey to Runcorn, with two or more breaks, on the eastern side of the Peninsula, and from West Kirby to

Chester, with breaks on the west side, are substantially (except as to the boulder clay cover which denudation has almost entirely taken away) unaltered, or not greatly changed, and the low-lying intervening lands are, so far as they remain, and except for the thinning by removing important portions of the clay blanket, very much as they were, but the two rivers and the sea have been eating away, and are not yet satisfied; they have, in fact, an insatiable appetite. On occasions in recent times, when the winds lashed the waves of the sea into a fury, a good deal of land was swept away and added to the sea area. No doubt a very considerable thickness of boulder clay covered the whole area of the Peninsula, both on the low lands and on the hills when the land came up out of the water. The prominences of the New red sandstone that are seen at various points to-day, uncovered so far as the clay is concerned, had probably as deep a cover as the low lands, but as denudation acted more forcefully on them, they soon gave up their blankets to the never tired forces that eat the cover away, and to some extent went on denuding the rock that had been uncovered. Passing from east to west, we find the first depression runs across from the Mersey to the sea front—the great float at Birkenhead occupies a part of this area, and it was the site on which the late Sir E. W. Watkin proposed to open up a new entrance to the port of Liverpool. There is not much doubt that in the earlier times the sea covered it. In that case Wallasey and New Brighton would of course be an island.

It is with what has happened since that long ago that more especially concerns us to-day. Geologists recognise that the term "everlasting hills" is poetry only, although very taking poetry to most of us. The water that found its way from the areas drained by the two rivers took its way to the sea along the lines of least resistance, as it is its nature to do, and it may reasonably be taken for granted found its way to the sea at points not very distant from where it gets to the sea now, but the changes are considerable in the case of both rivers, but especially in the case of the Dee, which ploughed its way along the lines of the great fault that underlies it. It will be seen from the map of the Geological Survey that the New red sandstone, the Millstone grit, and the Mountain limestone outcrops are contiguous to each other in a very limited surface area on the south side of the river in Flintshire. The river channel gradually widened as the water encroached upon the land, on the Cheshire side more especially, until in time the wide estuary was formed, and by reason of a protruding ridge of hard rock (probably because of a fault) the Island of Hilbre became separated from the main land; but doubtless the intervening space between the Island and the points of Hilbre was rockless, boulder clay-covered, low-lying land. The depression would be a mile or more wide. In this space the Surveyors of the Government suggest a "probable line of faults," as will be seen in the map. It may be noted that the rock exposed at Hilbre Point and that of the Island, some two miles away, are both on the pebble beds; so, unless the pebble beds are of considerable thickness, there may be both upthrow and downthrow faults in the area. The dip is an easterly one both on the shore and on the Island, and is apparently about one in five.

No rock is exposed on the surface between Hilbre Point and New Brighton, so far as I know, but it may be that Leasowe Castle was built on a knob of rock like that on which Irwell Castle, so recently demolished by the Manchester Racecourse Company, was built. At Hilbre Point, quite recently, denudations by the sea have uncovered a small section of rock with the cover of boulder clay resting *in situ* upon it. The clay is of a red colour, and on the sea front opposite Leasowe Castle, underlying the submerged forest is clay of the same colour, which may be an indication that the rock is near to the surface there. On the sea front between

New Brighton and Hoylake as well as on the Dee Estuary, much land has been swallowed up by the sea, some since the subsidence began. Professor Boyd Dawkins in his recent course of Lectures, in the Whitworth Institute, on "Prehistoric Man," exhibited on the screen a map of the probable boundary between land and sea, over an area from the Dee northwards along the Lancashire Coast with portions of the underlying forest marked on it, which if correct, showed very huge sea encroachments in, geologically speaking, recent times. In the second lecture of the course on the man of the Bronze Age, he referred to the fact that some personal ornaments in that time were made of jet and cannel; that reference to cannel reminded me to bring the specimens of cannel from the boulder clay at the Kilcobie Brick and Tile Works, of Mr. Statter, which are on the table.

Within the last ten years on the shore near the Royal Hotel at Hoylake, where large sandhills have been washed away, the land level of the time when man unmistakeably used the land, and of course before the conditions arose which produced them, my attention was called to some vigorous grasses or reeds that were growing in the uncovered black earth—on closer examination I found that the black earth consisted mostly of roots of the plant that was again growing out of the old soil—I found that at some time before the blown sand covered it man had not only been there but had cut the grass for some purpose or other. From the specimens on the table the members will see that the old growths had been cut by some apparently sharp tool. I brought samples of these, which I took to the Museum at Owens College. One of the consequences was that Mr. Hoyle allowed two of the young men of his staff to accompany me to the Peninsula. Mr. Jno. Sterling also went with us. An interesting Saturday's outing it was to all of us. Sample stones were picked out of the boulder clay cliffs, the outcrops of the new red pebble beds at Hilbre Point were carefully gone over, and we passed on to where I had not many weeks before picked up my specimens of grasses. A storm of sea waves had meantime passed over the spot, my beautiful grasses had been knocked over and were no longer things of beauty. One thing, however, of interest was found. Mr. Murray's keen eyes as a botanist discovered the new growth from an old stem, that is on the table, which seems to show that however long the time had been since the sand hills covered the vegetation enough life was left to produce a new growth on its exposure to the sun-light. So Mr. Hall, the Geologist, and Mr. Murray, the Botanist, were rewarded.

I have said that the time of the sand hills formation had not come at least in that area when the land was used by man for the purposes of agriculture. I am not attempting too much I hope to tell Time's tale. I have noticed the careful way some of our geologists avoid giving opinions on geological time, but in a case like this we have at any rate brought clearly before us man the agriculturist driven from his land by an encroachment of blown sand from the tide-covered area not very long ago, which could not be repeated by the conditions prevailing to-day. In to-day's conditions of the foreshore it is impossible for sand banks at this point to form; indeed, all the sand on the foreshore has gone, and the bared clay and mud only form the cover. I do not pretend to say what the cause of the change is, but there it is, and is to the geologically inclined student interesting enough to be worth notice and recording.

To lessen the encroachment of the sea an embankment of a good length of the sea front was made many years ago (early in last century), not merely for the preservation of the land from being washed away, but to keep the land lying behind the sand hills from occasional flooding by the salt water, to the injury and loss of the farmers on the low-lying land, several thousand acres in extent, which forms that part of the Peninsula.

I would call attention to the fact that the once deep cap of boulder clay that covered the area had been so reduced in thickness, probably by the sea's encroachment in an earlier time, as to have made it liable to occasional flooding. For it is certain that as early as during the Roman occupation there was a settled population on the land, not only on the land that is being farmed to-day, but on much land which the sea has taken up during the century. I take it for granted that sand hills at an earlier time were continuous from New Brighton to the Point of Hilbre, but that on the embanked length they had been carried away, detaching those that are found now east and west of the embankment. These have suffered much denudation within my recollection. It was the washing away of the sand hills that laid bare the interesting submerged forest, from which have been picked up by several careful collectors, and are preserved in the museums of Liverpool and Chester, numerous articles used by man. These collections leave no doubt that the submerged area was part of the land occupied by man from Roman times down to the fifteenth century. One important recent geological change is therefore the fact that the land of the Peninsula is slowly sinking under the sea, as it has done very often before. Possibly it is going under the sea as rapidly now as is its way of doing the work allotted to it. We have to bear in mind that except the sea tells us that the land is going down, we have not much opportunity to find it out. The City of Manchester is probably going down as rapidly (has, may be, in the last century gone down as much) as has the land of the Cheshire peninsula. Why not?

I might easily cover much more ground, but I will content myself with saying that I know of no place so near to Manchester where so good a section of boulder clay cliffs can be seen as are exposed on the Dee estuary. The sea washes the foot, and the rain and wind work away higher up the cliff, showing how the boulders, great and small, are embedded in it. They stand out from the face of the clay, and offer excellent opportunities for the snap-shot scientist to carry away with him very interesting pictures of this great natural phenomena in the (geologically speaking) recent ages of the country in which we live.

In closing, I would just say of the Dee shore clay that it contains numerous specimens of sulphate of lime, but none of coal or cannel, while at Outwood, where Mr. Statter is working, there are no specimens of gypsum, but many of coal and cannel.

On the motion of Mr. Dickinson a vote of thanks was passed to Mr. Pickstone for his paper.

The Chairman said: I feel we have listened to an extremely interesting paper. With regard to the arguable side of it I cannot accept the conclusion which Mr. Pickstone has come to. I believe, in comparatively modern times these sand hills have been advancing, and I am not inclined to attach any high value to the alleged indications of these cut stems. With regard to the statement that in Roman times a much larger area of land existed, I have no doubt that was so. As the ground is washed away the materials are left scattered by the waves on the layer of clay between high and low water marks. I think that the further point—that in all probability the coast line is sinking now—requires rather more evidence than we have at present. What we do know is that the coast is being worn away by the action of the sea, but I do not see any evidence of a lowering of the level of the land on any part of the coast. I would go further and say I do not see any evidence of any depression of the coast line in any part of the country in comparatively modern times. At the mouth of the Blackwater, one of the rivers in Essex, south, there happens to be a Roman pier reaching down from high to low water mark. Now as that pier was in Roman times it is now so far as the land level is concerned. I do not know of any evidence of a change of level since the Roman time in any part of our coast line. Of course in the pre-historic period the land stood higher above the sea than now, as is proved by discoveries at Cardiff and elsewhere in South Wales, and at Southampton and other places in the South of England. Sir Henry De la Beche the first director of the geological survey, speaks of a time when the land stood something like 60 feet higher than it does now, and was covered with a forest of oak, yew, Scotch fir, and alder, now submerged.

Mr. Dickinson: Mr. Pickstone has mentioned the red sandstone and the pebble beds and the millstone grit, but I did not hear him mention the coalfield at Neston, which has been worked for many years under the Dee. There were certain boring operations at Bidston, three miles north-west of Birkenhead. He had been told by Mr. Thom that they bored in the red rock, to a depth of 800 feet by the American process, and that afterwards the hole was deepened by Mr. Coulson with a diamond borer to a considerably greater depth. He had not heard whether they got through the red rock or not, and it would be interesting to know whether the actual thickness of that rock in the neighbourhood of Bidston has been ascertained. The coal field at Neston dips to the west, but on that and cognate points an interesting paper had been read recently before the Geological Society of London.

Mr. Pickstone: I would like to join issue with Professor Dawkins about the subsidence or non-subsidence of land on the Wirral Peninsula since the Roman period. I have been told by the curator of the Liverpool Museum that pans and other articles have been picked up on the now submerged portion of the shore. If so, I take it for granted that man was occupying that area 1500 or 1600 years ago. Personal ornaments have been found there, made of lead, some of iron, and a few of bronze, but mostly of lead. These are to be seen in the Liverpool and Chester Museums.

The Chairman: A great many Medieval things too.

Mr. Pickstone: There are hundreds of them. They have been found in the submerged area, so that it seems to me the Professor is wrong when he says there has been no subsidence since the Roman period.

The Chairman: My point is this. The things in the museums, of which Mr. Pickstone speaks—and I have probably seen them all—were picked up out of the mud on the foreshore, but it does not follow that that particular area was inhabited at any time. They have been washed out and are of widely different ages, but they offer no proof of the lowering of the land, because they are not *in situ*. They have been washed out of the soft ground forming the shore line. The process may be studied in all coast lines where there is a low-lying tract of land like that at Wirral being attacked by the sea.

Mr. Pickstone: I am not convinced.

Mr. Barnes: Is it not a fact that a change is going on in the land level on the west coast of Lancashire?

The Chairman: I don't think there is the slightest evidence of that.

Mr. Barnes: Oh, yes. Take the case of Southport.

The Chairman: I must say things of this sort will take a great deal of proving. Without accurate levels or anything in the nature of a pier by which you can measure the elevation or depression I feel inclined not to accept the evidence. I would put it, at all events, to a suspense account. Sir A. Geikie had an idea that there had been subsidences of the land levels on the Forth and the Clyde since the Roman times, but he now says he has had to give up the thought because the evidence was not sufficient. I should like to know what evidence there is of alteration in the land level at Southport.

Mr. BARNES: The water of the tide does not come up to the town as it did thirty or forty years ago.

The CHAIRMAN: It must have been banked up or blocked up in some way. Is there any accumulation of sand there?

Mr. BARNES: Yes.

The CHAIRMAN: Well, then, the sand has blocked the sea out.

Mr. DICKINSON called attention to the Otter and Gettern, ancient meres between Birkdale, near Southport, and Barton, and said the land had subsided considerably in that neighbourhood from solutions of rock salt.

The CHAIRMAN said he would be inclined to look closely into the evidence of these alleged subsidences.

Mr. PICKSTONE said he knew Southport sixty years ago, and at that time the foreshore was covered by the sea at high water. Hundreds of acres that are now part of the land were at that time covered by the sea twice a day. He thought the change had been brought about by sand blown over a great level area which caused the gradual rising of the surface of the land. But this was against his subsidence theory.

Several members expressed their gratification at the presence of Professor Dawkins and the part he had taken in the discussion.

Professor DAWKINS said the Society were indebted to Mr. Pickstone for his observations on the Wirral Peninsula, but he could not accept his theory of land subsidence.

This concluded the business of the Meeting.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART V. VOL. XXVIII. SESSION 1902-1903.

The ORDINARY MEETING of the Members was held on Tuesday, February 10th, 1903, in the Society's Rooms, 5, John Dalton Street, Manchester.

Mr. HENRY HALL, I.S.O., H.M.I.M., President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society:—

Mr. R. H. EDMONDSON, Garswood Hall Colliery, Wigan.

Mr. J. H. EDMONDSON, Garswood Hall Colliery, Wigan.

Mr. JOHN C. WALSEY, M.E., 184, Saltwell Road, Gateshead.

Mr. RICHARD OWEN, Colliery Manager, Messrs. Pearson & Knowles' Collieries, Wigan.

The following paper "On Finding Mineral Veins by Electricity" was read by Mr. JOSEPH DICKINSON, F.G.S.:—

FINDING MINERAL VEINS BY ELECTRICITY.

By Mr. Joseph Dickinson, F.G.S.

I see by the newspaper accounts, which may have escaped the notice of some now present, that an improved method of prospecting for ore has been discovered by Messrs. Daft and Williams, which is expected to save much expense of boring, sinking, and driving.

The invention was shown at Ealing on the 6th instant. The vein and mineral were represented by a strip of tin plate, about ten inches in length, buried completely in the ground; it being stated that lead and zinc ores in Wales and hematite in Cumberland had been similarly located, also lodes or veins in America, &c.

Briefly stated, the invention is a sort of wireless telegraphy. The transmitter is put into the ground and the rays thrown downwards into the earth. When the rays come into contact with mineral substances a disturbance is created, and the sounds of the disturbance can be heard in a receiver like sounds in a telephone.

The details given are scarcely sufficient to show how far the invention is an advance of what has long been known to metalliferous miners. In my paper on Lead Mining in the North of England and Derbyshire read before this Society in November, 1901 (Trans. Manchester Geol. Soc., Vol. 27), under the heading Part III., discovery of mineral veins and faults, are cited many methods of prospecting. Among them are those by electrical phenomena and other occult means, some of which are not always divulged in making the discovery known.

The ancient adage of "Nothing new under the sun" may therefore perhaps apply in this instance, but what is stated seems a step in advance. The *Mining Journal* which is in the room gives an account.

Since the reading of the paper Messrs. Daft and Williams have forwarded to Mr. Dickinson the following particulars relating to the invention.

"The earliest efforts at determining the presence of mineral ores invisible to the eye, may be said to have commenced with the employment of the Witch Hazel Divining Rod, which was followed by the use of divining rods of any and every formation, composed of various alloys and metals on the theory of some subtle attraction between the minerals, or mineral affinity.

Dismissing these and the futile and mischievous predictions of clairvoyants, who claim to find minerals anywhere for a small consideration, we come to the practical era, which began with the introduction of a galvanometer, or any instrument that will register the quantity of electricity flowing over a wire connected with a battery, which again is connected by wires to a positive and a negative pole which are planted in the earth.

To energise the needle of the galvanometer the current must obviously flow through the earth from pole to pole, and if the resistance of the earth is less at one point than another, more electricity will flow.

This was used on the theory that the presence of a mineral lode decreased the local resistance of the earth, thereby allowing more current to flow through the galvanometer, which would thus indicate the presence of the lode.

By the practical experience of numerous independent investigators this theory has been proved to be fallacious.

Mr. Alfred Williams has measured over a hundred lodes in Alaska, British Columbia, the United States, Wales, and Cumberland, and has been unable to detect the slightest variation in resistance on the surface.

A still later method has been to use more delicate instruments than the old galvanometer for the measurement of earth resistance, but has failed, as was inevitable, because the theory does not allow for the variation of an ideal condition.

These methods have from time to time been brought before a limited public for the last thirty-five years, and now are, and will continue, cropping up for an indefinite period to come.

In 1889, Mr. Alfred Williams worked on the above outlined theory of resistance, and employed a method which, under field conditions, was more practicable than any delicate instrument. In place of a galvanometer or potentiometer, he used the body of the operator by passing quickly pulsating induced currents from a dry cell and a small coil in series with the earth. By this method the slightest increased intensity in the current flowing by virtue of decreased resistance of the earth was instantly noticed.

He abandoned this method as useless for reasons characteristic of all earth measurements.

Influenced by Sir William Preece's remarkable demonstrations in earth currents, work was commenced on the present system by Messrs. Daft and Williams about four years ago.

The first practical experiments were made in Seattle, Washington State, and San Francisco, California, U.S.A., with instruments especially designed by Mr. Daft.

These met with a marked success, which resulted in an expedition to the South Eastern Alaskan Archipelago, where a large number of demonstrations were successfully carried out on various ore bodies.

From America the inventors moved their headquarters to London, and since that time have been employed in carrying out numerous investigations in Wales and Cumberland.

The Electrical Ore Finding System consists of a method whereby metalliferous deposits, invisible to the prospector and undiscoverable by mining engineering, are located, traced, and mapped out.

The system consists of transmitting Inductors, which deliver electric waves of a definite length extremely sensitive to the presence of minerals, and receiving Resonators tuned to detect these waves and determine their characteristics.

The waves from the Inductors are impressed upon the crust of the earth, in any desired locality, and are radiated to considerable distances, horizontally and perpendicularly. The area of the ground thus energised is increased or diminished, at the will of the operator, irrespective of the prime energy used. Areas as small as 100 metres square, and as large as 30 square miles, or greater, are excited by one Inductor.

The operator traverses that portion of the energised field to be explored for mineral, and constantly receives manifestations of the waves beneath. On approaching a mineral vein or lode the normal characteristics of the waves undergo a marked variation in intensity or direction (or both); the changes are heard in the Resonators and readily interpreted. When the Resonators are over the lode, the variation and intensity are greatest. Here some very specific changes abruptly take place, and by noting density of wave flux, rotation of path, and discord or overtone of the waves, considerable information as to the depth, width, and condition of the deposit is obtainable.

Veins or lodes which act as insulators as compared with their enclosing rocks are discovered with the same facility, the surface variations of the wave differing to a considerable extent.

Duplicate working is used where necessary. Two fields of force are focussed so that their waves will co-incide, at a predetermined angle, on the area to be investigated for mineral. The phases of the diplex Inductors are tuned to produce periodic harmonics."

In a further communication to Mr. Dickinson, it is added that Faults in coalfields have not been experimented upon, and that they will be happy to answer any further questions from him or his friends.

Mr. Burrows, in moving a vote of thanks to Mr. Dickinson; said he thought it had been suggested that the test would have been more satisfactory if a piece of ore, instead of the pure metal—tin, had been placed in the ground. However, one had to begin somewhere, and if there was anything in this invention it would be worked further, and might prove very useful.

The motion was approved.

The President: It seems rather like the Röntgen rays. I don't know how far they can test down into the ground. Of course all depends on that. If they cannot go far below the surface the apparatus will not be of much benefit.

Mr. Dickinson said this new method might be of more importance than it appeared to be at present and it seemed to be in advance of all others for determining where the mineral lay. Not only did it do that, but people said a delicate ear could discover by the sound what the metal was.

COAL-CUTTING BY MACHINERY.

The discussion on Mr. A. Dury Mitton's paper on "Coal Cutting by Machinery" was resumed. (*See Part II., Vol. XXVIII., of the Society's Trans.*)

Mr. G. C. GREENWELL wrote: "I should like to congratulate Mr. Dury Mitton on his bringing a subject before the Society which is undoubtedly of great interest to a large number of the members. The question of cheapening and of improving the quality of production is one which, at the present moment, is very important to all Coal Owners and Mining Engineers, and any information based on experience is of great value to them. Personally I have up to now had very little experience with coal-cutting machinery, but I am quite of opinion that in a comparatively short time it will be largely adopted in this country, and I think that such a paper as Mr. Dury Mitton's, and the discussion which will follow upon it—and which I shall read with the greatest interest—will be of assistance in hastening its adoption. I do not quite agree with Mr. Mitton with regard to the motive power to be used, as I think that, if it can be safely applied, electricity would certainly be the best and cheapest. A Home Office Departmental Committee is, however, sitting at the present moment to enquire into the use of electricity in mines, and when their labours are ended we shall no doubt be placed in possession of a large amount of most valuable information, and be very much better able to judge than we are at present."

Mr. BURROWS said that thirty years ago, or more, coal-cutters were in use at the Atherton collieries, and he had had experience of their working since. He wished Mr. Mitton would tell them how he laid the rails for the disc cutters, because it seemed to him that a disc cutter was exactly comparable to a circular saw. If the table on which the circular saw worked was not perfectly level the saw began to stick and it was necessary to readjust the table and begin again. It occurred to him that a good deal of the trouble met with in using disc coal-cutters arose in a similar way. The rails were laid from hand to mouth, as it were, and if they were not laid correctly the cutting went wrong and it was necessary to reverse the machine and go back to make a fresh cut. He thought that was why so little had been done with such machines in the past. He intended to try some when the Arley mine was reached by his firm, and he purposed having rails laid from beginning to end before cutting an inch. Whether it would pay or not he could not say, but the experiment would be tried. If the machine were properly adjusted he did not see why it should not work from end to end without any stop except to change the cutters. Another reason why coal-cutters were not more frequently used was that there were very few coal faces of any great length that had not some dislocations, and those things were generally fatal to a disc machine. The trouble of getting over the dislocations was so great as to make it laborious if not unprofitable. His mind turned very much more towards such a machine as the "Champion," there was one in his mine, but as yet they had only been able to try it in a strait place. But from what he had seen he thought a machine on those lines would suit their purpose, at any rate, much better than the disc machine. For this reason: no rails were required, it could be worked in the day or in the night as desired, and he thought a machine of that nature, of a portable type, would sooner or later be adopted in mines like those which he had to work, where there were many dislocations and many changes in the dip. Taking all things into consideration he favoured a light portable machine like the "Champion" in preference to the disc machine.

With the "Champion" machine each place had a little bit left uncut, but that was no hindrance. With the disc machine one could not get it to work steadily day by day because all the coal must be cleared before another cut could be made, whereas with these little portable machines you could begin where you liked and hole the coal as deep or as shallow as you desired. He calculated they would not save a halfpenny in labour by using the disc machine in the Arley mine, but if it proved a success there would be fewer main roads to keep up. The position therefore seemed to be this: When coal is dear and big prices are obtainable the gain of using machines is clear. If coal is cheap the gain is less. If any one thought of trying a machine and had compressed air of about 50 lbs or 60 lbs a "Champion" was well worth a trial. He inferred from what Mr. Mitton had stated that he laid great stress on the necessity of piece work, whereas he had come to the opposite conclusion. He expected a man to do a certain amount of work per day. If the man did not come up to the required standard he would probably be changed. That was, of course, to some extent piece work. Still he preferred it, believing that with careful supervision it might run piece work very hard. His idea was to make the fireman a sort of ganger, and he would also see to the safety of the working places.

Mr. SUTCLIFFE said: In looking through Mr. Mitton's paper a day or two ago, it struck me that he had not been very fortunate with his trials in cutting coal by machinery, although, according to his description, his seams are quite suitable for machines.

I can, however, congratulate him on his decision to use a power already at hand until he could satisfy himself that he could use his coal-cutters profitably; because if he failed with compressed air as a motive power, the gain by using the more economical power of electricity would scarcely be sufficient to convince him of the wisdom of employing coal-cutting machines permanently, although this gain is often very considerable in amount. At the same time the choice of a machine made to cut only 3 ft. 6 in. under the coal, in a seam 5 ft. thick, did not promise success.

If you look at a section of a seam of this thickness, with a 3 ft. cut made under it, the eye at once tells you that something is out of proportion, and so we find it in practice. A machine made to hole 3 ft. 6 in. means a 3 ft. cut, and when such a cut is made under a 5 ft. seam, often a foot or more of the coal remains up to fall, perhaps, on the machine the next time it came along. From the experience gained within the last few years, it is perfectly safe to say that a coal-cutting machine made to hole only 3 ft. 6 in. under the seam should not be employed in seams over 2 ft. in thickness, unless the circumstances are very special.

It is easy to understand that a 3 ft. cut, which is equal to double the thickness of an 18 in. seam, is out of all proportion when applied to a 5 ft. seam, the thickness of which is nearly equal to double the cut. Under these circumstances neither the machine nor the coal face seems to have had a fair trial.

As to the reversing of the machines, they are all made reversible now if required, and some machines require much less labour to reverse the cutters than others.

In coming to the 2 ft. 10 in. seam, I am glad to see that the result is better; but even here it may be seen that the cut is not deep enough. In seams like this in Yorkshire, where the cut would be at least 5 ft. deep, the price for filling would be fully 30 per cent. less, although wages are rather higher, I believe, there.

At Emly Moor Colliery, Messrs. Stringer & Jagger pay only 1s. 3d. per ton for filling a seam 30 in. thick; and Messrs. Pope & Pearson, at Altofts, where wages reach the highest point, pay only 1s. 4½d. per ton for a seam 2 ft. 10 in. thick.

Then, again, Mr. Mitton seems to have been rather unfortunate in the proportion of round coal if he can get only 55·55 per cent. out of his seam, which is only equal to 6½ per cent. increase on the hand-got coal. This again seems to prove that his cut is too shallow. At the D Pit, in the Lambton Collieries, Co. Durham, they have increased the round coal in the Five-Quarters Seam, which is 4 ft. thick, from 25 per cent. as got by hand to 80 per cent. with a deep cut by machine. This, of course, is an exceptional case, but 10 per cent. increase is a very low estimate indeed unless there is something radically wrong in the system where the machine is applied, either in making cuts unsuitable to the seam or in cutting on the bord face, &c.

I have always thought that people who put machines in to try them make a mistake, and I think so yet, after 27 years experience with them.

Either a coal-cutting machine should be put in to work or it should not be put in the mine at all. These trials are quite unnecessary, and are often expensive luxuries. A practical man can tell at once whether a seam and its surroundings are fit for a machine, and if it is introduced it ought to be done as a permanent arrangement instead of a "trial", which far too often courts defeat.

It is also often taken for granted that unless coal-cutting machines show a distinct reduction on the getting cost of coal they are a failure. Nothing is further from the fact, for I have known coal-cutters put to work under conditions where they could not compete in price with hand labour, and still were worked with marked advantage to the owners owing to the improvement in the sample of coal.

When coal is required for domestic use and for steam purposes it should be got in solid pieces, and to get it so it must be holed underneath, or at least set free at two sides of the square, namely, at the face and at the top or bottom, the latter preferably, as then gravitation brings it down; and the latest and best practice seems to be to attack the coal on the end and cut under it to a sufficient distance to enable it to fall. This distance is found to be less when done by a machine than it is when done by hand, as the former does it in a straighter line. When the coal is got in this way it is found from experience that it brings more money on the market, and so is of more value than when it is got on bord having the planes of cleavage parallel with the face. But if the coal is required for gas or coking purposes, where small or fine coal is as valuable as the large, the cheapest way of getting it is to allow the gases and pressure to assist by pulverizing it in bursting it off slice by slice. In this latter case coal-cutting machines are seldom required. In the former case they have been used in some of the thinner seams for several years, and have kept many collieries open to the present day which, without their aid, would have had to be abandoned years ago. Until recently the machines made were capable of holing only about 3 ft. under the coal, and this depth although suitable to some of the thinner seams was quite useless in the thicker ones, and owing to this Mr. Garforth, of Normanton, made experiments and found that by providing a machine capable of making sufficiently deep cuts to bring down the thicker seams he could get them by machines with much benefit to both the mine owners and the miners. Since then the thicker seams are being got by deep-holing machines with much success.

Last year Messrs. Pope & Pearson got 420,000 tons by 18 coal-cutters out of a total tonnage of 553,000 tons produced at their collieries. And at the D Pit of the Lambton Collieries three machines produced 73,000 tons last year.

At the Altofts collieries the yardage cut per machine per shift of eight hours was 83 yards, which is nearly equal to 100 yards per shift of 9½ hours, and all the cuts were made 5½ ft. deep. When we remember that the same amount of labour has to be given to lay the track and timber the face whether the cut is 3 ft. or 5 ft. 6 in. deep, it will be readily seen that a great saving must be made by the deep cut. And in addition to this saving, by adopting the deep cut, less timber is required per ton of coal got, as each cut brings the whole of the working place and timbering entirely under fresh cover.

Amongst the advantages obtained by the use of these machines are—(*a*) saving in the cost of getting, and improvement in the sample, of coal; (*b*) saving in cost of timber and by-work, through the face moving quicker; (*c*) saving in general datalling expenses, through having less airways and gateways to keep in order; (*d*) more coal produced by the same number of hands; and (*e*) the getting of seams which could not be profitably worked without them.

Electricity as a motive power is much more economical than compressed air in operating the machines, and Mr. Garforth, in making experiments in an experimental gallery on the surface, ran one of his enclosed electric machines under full load of 500 volts. and 30 amperes for more than an hour in the most explosive mixture of gas and air (about 1 in 10) without obtaining any explosion; but an open running machine, under the same circumstances, caused an explosion at once.

It seems impossible to give the horse-power used by a machine in cutting coal; because a machine working in a face, and using 10 horse-power under one set of attendants, may use 15 or 20 horse-power with another set of men, to do the same work, owing to various reasons. The power may be anything from 5 to 25 horse-power.

Mr. Lowe said he had had some experience of working a "Champion" machine, but only in a strait place. He had not, had a chance of seeing what it could do in a long-wall face. Speaking generally, he thought it was a good machine, particularly for strait work. He had one at work in the Wigan Four Feet Mine, and it was capable of undercutting a depth of 9 ft. in the centre, but it had to be re-set to cut an equal depth at the sides and also to shear the sides; but in his case it was arranged to cut a uniform depth of 4 ft. across the narrow work at one setting.

Mr. Burrows said he did not wish to convey the idea that one "Champion" machine could do the work of one disc machine. That was not the point. The question that appealed to him was whether, when he had spent so much money in connection with the working of a disc machine, he would find any advantage as compared with the man who used a Champion machine.

Mr. W. McKay said he had had experience of other machines besides those already mentioned. He had worked the Diamond machine on an inclination of 1 in 3 and 1 in 6, and less than that—about 1 in 8, perhaps. And in the places where the seam was about 5½ ft. in height and the inclination 1 in 3 the machine did remarkably well on a face 70 or 80 yards in length, which it crossed about twice per week, the holing being about 5½ft. deep. In a seam where the inclination was 1 in 6 the machine had cut about 130 yards in one shift. They had cut this and cleared the coal out in the same day. That was one of the main points in the working of mechanical cutters—to clear the coal away every day if possible. As to laying the rails, the men managed that part of the work very well by just laying the road, levelling the rails, and putting them in position as they went along. It had been done where they had had dislocations. The machines worked as well in the higher inclinations as they did in the lesser ones. There was not much levelling of rails required when working the machine up hill.

Mr. LOWE said it took about 12 minutes to take the "Champion" machine down and refix it.

Mr. PILKINGTON said the chief difficulty in regard to disc machines was in steep mines. He had tried one with fair success, but had not worked it long enough to enable him to pronounce a very definite opinion. He thought if the machine was stronger, it would be easier to overcome the difficulty of keeping the machine up to the face.

The PRESIDENT remarked that colliery people seemed to be rather prejudiced against electrically-driven machines.

Mr. STANLEY ATHERTON gave some figures he had prepared, showing the actual cost of working coal-cutters in Canada. They were as follows:—

Holing machine	..	1d. per sq. ft.	
Rooms..	Shearing....	1½d. per ton.	
	Boring ..	¾d. ,,	
	Shot firing ..	3d. ,,	and find powder.
	Loading	4d. ,,	
Narrow	Shearing ..	1½d. ,,	
	Boring	¾d. ,,	
	Shots	3d. ,,	
	Loading....	4d. ,,	
Dips..	1/6 per ton, contract, all labour.		
	5/- a day for loader.		

Hand Rooms. } 20½d. per ton, 6 ft. and upwards.

Cross-cuts 20½d. ,, 9 ft. wide, and 35d. per yard.

Headings 20½d. ,, 10 ft. wide, and 45d. per yard.

1½d. per inch for cutting faults only in bottoms.

The President asked Mr. Atherton to tell the meeting what his impression was as to whether work could be done more economically by machines than by the men in Canada.

Mr. Atherton said that by a rough calculation the machines meant a saving of 30 per cent. in parts of Eastern Canada, but not in Western Canada. The reason being just the same in the United States and in Eastern Canada, where they can make things cheaper than we do, and pay higher wages to the skilled workman, because they employ one skilled man to six "dummies", as they called them, whereas in similar circumstances in this country three skilled workmen would be employed. The higher wages of one were obtained at the expense of the others. In Canada West where they were using machines the whole of the hard manual labour was done by Chinese and Japanese; but at the time he was there the Legislature passed a law excluding these foreigners from the mines.

The President: Are we to understand that machines were able to compete with Chinese labour?

Mr. Atherton: No; they were not able to compete with Chinese labour at the current wages of the day.

The President: My impression is the use of the machines is an advantage, a great advantage.

Mr. Smethurst said that his experience of the working with Mr. Gillot's machines showed there was a saving of 3d. or 4d. a ton. That was when everything was favourable.

Mr. W. Saint said he had often noticed that when the machines were at work they made such a great noise that it was difficult to hear any other sound. It had occurred to him that the excessive vibration and noise might be very much diminished by fitting them with double helical gearing instead of the ordinary toothed wheels. One realised the importance of having as little noise as possible in a working place where, owing to subsidence, some danger might arise from the "weighting" of the roof, and it was desirable for the workmen to hear any warning that might be given. He thought, therefore, it would be a move in the direction of safety if the machines were made as noiseless as possible.

Mr. Knight: Is there much difference between the bar and the disc machines in the matter of noise?

Mr. A. Dury Mitton: I think the bar machine is quieter from what I have seen, but I don't think there is very much difference.

Replying on the discussion, Mr. Mitton explained the mode he had adopted in arriving at the figures given in his paper as to the cost for compressed air for the machines. With regard to the objections to the use of electricity as the motive force, he recognised the danger from sparks and the fusing of cables in mines where large quantities of gas were given off. He would like to ask Mr. Peace, knowing that that gentleman once had an electric coal-cutter at work in his pit but abandoned it, what his reasons were for ceasing to use the machine. When a person actually abandoned an electric coal-cutter one would like to know whether the abandonment was due to the fault of the mine or to objection to the use of electricity. As to the possibility of sparks coming from the coal-cutters themselves that seemed a very important point, for there was a great amount of danger likely to occur in coal getting if sparking were going on. He noticed that one speaker had said they were running the cutters at the rate of 60 revolutions a minute. That seemed a tremendous rate. In the Bridgewater pits the cutters were not run faster than 12 revolutions per minute. He had watched the machines at work, and had asked the colliery officials who were constantly with them, and they assured him they had not seen any sparks come from the cutters. In answer to Mr. Burrows on the subject of laying rails, his practice was to lay rails down 18 feet in length and absolutely level. Trouble was caused by the machines slipping and the cutters working up into the coal, leaving coal on the bottom, but that was through carelessness. As to the question of piece work, he adhered to his view that it was the best. With regard to Mr. Pilkington's remark concerning cutting in a steep mine, he had to say that three or four days ago he saw Gillot's machines, weighing 25 cwt., working without the slightest difficulty on a gradient of 1 in 3½. He had found no difficulty in working the machines in steep mines, and he had tested the machines very carefully.

Mr. SUTCLIFFE said there was no question about sparks being emitted by cutters going at high speeds in certain sorts of earth or coal. For this reason one ought to have a machine to suit the material in which one had to work.

The PRESIDENT said he thought the discussion had been very interesting, and that what had been said would be of very great benefit to people who were just introducing machines into their collieries. They must have got a good deal of information, though he still thought the matter might be carried further. There were various opinions on several points, so that he thought they had better adjourn the discussion. Someone might bring them some further information. At any rate no harm would be done by leaving the matter open. As to his own views on the subject of coal-cutting by machinery, he could not go about without hearing what people said about these machines, and without seeing them at work from time to time. The conclusion he had come to about them was this: If by the introduction of a machine the holing could be done in the clay under the seam instead of in the coal itself, then that was the kind of seam to put a cutter in, for the difference between holing in coal and in the clay might amount to as much as 10 per cent. of round coal. There you had an advantage at once, even if the cost of labour were the same. His impression was there was not much to be gained in the matter of labour. Seldom did he find more than 5d. or 6d. a ton difference between what was paid with a cutter or without a cutter. Hence, he imagined that if the getting price that had to be paid to the men was anything less than 2s. 6d. a ton it would be better to continue the men and not attempt to put in a coal-cutter. But if the getting price was beyond 2s. 6d. and up to 5s., there was the opportunity to apply a coal-cutter. And with regard to the height of a seam in which to put a cutter, his impression was if it were more than 3 ft. 6 in. the Lancashire colliers would do the work as well as the machines, but if it were less than 3 ft. 6 in. the coal-cutter might have the advantage.

The discussion was again adjourned.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

PART VI. VOL. XXVIII. SESSION 1902-1903.

The ORDINARY MEETING of the Members was held on Tuesday, March 10th, 1903, at the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Mr. W. WATTS, F.G.S. (in the absence of the President), in the Chair.

In opening the proceedings Mr. WATTS said: I need not tell you how pleased I am to come once more into this room and to receive the kindly greeting and the warm shake of the hand I have received to-day. It has been my pleasure for a good many years to attend these meetings and to contribute to the proceedings of the Society, and I can assure you that although I am separated from you by a number of miles you are very frequently in my mind, and certainly on that day when I get my circular announcing that a meeting of the Society is to be held. We have to-day to hear a paper on what I think is a very interesting subject. At all events it is a paper which has brought me from the Little Don Valley Works in the hope of being enlightened on the subject of underground water supply. It is, as you know, a deeply interesting subject to all waterworks engineers and to all colliery engineers and managers, and if Mr. Pickstone can give us some further information than we have published, or than we find in our daily experience, I am sure we and the Society will be indebted to him. I say no more until Mr. Pickstone has read his paper. But before the reading of the paper Mr. Dickinson has a brief announcement to make.

THE LATE MR. THOMAS WARD, J.P., F.G.S.

Mr. Dickinson said: Since our February meeting this Society has lost by death Mr. Thomas Ward, J.P., F.G.S., of Northwich and Winsford, a member of 18 years standing. He was only an occasional attender, but he will be well remembered by his useful papers on the salt districts which appear in the "Transactions." His loss to Cheshire will apparently be great, as he held many positions of usefulness, including that of Managing Director of the Salt Union. He was a quiet, convincing speaker, to whom it was a pleasure to listen; and it seems that but for the still greater claims of the present Member he might have represented these salt districts in Parliament. I move that we express our sympathy, accompanied by the hope that one of his sons may take his place in this Society.

The motion having been seconded, the Chairman said: You have heard the kindly reference Mr. Dickinson has made to the late Mr. Ward, who was one of our members. I am sure we all sympathise with the family in the great loss which they have sustained. It is not only a loss to them, but to our Society.

The resolution was carried unanimously.

The following paper on "Our Underground Water Supplies" was read by Mr. William Pickstone.

OUR UNDERGROUND WATER SUPPLY.

By Mr. William Pickstone.

The question of our water supply, whether underground or overground, will be admitted to be one of the most important that can be brought before a society of thinking citizens, I therefore make no apology for bringing it before the Society, especially as the underground is a geological question. It is to that section of the subject that I shall chiefly call your attention, my object being to raise a discussion. Crowded populations have to requisition outside or world-wide areas to satisfy their wants in many respects. Three of these are of paramount importance—Food, Firing, and Water. The two former may be obtained from anywhere the wide world over, we may say. The latter must be obtained from places reasonably near to where the consumers reside. It would hardly seem at first sight as if water was of more importance than food; but when it is looked at from the standpoint that it alone of the trio must of necessity be obtained from our home supplies its paramount importance from a national point of view is self evident. As a nation we have come to recognise that the coal supplies within Great Britain and Ireland are of such importance that two Royal Commissions have been appointed within recent years to take account of what they are, and consequently of where we are, as a nation of manufacturers and traders, in regard to them. Much attention also has been given to our food supplies. This is especially so to-day as to "our food supplies in time of war." The increasing importance of all the three as million by million is added to the population will be admitted. The look out to-day, if only we are to keep our place among the nations, would seem to indicate a possible hundred millions within the present century. Yet to-day there is difficulty in obtaining adequate supplies of suitable water for the more populous areas.

Some of us are old enough to remember the time when Manchester had not given up its wells, and pumps, and fountains, and but yesterday, as it were, the Royal Borough (so much to the front just now) made its first contract with its big brother for a supply of three million gallons per day, which supply I imagine was at that time thought sufficient by the Mayor and Corporation of Salford for many more years to come than it has been found to be. Outside London little if anything had been done up to the end of the eighteenth century to supply town populations with "pipe water." Even so late as the middle of last century not much had been done in towns of 50,000 and under in the shape of house to house supply. Still later came the time of continuous supply. Yet with our forty millions of people to day, three-fifths of which may be located in towns of 10,000 and upwards, what are the facts that are presented to us? Except Glasgow there is probably not one large centre of population that has made provision for its probable wants up to 1950. In fact on the subject of provision many town populations are crying out loudly for better supplies, and districts are combining with the object of securing them. The latest of these is to control our chief Derbyshire rivers. Liverpool has gone to Wales, Birmingham is going to Wales, and it is quite on the cards that London may have to go to "Little Wales," in which connection it would be supremely interesting to the people of Denbigh to have it made clear to all the people of the United Kingdom that one of the citizens of the county of Denbigh was the first man in this country to take steps to supply London with water. It is difficult to say what "Little Wales" may not yet have to do for the

Empire. This may, Mr. President, be considered a rather long introduction for my paper on "Our Underground Water Supplies." I may say at this point that looking forward to the time when one hundred millions of people will need supplies—eighty millions most likely in towns of 10,000 and upwards—it is, in my opinion, necessary that all the supplies should be under the control of a Government department. The first necessity of our continued existence as a nation should be removed outside individual control, and, if you like, individual emolument. I have urged in a recent paper that coal should be so. Yet coal could be brought from other countries, so the case of water is more urgent than coal. Way-leaves in the case of coal are often great nuisances, but way-leaves in the case of water are even now an abomination in some cases. The experiences of Manchester, Liverpool, and Birmingham might furnish some interesting ones. Fortunately in the case of underground water, way-leaves would not stand in the way until the water is stored in surface reservoirs. It is not many years since Liverpool took all its water from underground, and until it was in the presence of a possible and dangerous failure the great city took no direct step to go further afield. After tapping Horwich it calmly sat down, but soon discovered that some larger and additional gathering ground was needed. Bala Lake was discussed for some time, but ultimately the watershed of the Dee was abandoned for the more distant watershed of the Severn. The sister population of Birkenhead, and I think I may say the same of most of the towns and villages of the Peninsula of Wirral, of which Birkenhead is the chief, obtain their water by either pumping or by artesian wells from the New red sandstone. Southport does the same. Rhyl until recently pumped its water from below, but I do not know from what rock section it was obtained. Knutsford has for a good while been boring into the New red sandstone, but for reasons I need not explain, has not been successful. At never-to-be-forgotten Hawarden, which the late Mr. W. E. Gladstone has sanctified, the authorities are now trying to increase the district surface supplies by putting holes into the underlying rocks of some part of the district. I apprehend this is being done outside the coal field that is being worked there.

London, with five millions of consumers, is at present in the throes of getting out of the hands of private companies, with the object of doing something more adequate to its wants than the several companies have done. It has been argued by water engineers and other authorities for years that other sources of supply in addition to the Thames, the Lea, and the underground supplies, which latter have been very largely used, should be secured. Some of the engineers have asserted that the underground waters were inexhaustible, but in recent years it has apparently been proved that the contrary is the fact. Multiplying bore holes has not increased the output. The limits of that source have, it is now admitted, been reached. Where the new water authority will go for the more certain and additional supply is not yet, I think, determined; but it would seem necessary that some mountainous country must be resorted to. There are, no doubt, considerable underground supplies that have not been much worked upon, but the quality in some cases is not such as to be suitable for domestic purposes. Exposure to the air (artificial aeration) might do something, and so might chemistry, to render such waters more suitable than they are in their natural state. But in some cases in which untouched rock strata capable of taking in water, and are found full of water on being punctured by the boring tools, the supply turns out after a while very disappointing to the water finders. The conditions that are so highly pleasing to the man who is seeking to open up coal and other minerals are to the water seekers unpleasant in a very marked degree.

This underground water question was dealt with in a very exhaustive paper read before the Society by Mr. Jas. Keen on the sinking of the Maypole Pit, of the Moss Hall Colliery Company, at Abram, near Wigan, so far as the particular section operated in was concerned; but it may be noted that this was a case somewhat peculiar. A block of coal land was surrounded by other coal lands, which, because they had less unprofitable cover on them and little water, had been worked for years. Mr. Keen expressed the opinion that the section he was operating in was a down-throw. That was, I think, a misapprehension on his part, the fact being that the surrounding lands were up-throws, and having been subject to the same denuding influence a thickness of several hundred yards of cover was found in his section that had wholly gone from the other, leaving a crust of new red and permian water-bearing strata. It is not unusual in such cases to find the rock within the confined area surcharged with water as in this case, and it is quite natural that on sufficient pumping being resorted to that the strata would be emptied, as in this case to the great delight of Mr. Keen and his Company. Had he been digging for water instead of coal he would have had reason to regret if his millions of gallons per week became thousands. The paper was read over four years ago. At that time water continued to flow from the foot of rock where it rested on the coal measures—which were free of water—to the extent of 60,000 gallons per hour. I judge that the supply will ere this have decreased considerably, as, in my opinion, it was entirely local in its origin. Such local supplies where, as in this case, there is a deep surface cover of clay are of little or no use in estimating "our underground water supplies" for domestic or household purposes. If in any area you are to go on pumping it is absolutely necessary that there should be opportunity of percolation of rain water or sea water. I must curtail my paper, but I must refer to the importance of underground supplies for manufacturing and trading use, including Brewing. I am assured that in Greater Manchester—which naturally includes Salford—there is much more water pumped out of the red rock daily than is supplied from the Corporation mains, and the same occurs at Liverpool and many other places. Let us in this connection refer to that very remarkable Brewing centre Burton-on-Trent, in which nature seems to have given water for making malt liquor of a quality that cannot be excelled. One is inclined to ask whether if the water there was under Government control the opportunity to limit the supply of the particular form of intoxicants would, in response to the demand of the various sections of the Temperance Party, be brought into exercise. I will close by a reference to the recent attempt to find water south of London, which has, as it would seem, resulted in the discovery of natural gas. In my paper on "the nationalisation of our coal supply" I recommended that a general system of search by boring should be instituted that it might be proved what was hidden away below ground in those areas of which we had no positive knowledge. Such an expenditure of public money would, in my opinion, be wisely spent in the case of water also.

The CHAIRMAN said: You have heard Mr. Pickstone's paper, and I quite agree with him that the merits of it consist in the main in what may be derived from it. It is open to very considerable discussion, and some of the points, I think, may be dealt with by those present. I cannot agree with him when he advocates an in-rush of sea-water into a well if that well water is to be used for any kind of domestic consumption. If it be used, however, for mechanical purposes you may have as much sea-water in the well as you care for. There is no doubt that by atmospheric exposure, bleaching and subsidence of impurities, water does get clarified, but his reference to the aid of chemistry I do not agree with. I do not advocate a water that has to be treated chemically to make it usable. I like naturally clean water, and I think we all do. With regard to the scarcity alluded to, I think a good deal is owing to the great loss of water by the non-utilisation of it by Corporate bodies or waterworks committees not having sufficient storage room to take care of it when it comes. As a rule floods are few in every year. They do not come probably more than five or six times. When they do come, however, they are very large, and if there is not sufficient storage room provided it passes to waste. The following table shows how some Corporations utilise their drainage areas, the rainfall being practically the same in each district.

STORAGE CAPACITIES OF RESERVOIRS.

Name of Reservoirs.	Drainage Area in Acres.	Storage Capacity of Reservoirs in Gallons.	Storage required at rate of 60,000 cubic feet per Acre of Drainage.	Cubic Feet of Storage per Acre of Drainage.	Effective Rainfall to fill.	Remarks.
		Millions.	Millions.			
Thirlmere	11,000	8,155	4,112	119,000	32·78	Raised Lake.
Vyrnwy	22,300	12,131	8,335¾	87,311	24·05	
Oldham	4,380	1,996½	1,637¼	73,466	20·16	
Elan Valley ..	45,560	18,000	17,030½	63,415	17·47	
Derwent	31,946	9,996	11,941⅓	50,226	13·81	Not yet constructed.
Loch Katrine...	45,800	9,968	17,020	34,935	9·62	Natural Lake. T.W. may be raised.
Longdendale ..	19,300	3,905	7,214½	32,477	8·95	Denton Reservoirs not included.
Swineshaw	1,300	260	486	32,103	8·84	
Cardiff	10,000	1,257	3,738	20,177	5·56	Powers to construct additional Reservoirs.
Bury, Lancs. ..	3,760	127¼	1,405½	5,431	1·50	

Now there is no science in arrangements of this kind. Here you have a Corporation providing storage for 73,466 cubic feet of water per acre per annum and another 5,431. One Corporation is certainly utilising to the full extent, almost every drop of water that falls upon its drainage area, whilst the other is not. There is also a great loss of water in pumping from tunnels. The tunnel under the river Mersey at Birkenhead yields a large quantity of water which is pumped to waste. It is the same at the Severn tunnel. With regard to the short period for which some corporations have provided water, I think Mr. Pickstone will find that quite a number of them have anticipated their wants for at least 50 years. Liverpool, Manchester and Birmingham have, and I think Sheffield, when its Derwent and Little Don schemes are completed, will be in a similar position to that of the two Lancashire cities. With regard to the wisdom of providing so far in advance I am rather disposed to doubt it, because if you appropriate a drainage area to-day which is sufficient for your increased population 50 years hence, there must be a considerable amount of water running to waste in the meantime.

Mr. JOHN UNSWORTH, in moving a vote of thanks to Mr. Pickstone for his paper, said he came from a township where provision for the supply of 4,000 people with water had to be made, and the authorities had undertaken to supply about 20,000 more. He had been connected with the scheme for supplying these people ever since its inception, and he found, as Mr. Pickstone suggested, it was necessary they should combine to do something in order to make sure of the waters they had obtained and which were necessary to supply the people they had contracted to supply. He did not quite understand Mr. Pickstone's meaning as regards water leaves—whether it was as to water bottled up and kept up for ages in the bowels of the earth, or the surface-water which issued in the form of springs and made its way to the streams, from which some places derived their supply. In one area with which he was acquainted there were 73 acres of moorland, and on it there was secured an average quantity equal to 160,000 gallons a day, while from an adjacent area of 19 acres an equal quantity was obtained. Now here came, as he understood it, Mr. Pickstone's principle in reference to underground waters. It seemed to him that the difference in the amount collected in the two areas in question was accounted for by the probability that in one case the surface-water found its way in heavy rainfalls down to the rock; and that the rock absorbed and diverted the water, and gave it off on the smaller area. He desired to ascertain whether the theory he had formed was correct—that was, that the smaller area of 19 acres, which was yielding as much water as the 73 acres, was fed from the adjoining land owing to the water being drained down to the rocks below. He thought it was.

Mr. J. Gerrard said: I can assure Mr. Watts that his pleasure at being present was cordially reciprocated by the members present. I am sure we are delighted to see the Chairman here on every occasion that he can possibly find it convenient to come, and that we are specially fortunate in having him with us to-day considering what an authority he is upon water questions. I would like to ask whether it is possible for water, that is not absolutely pure, to be used by Corporations, say, for sanitary purposes, flushing drains, watering the streets, and, possibly, for manufacturing purposes If that could be done we have an enormous supply close at hand; the use of that water would remove a very serious cause of anxiety in connection with and cheapen the working of coal mines, and would open up large areas of coal which are at present water-locked. It seems to me it is very desirable to make public use of these waters if it is at all possible. The Manchester Corporation might get a very large quantity of water in that way. There is an enormous pound forming now in the Dukinfield area owing to the stopping of the Dukinfield collieries, and that accumulation is now giving very serious anxiety to the workers of the coal in the neighbourhood and is locking up a very large area of coal. There are other places similarly situated, where smaller pounds of water are accumulating, so that a very large quantity of water is available for other than drinking or domestic purposes. I beg to second the vote of thanks to Mr. Pickstone.

The motion was adopted.

Mr. Dickinson: I have listened with much pleasure to the paper, and from what I gather, Mr. Pickstone's main point is that the water supply of the country should be placed under Government control. Our Chairman has described his view, in which it appears he relies chiefly upon the extension of reservoirs for the collecting of the present rainfall and the springs. I believe that recommendation is like unto that which was made by our Bishop of Manchester (Dr. Moorhouse) when he was Bishop of Melbourne. He was asked to organise a prayer meeting for the supply of water. He told them he thought the matter was in their own hands; that if they would collect what was then going to waste they would have no scarcity. I agree pretty much with what our Chairman has laid down very clearly. Mr. Unsworth has also dwelt upon the surface supplies and the underground supplies, as did Mr. Pickstone, and Mr. Gerrard has emphasised the importance of utilising the underground sources of supply. Now there are comparatively pure waters valuable for domestic and other uses, and there are impure waters valuable for the mineral they contain. In a report made by me in 1873, on the landslips in Cheshire, and printed by order of the House of Commons, I put it that: natural flows of water on the surface may be used as they pass, but not fouled, or turned into another shedding; and that below-ground water belongs to the person in whose digged well, shaft, or working it is found. Any number of neighbours' wells may be drained into a properly worked mine with impunity, "the miner getting what he does not want, and the neighbours losing what they greatly prize." The right to use brine had then from time immemorial been treated in the same way as water; and the solution of rock salt by the pumping of brine was destroying property far and near without any compensation being paid. The report showed that this was unreasonable, and wound up by suggesting that a tax should be levied to compensate. A Bill called The Cheshire Salt Districts' Compensation Bill followed in 1881, but it failed in Committee; the details of the evidence given being abstracted in a Supplementary Report in 1882, made by me, like the former one, by direction of the Government. Ten years afterwards, "The Brine Pumping (Compensation for Subsidence) Act, 1891," framed on a more equitable basis, became law, subject to certain conditions, and it is now in operation in the Northwich district. The conditions may, however, be very expensive. Therefore, in some other districts, the damage seems now to be compensated voluntarily. Water impregnated with copper from mines is also used. The precipitation is usually done above ground, but where the flow went forward into another mine, I have seen the copper precipitated below ground, and the water thus impoverished allowed to flow on for pumping at the neighbouring mine. Contentions have often occurred at mines where, to avoid pumping, water has, by sough means, been caused to flow into a neighbouring mine. Exceptionally, on the other hand, where the water was wanted, I have known objection made to the taking of it away into another mine by sough means. Some of the speakers have pointed out the difficulties Corporations have had in obtaining rights for the collection of water, and those who know the facts of the difficulties that had to be met in the obtaining of an Act for the compensation of the sufferers in the salt districts will know that it is not an easy matter for Government to step in and legislate on a matter that affects such a wide community.

The CHAIRMAN: I am sure we have listened to Mr. Dickinson with great pleasure. He is always fresh and green, and I hope that he will long live to take part so intelligently in the discussions of the Society as he has done to-day. Mr. Dickinson has introduced one or two very interesting points. With regard to the underground water we must not forget, however deep seated, it is never at rest; but is constantly being supplied from the surface. With regard to the disparity between 19 acres and 73 acres, I think it is clearly accounted for by the permeability of the different beds. It is not possible for the same amount of water to collect on 19 acres as on 73 acres. There must be some physical causes to account for the water running in and running off the surface. Wherever you have open strata you have the rainfall percolating through it, and being given out as spring water. Wherever we have a drainage area covered with impervious material the water runs off the surface quicker. We have in such a case also a great deal less evaporation. With regard to Mr. Gerrard's idea, of some system being adopted—some dual system—for the use of two classes of water, I may say I quite agree with him that if a dual system were adopted, in many cases a great deal of water would be saved for the different communities; but it is expensive to put down a dual system. During the last few years the Oldham Corporation have adopted it. They had a certain area the water of which, owing to the growth of population and manufacturing industry, was practically unfit for domestic use. To that drainage area was attached two reservoirs. The Corporation very wisely said, "If we cannot use this water for domestic purposes we will put down a separate main and use it for consumption by some of the palatial mills, so many of which exist in Oldham." That was a wise thing to do. With regard to different boreholes yielding different quantities of water, that is accounted for by tapping the ground at a different level. Again, every land owner has a right to the flow of the underground water, but I maintain it is not exactly right for my neighbour to sink a well a little lower than mine and drain it without giving me some compensation. I know it is the law of the country, that he who sinks the deepest shall get the most, but I am not going to speak in favour of the justice of a law of that kind, but in favour of common sense. If a man sinks a well lower than mine I say "you must provide me with a water supply or sink my well as deep as yours", and that ought to be done.

Mr. UNSWORTH: It is not the law.

The CHAIRMAN: I quite admit that; but it ought to be done.

Mr. DICKINSON: In some of the Irish leases where the minerals are being worked a clause is inserted by the landlord that in the event of the mine taking away some of the surface tenant's rights the tenants shall be compensated.

The CHAIRMAN: I was not aware of it, but I know they are in advance of us in some things even in Ireland.

Mr. DICKINSON: They have some good points.

The CHAIRMAN: A man has only an absolute right to underground water when the channels are defined. If you can define the channel your neighbour cannot rob you, but you must prove the channel to be a definable one.

Mr. UNSWORTH : Mr. Dickinson in the opening part of his remarks quoted from a report which he made to Parliament, that water could not be lawfully turned out of one shedding into another.

Mr. DICKINSON : That was the way I put it in my report.

Mr. UNSWORTH : I understood you to say it could not be legally done.

The CHAIRMAN : And I think he is right.

Mr. UNSWORTH : No, he is not.

The CHAIRMAN : I believe I dealt with this question in a paper which I read before this Society some years ago.

Mr. DICKINSON : I put it that natural flows of water on the surface may be used as they pass, but not fouled or turned into another shedding.

The CHAIRMAN said he thought one might divert a stream, but no one had a vested right in it. If, however, you diverted water from stream A to stream B you simply deprived the riparian owners below the point A of an advantage. That was an injustice, and a riparian owner could legally step in and say "You cannot do that."

Mr. UNSWORTH : Precisely, and Parliament supports that view and says you must compensate.

Mr. DICKINSON referred to the case of the Moston Old Colliery now inundated, and said there was an almost inexhaustible supply, and when the inundation took place the question was gone into whether the water should be used for domestic purposes or not, but the analysis, he thought, showed it was not suitable.

Mr. Unsworth spoke also of there being an inexhaustible supply of water in one of the pits of the Wigan Coal and Iron Company.

Mr. Gerrard suggested that if, for example, the water which was a source of trouble in the Dukinfield district could be applied to public use it would set free a large area of coal, the working of which would find employment for a large number of rate-paying residents.

The discussion was adjourned.

THE NAME OF THE SOCIETY.

At four o'clock the ordinary business was suspended while the members present voted upon a proposal to change the name of the Society from "The Manchester Geological Society" to "The Manchester Geological and Mining Society."

The CHAIRMAN said they were asked if they were willing to have the name of the Society changed as proposed. A card had been sent to each member asking for a "Yes" or "No" to the proposition, and out of 201 members 134 replied "Yes" and 10 members replied "No." The Council at its meeting just before the ordinary meeting of the Society, decided that those 134 affirmative replies should be added to the votes now to be given for the resolution. He might say the Council, according to the rules of the Society, had power to change the name without consulting the members, but they had thought it better to bring the matter formally before them. There was no doubt the Society was substantially of a mining character. He dare say that was a little bit regretful to the geologist pure and simple. But they were living in times of change, and, therefore, they must adapt themselves to the changed conditions of life and work.

A question was raised by Mr. Unsworth whether those members who had voted by card would be allowed to vote by hand as well. It was agreed to take a show of hands irrespective of what had been done otherwise and to eliminate from the cards those that had been written by the members now voting. The same course to be taken relative to the ten replies sent to the secretaries against the proposed change of title.

Mr. A. Dury Mitton said he had pleasure in moving a resolution on the subject, he having been the first to suggest that the change should be made. It was a matter in which he had taken considerable interest. His idea in having the word "mining" attached to the old name was to bring the Society more in touch with the mining members, of whom he found there was a large number, and with members of mining institutes in other parts of the country. The Chesterfield and Yorkshire Institutes were joined to form the Midland Institute, and the North of England had its Institute. There was another Institute for Staffordshire, and one for Scotland. All these institutes were federated, and he felt that by having the word "mining" attached to the name of the Society, the members would be brought more in touch with these kindred institutions, and the Society would become more of a mining institute. In making the change they would not lose the geological name of the Society which it had held for many years with distinction.

Mr. J. Dickinson said as he was the senior member of the Manchester Geological Society, he had much pleasure in seconding Mr. Mitton's proposal. There was nothing radical about it. We have two objects in our rules, namely, geology and mining. It was merely therefore adding a name that properly belonged to us.

The resolution was then put and carried unanimously.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL AND MINING SOCIETY.

PART VII. VOL. XXVIII. SESSION 1902-1903.

The ORDINARY MEETING of the Members was held on Tuesday, 21st April, 1903, in the Society's Rooms, 5, John Dalton Street, Manchester.

Mr. HENRY HALL, I.S.O., H.M.I.M., President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society:—

Mr. WILLIAM CLARK, Manager, Garswood Coal and Iron Co., Park Lane, Wigan.

Mr. EUSTACE MARSHALL, The Larches, Wigan.

Mr. G. HAROLD ORRELL, Mining Engineer and Surveyor, Swallowfield, Horwich.

THE LATE MR. GEORGE WILD.

The PRESIDENT: Since our last meeting we have lost by death one of our members, Mr. George Wild, and I believe Mr. Dickinson has something to say in reference to Mr. Wild.

Mr. JOSEPH DICKINSON, F.G.S., said: Soon after our meeting in March last this Society has lost by death our late valued member, Mr. George Wild, late of Albert Street, Bardsley, Ashton-under-Lyne. He was descended from an old and highly respected family of colliery managers, his father having been for many years the manager of the Glodwick Collieries, Oldham. He became an Ordinary Member of this Society in 1867. As such he contributed many valuable papers and much useful information on colliery management and geology, especially on the fossil geology of the coal measures, in which he was an expert. His services stood out so prominently that under our old rules he was elected an honorary corresponding member, and afterwards under our new rules he was elected an honorary member. It is pleasant to add that after his many years of successful management, including the opening of the Arley mine, teeming with firedamp in the Fulledge Colliery, Burnley, and the deep sinking to the Royley Mine, Bardsley, his general public services were so appreciated by friends and neighbours that through an influential committee he was recently presented with a substantial testimonial, towards which those of us who knew of the intention had the pleasure of contributing.

The PRESIDENT moved that an expression of sympathy with the relatives of the late Mr. Wild be sent to them on behalf of the Society.

Mr. J. Gerrard, H.M.I.M.: I beg to second the motion. I have known Mr. Wild for many years, and can bear testimony to the vast amount of information he had about the geology of the district. If one were in a difficulty Mr. Wild was always not only willing but anxious to help and give all the information he possibly could. I saw him only a few days before his fatal illness, he gave me a lot of information, and I am sorry to think that so much of the knowledge he had acquired is now lost to us. There ought to be written an account of his life by some competent person. I know there is a large amount of material for such an account—his house was full of papers, plans, and all sorts of notes, and if somebody would write a memoir of Mr. Wild and let it appear in our "Transactions" it would be not only interesting but of very great value.

The resolution was adopted.

Mr. Owen Hughes read the following paper on "Coal-Cutting by Machinery":—

ON COAL-CUTTING BY MACHINERY.

By Mr. Owen Hughes.

Introduction.

In placing before the Manchester Geological and Mining Society the results of practical experience in the working of coal mines with mechanical coal-cutters, I cannot hope that this communication will rank in literary merit with the many excellent contributions of previous writers on the subject, addressed to this and kindred societies; but at least I feel that the information may be interesting and possibly useful, being the record of actual operations, under varying conditions, extending over a considerable period.

The subject is full of interest and of vital importance to the mining industry. It is likely to become more prominent in the immediate future, and as there are many difficulties and prejudices to be encountered and overcome, I believe it to be the duty of everyone, who can from experience add to the general knowledge thereof, to set forth to the best of his ability the information he has acquired.

The Adoption of the Machine.

Some five years ago difficulties which had arisen in connection with the working of a seam at a colliery under my charge suggested the adoption of coal-cutting machines; with what amount of success the initial attempts were attended may be judged by the fact that we now have in regular operation 15 Rotary Machines and 14 Percussive Machines.

The application of the mechanical holing machines materially affects the working of coal seams, and the selection of a suitable machine for the purpose is of great importance. Such being the case, the machine must always be subject to the requirements and conditions of the mine, since the mine cannot always be modified or the conditions adjusted to suit the machine. At the same time the machine is only to be regarded as a substitute for the pick, and a more powerful and a more perfect implement, but like the pick in the sense that it requires skill and intelligence to use it, and in the fact that a good workman can obtain with it better results than a poor workman can be expected to show.

Perhaps many of the failures with coal-cutting machines are due to a want of recognition of these facts.

Difficulties are to be expected, and these we must overcome: and whilst the system of mechanical coal mining offers many advantages, it must be understood that it is not calculated to relieve the mining officials of any responsibility or make their lot more happy. It is not a case of mining made easy, nor will the introduction of the machine tend to lighten their duties. It rather tends to raise the standard and develop the intelligence of the colliery official. As to the machine operation, there can be but one result. Give a good workman a high-class tool and he himself becomes a better, a more skilful man, and in every sense a superior type of workman.

The Advantages claimed for Machine-Cutting.

The advantages claimed for the systematic working of coal seams by mechanical coal-cutters are too well known to need mention here, but it may be said that experience teaches us that most, if not all, the claims have been fully realized, viz.:—

1. An increase in the proportion of round coal.
2. Smaller loss in working (that is a greater yield per acre).
3. In most mines a reduced working cost.
4. The necessity for explosives is reduced, in some mines amounting to entirely dispensing with shot firing, thus removing a great element of danger.

5. A larger output from a smaller area in a given time.

6. Reduced loss and cost of timber, together with fewer accidents from falls of roof.

7. A larger daily wage for the collier, whilst relieving him from the most dangerous and most laborious part of his work, viz., holing.

Prejudice of the Men.

One of the first and often the most serious of the difficulties to be overcome in many cases is prejudice.

We have been singularly free from objection on the part of the men, and it may be interesting to explain how the first machine was introduced without arousing their opposition.

The first mine into which we introduced a machine was one of the following section :—

Metal roof.
"Ley" 6 in. (which falls with the coal).
Coal 2 ft. 9 in.
Fire clay 1 ft. 2 in. (too hard for hand-holing).

Two mines below, in close proximity, had previously been worked leaving the upper seam hard, woody, and difficult to work by hand. The getting price paid to the collier was 3s. 6d. per ton including allowances, but men could scarcely be induced to work in the seam even with the offer of increased allowance.

Commencing operations on a small scale.

A machine of the Gillott's type was introduced. Operations were commenced on a limited scale. The "drawings" were reduced to the shortest possible distance, and the machine was commenced at the outset on a face only 25 yards in length. This necessitated a mere handful of men, one might say, to keep in good humour, and served as a training ground for the few employed.

At each succeeding cut the face extended and the number of men on the face was increased one or two at a time as required. In this way the operations developed gradually to the full extent, whereas had a start been made with a long face and with 80 or 100 men, it is more than probable some malcontent would have raised difficulties and unsettled the others, and to pacify the larger number would have proved a greater task than the education of a few men at a time.

Eventually the length of working face became 170 yards, across which the machine cut each night.

The coal holed by the machine at night time was dealt with by the colliers during the following day, and at the same time they prepared the face for the next cut.

During the second half-year after the commencement of this machine, it worked 145 days, or rather nights, and the amount of coal got by it was 14,278 tons or an average of nearly 100 tons per day.

Encouraged by the success of the first attempt more machines were obtained and put to work in this and other mines until at the present time we have about 30 machines of one type or another regularly working in the various seams. Two or three machines are also kept ready for work in the event of those in service getting out of order.

Commencing a Cut.

At this point it may be well to describe, generally, the system adopted with the machines and the preparation of the coal face.

I will describe a face with only one machine working, and cutting across from end to end.

To commence the cut we form, say at the extreme left of the coal face, what we call a chamber or stable; this is an opening into the coal as wide as the machine, and as deep or deeper than the wheel or cutter—where this is not done you will generally find the middle portion of the coal face in advance of the cutting ends, and the faee gradually being worked into a curved line which is not desirable.

We find this plan preferable to that of commencing the cut by starting the machine at an angle with the face and gradually working the wheel under the coal, as can be done with some machines, for by commencing at one of these properly made stables the machine at once attacks the coal with a cut of full depth and proceeds across the face. It is also important that the machine should cut out and finish in the open, otherwise the machine wheel would remain under the coal, which might break and fall upon it, and also make it more difficult for the collier to get the coal out. For this purpose a chamber like the one at the commencement of the cut is made either by hand holing or a heading machine, and the machine cuts right through into this chamber, where it remains in readiness to commence the next cut across the face in the reverse direction.

Timbering.

The roof in the case of most of the mines referred to may be described either as bad or very bad. Timbering is carefully and systematically carried out, indeed this is an essential feature of the system of working.

Before the machine commences to cross the face and hole the coal, the roof is supported by bars set at right angles with the line of face. At one end the bars are notched into the coal, and at the other end are supported by props. The nearest row of props is set about 4 ft. 6 in. from the face for a Gillott's machine, but with the Diamond machine, which is narrower, the distance need not be so great.

The props and bars are set 4 ft. apart.

To each machine there are three men who are classed as first, second, and third man. The duty of the first man is to superintend the front of the machine and to see that the rails have been properly laid by the third man, whose work it is to lay the rails in advance. The second man stops and starts the machine, and is called the "driver".

Behind the machine, as it progresses, the "driver" sets a prop under each bar about a foot from the face, since the under-cutting of the coal has weakened the support of the bar at the face. Sprags in the ordinary sense of the word are not used with machine-cutting, but wedges of timber are inserted in the cut at frequent intervals. Let me here point out the necessity of having a plentiful supply of props and wedges in each place for the use of the machine men, otherwise they will have to go in search for some and thus stop the progress of the machine.

Getting and Filling the Coal.

As a rule the holed coal breaks down and away from the roof, with little necessity for blasting, in large blocks with a cubical fracture, yielding good sized cubical lumps, which find much favour with the customers, and the round coal is sounder and larger than that got by hand-holing.

The collier gets and fills the coal at a price which includes drawing the tubs to a maximum distance of 200 yards. He also during the process of removing the coal sets the props and bars as previously described, and prepares the face for the next cut.

Yield of Large Coal.

In the case of one seam 4 ft. 4 in. thick the cost of machine-cutting leaves little or no margin as compared with hand-holing. For the latter the collier is paid 2s. 8d. per ton. By machine the collier receives 1s. 11¼d. per ton, and it costs 4¼d. per ton for cutting and cleaning out the holing, which amounts to 2s. 3½d., leaving only 4½d. per ton for power, maintenance, &c.

Detailed particulars of these items, and other costs, are given later on.

In such a case one expects the question: Where lies the advantage of machine-cutting?

It has already been mentioned that a reduction in the getting cost is not the only advantage, indeed it is not always the most important point, and in the case of the mine to which I refer there is an increase of 18% in the proportion of round coal which is equal to 10d. per ton increase in the selling price, this will I think justify the adoption of machines, even in the absence of other advantages. By hand-holing this mine yields 52% of round coal, then, the face has to be stepped, owing to the difficulty of keeping up the roof with a straight face. With machine-holing the mine yields 70% of round coal. The face line is of course straight, and moves more quickly than the handworked face, thus the difficulty with the roof is overcome.

The stated proportion of round coal is that which passes over a mesh 1¼ in. square.

Average Results of Working.

The average results of working are set forth in detail in the following particulars which relate to tests recently made (under ordinary conditions) to ascertain the fuel consumption for machine cutting.

All the figures giving the weight of fuel consumed, &c., were very carefully ascertained for the purposes of this paper. In each case all other operations were stopped during the test, no steam being used for winding, pumping, or hauling, so that the steam was used for air-compressing only.

No. 1 Test, which lasted four hours.

Five Gillott's machines were working at this colliery; all were holing in the floor.

No. 1 machine worked three hours and cut 45 yards (the full extent of the face that happened to be ready). The depth of undercut was 2 ft. 10 in. and the area of the cut 42 square yards yielding 38 tons; the mine being 2 ft. 10 in. thick.

Nos. 2 and 3 machines were working in a newly opened mine in which the extent of face was limited for the reasons previously explained.

No. 2 worked two and a quarter hours and cut 42 yards.

No. 3 worked one and a quarter hours and cut 20 yards, or a total of 62 yards for both machines.

The coal is 2 ft. 7 in. thick, the depth cut averaged 2 ft. 11 in. and the area cut was 60 square yards, yielding 49 tons.

No. 4 machine worked four hours and cut 75 yards in length, and 3 ft. under, or 75 square yards, yielding 102 tons; the mine being 4 ft. 4 in. thick.

No. 5 machine cut 51 yards in four hours, 2 ft. 11 in. deep in the same seam (4 ft. 4 in. thick), and from a cut of 49 square yards produced 68 tons of coal.

The total yield of coal from the five machines was 257 tons.

The total area cut was 226 square yards.

	£	s.	d.
Weight of common slack consumed, 4 tons 3 cwts., at 4s. 6d. per ton..	0	18	8
Stoker and engineman's wages one-third of a shift..	0	2	8
	1	1	4

	d.
Cost per ton for fuel and wages to compress the air for the machines	0·99
Cost per superficial yard of holing for fuel and wages to compress the air required	1·13

To give the cost per ton only, is not a satisfactory figure for comparison, as the tonnage result depends a great deal on the thickness of the seam, hence the reason for also giving the cost per square yard of undercut.

The compressed air was conveyed to a maximum distance of 750 yards, the nearest machine was 650 yards from the compressor.

No. 2 Test, which lasted six hours.

A similar test was conducted at another colliery where four machines were at work. The following particulars show the results:—

No. 1 machine worked six hours and cut 61 yds. by 2 ft. 10 in. deep, or an area of 57 square yards; and produced 36 tons of coal from a mine 2 ft. thick.

No. 2 machine worked six hours in the same seam and cut 66 yds. by 2 ft. 10 in. deep, producing 39 tons of coal from an area of 62 square yards.

Both these machines were cutting in *very hard dirt.*

No. 3 machine worked three and half hours in a mine 3 ft. 7 in. thick, and cut 57 yds. by 2 ft. 10 in. deep, or 53 square yards; the yield of coal was 61 tons.

No. 4 machine worked in a seam 3 ft. 7 in. thick and cut 53 yards in four and quarter hours, 2 ft. 10 in. deep = an area of 50 square yards, and produced 56 tons.

Nos. 3 and 4 machines cut as far as the face was ready, coal being down in the way.

The total yield of coal from this test was 192 tons.

The total area cut was 222 square yards.

	£	s.	d.
Weight of slack, commonly known as "Dant" consumed at the boilers was six tons, at 3s. 6d. per ton	1	1	0
Stoker and engineman's wages, half shift ..	0	4	0
	£1	5	0

	d.
Cost per ton for fuel and air-compressing	1·56
Cost per supl. yard „ „ „	1·36

The maximum and minimum distances from the compressor to the machines were 2,000 yards and 700 yards respectively. In all these cases the machines were working practically on the "end" of the coal.

The inclination of the mines is about 1 in 7.

The following particulars of cost refer to the getting of coal at the colliery where No. 1 test of fuel consumption was made. The figures relate to six months working with machines, and are compared with the cost of hand-holing.

Three machines of the Gillott's type were employed, one working in a mine 2 ft. 10 in. thick, and two in a mine 4 ft. 4 in. thick. The extent of face in the 4 ft. 4 in. seam was 230 yards, and the advance of the face in six months was 110 yards (*i.e.*, 25,300 square yards of cutting). With hand-holing the face would only have advanced 40 yards during the same period.

The yield of coal from the three machines was 38,090 tons.

The cost of datalling work required in the ordinary drawing roads of these mines when worked by hand-holing is very great.

Details of Cost per Ton.

	s.	d.
Cost per ton for cutting and clearing dirt from under the coal		4·25
Paid to collier for filling, timbering, cutting out, and drawing the tubs to a maximum distance of 200 yards..	1	11·50
Repairs to machine, including hose pipes, sharpening cutters, and laying air-pipes =		·42
Cost of compressed air power as shown in No. 1 Test .. .. =		·99
	2	5·16

For hand-holing the payment to the collier was 2s. 8d. per ton, thus showing a saving in favour of the machines of nearly 3d. per ton.

To this must be added a gain of 10d. per ton in the selling price due to an increase from 52% to 70% of large coal, making a total gain of 1s. 1d. per ton.

The following particulars show the result of six months working at the colliery where No. 2 test of fuel consumption was made.

The mine in this case is 2 ft. thick. The machines hole in the dirt under the coal, which is of a very hard nature.

Two Gillott's machines were worked on a face 200 yards long, and during the last six months the face has advanced 90 yards. With hand-holing the face in this mine has advanced only 38 yards in the same time.

The yield of coal from the 18,000 square yards of cutting was 10,060 tons.

Details of cost per ton.

	s.	d.
Cost of cutting and cleaning dirt from under the coal..	0	6·25
Paid to colliers for filling, timbering, cutting, out, and drawing the tubs up to 200 yards.	2	1·25
Repairs to machines, including hose pipes, sharpening cutters, and laying pipes.. ..	0	1·47
Cost of power (compressed air) as per No. 2 Test	0	1·56
	2	10·53

The price paid to the collier was 3s. 10d. per ton; thus showing a saving of 11½d. per ton in favour of the machine; there was also a further gain of 9½d. per ton in the selling price, due to an increase in the proportion of round coal from 43 per cent. to 58 per cent. or a total gain of 1s. 9d. per ton.

The higher cost per ton for repairs, &c., in this case is to be explained by the fact of the holing being very hard, and the mine thin, yielding a lower tonnage for each superficial yard of cut.

In neither of these cases have I taken into account the cost of plant or depreciation. The power plant is used for other purposes, and it is difficult to correctly apportion the share which should be borne by the coal-cutting operations.

The importance of adapting the Machine to the Mine.

Earlier in my remarks I ventured to point out that a machine which gave excellent results in one mine might prove a failure in another. In other words, each mine must be separately studied and a suitable type of machine introduced to meet the particular requirements.

As an instance I may quote the case of a mine of hard coal, 4 ft. 6in. thick, with 12 in. of "ley" which came down with the coal.

A Gillott's machine was first put to work on a face 90 yards long.

The price paid for hand-holing, including the removal of the ley, was 2s. 8d. per ton, the coal being worked on the face. The Gillott machine worked on the end and holed about 2 ft. 10 in. under the coal. Shots of 3 oz. had to be put in every 2½ or 3 yards apart to break the coal down, and this, together with the large amount of pick work necessary, gave no advantage as regards the proportion of round and small which remained the same, viz.: 50 per cent. of each, and the cost was about the same as for hand-holing.

The Gillott machine was therefore deemed unsuitable for this mine, and a Diamond machine cutting 4 ft. 6 in. under the coal was introduced. The results were remarkable, the proportion of round coal was increased by 22 per cent. Instead of shots being fired as stated, only one 3 oz. charge was required every 20 or 30 yards and sometimes no blasting was necessary.

The saving in cost per ton was as follows:—

	Hand worked. s. d.	Gillott's machine. s. d.	Diamond machine. s. d.
Cost for cutting and clearing the dirt from under the coal	—	.. 0 4·25	.. 0 4·0
Paid to collier for filling, timbering, cutting out and packing the "ley" and drawing the tubs up to 200 yards	2 8	.. 2 3·50	.. 1 8·0
Power, say..	—	.. 0 1·00	.. 0 1·0
	2 8	.. 2 8·75	.. 2 1·0

The saving in favour of the Diamond machine was nearly 7¾d. per ton to which must be added 1s. 0½d. per ton increased selling price, due to an increase from 50 to 72% of round coal, making a total gain of 1s. 8¼d. per ton.

It should be explained that in this particular case a block of coal was being worked out which had been left in the midst of old works and pillars for more than 20 years.

During the time occupied, rather under 12 months, no repairs were necessary to the machines. The sharpening was done, by the smiths, together with the colliers' picks, and no separate record was kept. The pipe-laying was done by the machine men.

In another mine 3 ft. 6 in. thick, two machines recently started are now working on the "end" of the coal. One machine is a Gillott, the other a Diamond. The underclay is too hard to hole in so that both machines hole in the coal, which sticks to the roof and the floor. The Gillott machine leaves three or four inches of bottom coal which has to be got up with the pick, and the cut is not deep enough to cause the coal to break away from the roof, consequently there is a lot of pick work, the proportion of small coal is high and the cost is nearly the same as for hand-holing.

The Diamond machine on the other hand cuts to the floor level, and leaves no "bottoms" on, whilst the deeper cut

(4 ft. 6 in.) causes the coal to break away naturally in large blocks. No explosives have been used in this mine for coal getting, and with the latter machine the necessity for blasting would almost appear to be removed.

The comparative costs per ton are as follows:—

	Hand worked. s. d.	Gillott machine. s. d.	Diamond machine. s. d.
Cost of cutting	—	0 3·25	0 2·25
Paid to collier for filling, cutting out, timbering, and drawing the tubs up to 200 yards	2 4·5	1 11	1 3
Repairs to machines, sharpening, &c., not taken into account in either case..	—	—	—
Fuel and wages for power as per test No. 1	—	0 0·99	0 0·99
	2 4·5	2 3·24	1 6·24

The saving in favour of the Diamond machine is 9d. per ton. The increase of round coal from 50 to 74% is equal to 1s. per ton on the selling price; the total gain in favour of the Diamond machine is 1s. 9d. per ton.

Percussive Machines.

Hitherto I have referred only to machines suitable for longwall faces; our application of mechanical coal-cutters, however, also includes machines of the percussive type, usually described as mechanical picks.

For certain purposes we have found these to be most useful appliances. Of course they cannot compare with the disc machines in longwall working, nor are they intended for that purpose. We have employed the Ingersoll-Sergeant and the Champion machines for heading out purposes. Both are perhaps capable of further improvement, but they have good points, and the results with them are very encouraging.

The Ingersoll can be transported from place to place intact. It requires considerable skill to work it to the best advantage, but when the knack of working it properly is acquired a good man can undercut with one machine an average of four places, each 10 or 12 feet wide and 3½ feet deep, in a shift of nine hours (including meal times), and also flit the machine from place to place, provided the headings are not too far apart.

The Ingersoll makes a cut something like that made in hand holing, *i.e.*, high at the front and tapering out at the back of the cut, so that the proportion of small coal is not appreciably reduced when holing in the coal; but these machines will hole in the underclay which would be too hard for hand-holing.

The Champion machine, on the other hand, is capable of doing an equal amount of work and of making a parallel cut of a uniform height of only about three inches in any desired position, and is equally applicable to flat or steep seams. We have found it a very handy and useful machine. It is not difficult to transport it, but if it could be designed for removal without the necessity of taking it to pieces it would be a great improvement.

A great advantage with this machine is the fact that it is easily learnt, and manipulated at less cost than some other heading machines. With it a seam would yield a larger percentage of round coal, and when fixed a lad can work it.

There is a difficulty in working the Ingersoll in steep seams; but, on the other hand, it can be employed to advantage in thick seams where there *might* be a difficulty in applying the Champion machine owing to the extra length of standard required.

We have found both machines very useful in cutting the necessary strait work through the shaft pillar, and also in driving to the boundary in the case of a mine which is to be worked by means of disc machines on the system known as Longwall retreating.

We have a seam 2 ft. 8 in. thick which is too costly to work on the pillar and stall method, the field rate for strait work being 6s. per ton. On the other hand a very bad roof makes longwall working very costly, on account of the expense of maintaining pack roads. In these circumstances four Ingersoll machines were introduced to cut out to the boundary. The levels through the solid coal are 35 yards apart, with cut-throughs only, as required for ventilation. These levels are to be carried out to the boundary, and the intention is, when the boundary is reached, to work the coal out by a retreating longwall face with disc machines.

The cost of driving the levels with the Ingersoll machine is:—

	s.	d.	
Collier for getting the coal down, filling, and drawing the tubs..	2	3	per ton
Cutting	1	0	„
	3	3	per ton

as against 6s. per ton by hand.

The places are 12 ft. wide and 9 in. of ley is got down by the collier, after which the roads stand without further expense.

We also have a seam of the following section, viz.:—

	ft.	in.
Coal	1	8
Very hard dirt parting	2	5
Coal	2	4

A down brow was being driven where water proved very troublesome. It was very costly working by hand, and not more than two yards per week was driven. An Ingersoll machine was put to work, which holed in the middle dirt on the top of the bottom coal; four yards of this coal was always left on to keep the water back. By this means the brow was driven 10 to 12 yards per week.

The places are of course driven in considerably less time than would be possible by hand-cutting.

These punching machines require an air pressure of from 50 to 70 lbs. per square inch. The higher the pressure the better results will be obtained from the machines.

To facilitate the working of either of these punching machines it is important that the necessary platform for the Ingersoll, and the packing pieces for the Champion machine should be provided in each working place.

General Remarks.

Power.

The working of coal-cutting machines is of course a case of power transmission. My own experience relates to compressed air power only. I have no personal experience of electricity for this particular purpose.

I am anxious that the fact of all the coal-cutting machines at the collieries referred to being operated by compressed air, shall not be interpreted as an indication of any want of confidence on my part in electrical energy. I believe that good results are being obtained by electrically driven machines.

It is with regard to compressed air that I have to speak, and I would here call attention to several details which enabled certain difficulties to be overcome. It is remarkable how largely the operations are affected by what are apparently minor details. It is to be feared that in many cases where the operations have been unsuccessful, the real cause of failure has been some minor detail which has perhaps not had sufficient attention, or has probably escaped notice altogether.

In working a coal-cutting machine it is necessary to provide ample power. The load is most variable and difficult to estimate.

Pipes conveying the air are often too small necessitating a high velocity of the air, which means great loss of power in frictional resistance, and a low pressure at the machines. Often the initial pressure of the air is too low, it should never be below 50 lbs., and 60 lbs. is better, although not by any means too high.

We usually put in pipes of the following dimensions, viz., pipes of 5 sq. in. area up the gateways for supplying one machine, but this size of pipe should not be longer than 150 yards. The pipes from the bottom of the gateways to the bottom of the pit shaft, if not too great a distance, should not be less than 7 sq. in. area, and pipes of a rather larger area from the compressor and down the shaft. The area of the pipes should be increased in proportion to the number of rotary machines intended to work off them.

Difficulties are sometimes experienced with ice forming in the exhaust ports of the machine. This is an inherent trouble with compressed air motors, but the trouble may be reduced to a minimum. We have succeeded in overcoming the difficulty in rather a simple way. As near to the machine as may be convenient we place a receiver—a cast-iron pipe of 18 in. to 2 ft. dia. × 9 ft. long. The inlet air enters at one end of the receiver. The opposite end is closed. The outlet pipe leading to the machine is connected to the receiver *at the top near the other end.* This has the effect of deflecting the air and of separating from it a large portion of the moisture, which is thrown down and collects at the bottom of the receiver, from which it can be drained from time to time by means of a tap. Whether this is a true explanation or not, it is a fact that since the adoption of these receivers, with the outlet pipes at right angles with the inlet pipes, we have had no trouble with freezing either at the coal-cutting machines or hauling engines.

The flexible hose used for coupling up from the machines to the air pipes is rather expensive and should be taken great care of, and put out of the way when not actually in use. The iron or steel pipes should be extended from time to time, and so arranged as to enable the machine to be connected with not more than four 30 ft. lengths of hose, service taps being provided on the pipe line every 40 or 50 yards for the purpose.

Pipes with screwed joints are not to be recommended, nor are spigot or faucit joints. Flanged pipes which can be coupled together at either end, with joints such as the Acme and the Eadie joints, are generally to be preferred as being more easily handled.

Pipes conveying compressed air should be so fixed that the joints are visible so as to detect any leakage; and out of the way so that the flanges cannot be damaged either by a fall of roof or a passing tub.

Dust and Noise.

A great objection to air-driven machines is the great noise of the exhaust and the clouds of choking dust in a dry mine. The exhaust in the Gillott and certain other machines blows directly on to the floor. The best remedy for this is a baffle plate of sheet-iron fixed under the exhaust which not only deadens the noise to some extent but overcomes the difficulty from dust almost entirely and keeps the bearings of the machine clean and cool.

Types of Disc Machines used.

The Gillott machine is the one we have used more extensively up to the present, but the Diamond machine possesses a number of inportant features which greatly enhance its value, and, as I have shown, it gives better results under certain conditions.

The Diamond machine does not take up so much space in width, but on the other hand, it is somewhat longer than the Gillott, and whilst it permits the row of props being set nearer the face, it is not always so easy to handle, where its extra length might take up too much room. The Diamond can *also* be made to cut actually on the floor level. The several sizes of this machine cutting from 3 ft. to 6 or 7 ft. in depth renders it more adaptable to varying conditions. The simple mode of attaching the cutters is excellent.

I should also say, that, where a depth of undercut not exceeding 3 ft. is sufficient, the Gillott is a very handy machine.

I should like to mention here that I do not believe all mines can be successfully and profitably worked by machines. We have more than one seam where I feel sure the introduction of machines would prove a failure.

Saving of Timber.

It has been mentioned that one of the advantages of machine cutting is the reduced cost of timber.

This is not because a smaller quantity of timber is actually in use, but rather because the amount of lost and broken timber is less.

With hand-holing and a slowly advancing face, the weight comes on and breaks the timber. With machine-mining the faces move so quickly that the timber can be withdrawn and reset before much of it is called upon to carry any great weight.

Repairs.

With regard to repairs, when a machine seriously breaks down, we find the best plan is to send it up the pit to be thoroughly overhauled and put in good working order before it is allowed to be put to work again. In the meantime, one of the reserve machines will have been brought into operation.

The plan of tinkering at a disabled machine in the mine is not to be recommended, no doubt a machine can be patched up to continue working for a short time, but sooner or later it will break down again and cause delay, and the last state of the machine will be worse than the first.

Speed of Cutting.

By way of showing what is possible with coal-cutting machines, on one occasion we made preparations for a special test with a Gillott's machine.

To give a quicker rate of advance the usual propelling gear was modified. The hauling rope, instead of being passed round a pulley attached to a prop ahead of the machine and brought back to the drawbar of the machine, was paid out singly for a distance of nearly 70 yards and secured to a prop. This gave not only a greater length of travel without having to stop to readjust the hauling rope but also doubled the usual speed of travel.

Every facility was given for straightforward cutting, and the rails were laid well in advance of the machine.

The distance cut along the face was 65 yards, the depth of cut 2 ft. 10 in., and the time occupied 67 minutes.

Of course this was a special test, and does not represent the usual rate of cutting, but it shows what is possible for a short time under very favourable conditions.

The Mine Officials and the Machines.

For the successful working of coal-cutting machines it is very desirable, indeed it is most es·ential, that the mine officials, although not themselves operating the machines, should be capable of doing so if occasion should arise. At least they should be quite familiar with the details of the machine and its operation, otherwise it is possible some machinemen may be inclined to impose upon them and give all manner of excuses to account for slow progress or unsatisfactory work.

Some machinemen will not hesitate to take advantage of the inexperience of the officials, as the following instance will show.

In one of our collieries a machine had already been introduced before my employers took it over. The machine had only worked intermittently and with indifferent results. The men alleged that the machine constantly broke down, and although the face was only 70 yards in length they only occasionally cut across it in 14 hours. We changed the officials; the new under-manager, a man who knew a coal-cutter when he saw one, personally superintended a cut. Operations were commenced at 5-30 p.m., and at 9-30, four hours later, completed the 70 yards. The men recognised the new intelligence, and afterwards breakdowns and stoppages were few, whilst additional machines were introduced.

In conclusion, I will give another source of trouble at one of our collieries which was alleged to be a want of air pressure. The machines were not giving good results and were making slow progress. The engineman insisted that the pressure had been kept up all night. An automatic pressure recorder was fixed, to make a chart showing the exact pressure of the air at any moment during the 24 hours. In the face of the indisputable evidence of this instrument the men recognised the futility of their old excuse, and there were fewer complaints of want of air pressure.

The PRESIDENT said: I feel sure the Society is to be congratulated on the fact of having had a paper on coal-cutting from Mr. Hughes. He has more coal-cutting machines at work than any one else in this part of the world and he was really the right man to give us a paper on the subject. I am sure we shall all be agreed that the paper, if not the best written on the subject, comes very near being so. So far as I can judge it is full of practical information, and put in a way that mine managers can understand. He has not been shy in giving us the cost. In some quarters there is a shyness in regard to matters of cost of machines in comparison with the cost of labour.

Mr. SMETHURST moved a vote of thanks to Mr. Hughes for his valuable communication.

Mr. R. WINSTANLEY said he had pleasure in seconding the motion to Mr. Hughes who had passed several years at collieries under his own supervision. He was consequently proud to know that Mr. Hughes had followed up his early training and paid such attention to the subject of machine coal-cutting, as was revealed by his paper.

The motion was cordially approved.

Mr. GARFORTH: I think the paper is one of the best I have ever listened to, and I endorse all that the President and others have said in its praise. I am rather surprised at some of the figures given by Mr. Hughes. They are better than I expected; but, as he says, every seam requires different treatment, so that a machine while suitable in one seam may be a failure in another. In one of the mines which I am associated with we have a large quantity of work done by machines. Out of a total output of 553,000 tons, 420,000 tons were cut by machinery, and I am glad to say we are raising over 1,000 tons a day as the product of machines in one seam of coal which has been at work for nearly four years without a single accident occurring at the coal-face. Immunity from accident is a matter which I should like to see referred to by Mr. Hughes. The advantages which we gain as regards safety and freedom from accident are, I think, the most pleasing features connected with coal-cutting. But there are many interesting points connected with the introduction of machinery which will lead to a more scientific system of mining. A straight line of cut produces a straight line of fracture, and that leads to a straight line of timbering, which I believe will overcome many of the difficulties now met with in attempting to introduce systematic timbering. That is a large question, but if at some future time you would like to see 50 or 60 photographs I have had taken in connection with this subject, and which may help in this discussion, I need not say with what pleasure I shall have them brought here. I have only to congratulate Mr. Hughes once more on his very good and practical paper.

Mr. Gerrard: May we take that as an offer?

Mr. Garforth: Yes! I may add that judging by the fact that the photographs have been exhibited on two different occasions by request, members will understand they may be of service to those who have not had much experience in coal-cutting.

Mr. Dury Mitton: I have listened with very great interest to Mr. Hughes's paper. I made a few notes of pertinent things to ask questions about, but Mr. Hughes has forestalled me by answering, in his paper, the points I thought of, which shows how fully he has covered the ground. I was rather surprised, as the last speaker said, at some of the figures. In regard to the increase in the yield of coal, I should like to know how Mr. Hughes arrives at his percentage—whether he took the whole of the coal coming out of the mine or not. His figure seems to me rather high. He does not mention anything about depreciation for coal-cutters in his comparison between the cost of hand labour and machine work. I think that should be taken into consideration for there is a large amount of wear and tear. He gives so much for repairs but the amount he mentions is very low, when you come to think that they do wear out and have such a heavy strain to bear. A few weeks ago I was watching two coal-cutters at work in a 3 ft. mine with very hard stone underneath, and it struck me that the Diamond machine was the most successful. It was under-cutting between 60 and 70 lineal yards a shift, and there was no trouble with it; but the other was working very unsatisfactorily, namely, the Morgan-Gardner machine. It struck me that with a rotary machine we seem to get more power than with a chain machine. I was also impressed with the immense amount of sparking given out by the Morgan-Gardner machine, whether that was due to the fact that the power was not directly applied at the end of the holing or not I cannot say, but if the sparking resulted from that fact it certainly was unfavourable to that machine which was only cutting about 30 yards in one shift. That was the only experience I had had of the Morgan-Gardner. It would be interesting to hear further on this point as the sparking from the cutters is a danger. I should like to ask Mr. Hughes as to the pressure of air he has on his rotary machine.

Mr. Burrows said there was everything in favour of the deep cut if the coal could be filled out quickly. He wished to know if Mr. Hughes made a point of clearing the coal out each day.

Mr. Pilkington asked if Mr. Hughes could say which was the best machine to use when a steep mine had to be dealt with. The dip of his mine was 1 in 3½, and he had three kinds of machines at work. The machines had not been working long enough for him to be able to come to a definite conclusion.

Mr. Percy Wood said his experience had been that the Gillott machine holed too deep, and he was much surprised one night while watching it cutting, perhaps, four or five yards. As it cut along there was not a spade full of coal obtained from the machine. The coal dropped down, and practically every particle of it was removed by the machine, being ground up to dust and mixed with the dirt in which the machine was cutting. They had therefore to stop the machine because it was cutting too deep, and that was principally on account of the machine working along the line of the cleavage in the coal. Probably it would be better if it was worked across the line of "shut." As to the cost of repairs, his experience had been very different from that of Mr. Hughes. They had one machine, and after working two months it had to be brought out of the pit and, practically, they had to repair a good half of the machine. If necessary repairs went on at that rate the machine would be worn out in twelve months.

Mr. Hughes in replying said the pressure of air was from 50 to 60 lbs. per square inch at the compressors. He knew of a Gillott machine which had been working for 12 years, and he was informed that it was in as good condition now as it was six or seven years ago. The stated percentages of slack made by the machines and by hand-holing, were the results of special tests which were made periodically. With regard to Mr. Burrows's question in the case of the mine, 4 ft. 6 in. thick, he thought that for six months a day never passed without the loose coal being cleared from the face; the drawing roads were made 20 yards apart, with a temporary, or what was sometimes called a blind road, between these, but in another case where the coal face was 250 yards long and there was only one machine to do the work with they had not been able to clear the coal out every shift. Of course it was intended to put more machines in. If we had a machine making a cut, say 4 ft. 6 in. deep, and sufficient machines to cut across the face each day it would help to get the coal out sooner if the drawing roads were arranged as already stated. It was also advisable to have the drawing roads near each end of the face closer together to enable the coal to be cleared out quickly so as to allow the machine to be put to work at the proper time. As to there being any difficulty in timbering in conjunction with the deeper cut his experience showed that the roof could be controlled much easier. He had had no experience of machines working in steep mines, so could not say which form of machine was the best for working them. In reply to Mr. Wood, if the coal came over on the machine when working on the face of the coal the difficulty might be remedied by putting the machine on "half end." If that would not answer he would put it to work on the "end" of the coal, and if not satisfactory then he would take the machine out of the mine. In regard to repairs it was expensive to send fitters down the pit to repair machinery. If the necessary repairs were so extensive that the man in charge of the machine could not put them right, he found it was much cheaper to take the machine out of the mine to the fitter. A great deal depended on the care taken of the machines by the machine-men. On more than one occasion men had been discharged because of the frequent repairs that their machines required.

The PRESIDENT suggested that the meeting had perhaps lasted long enough, and that it would be well to defer further discussion until the paper had been printed and placed in the hands of members. With regard to the question of financial gain, he wondered how it was that coal-cutting machines were not used in every mine if the gain was, as Mr. Hughes said it was in his case, from 10d. to 1s. 9d. a ton. Tenpence would be a handsome profit, but 1s. 9d. was very great. He was not certain that in considering the machines they were quite fair. There was the point about the increased quantity of round coal. In a large number of cases the increased quantity of round came from the fact that the machine holed in dirt and the man in coal. He wanted to know whether the machine could hole in dirt that a man could not hole in. He knew it was usual for the collier to hole in coal, but it was a matter of custom, and he did not think it fair to give all the advantage to the machine cutter. There were many mines in which if the men were willing they could hole in the dirt, and if the masters were willing to give them threepence a ton more probably they would gain this additional advantage of round coal. Then they did not take into account the quality of the slack. That which the machine made was almost worthless, but the slack which the man made was not so. Two-thirds of it would make "nuts." Of course machines made less of it. As to sparks, there seemed to be some doubts whether sparks would light gas or not. He had occasion to make a test the other day, in connection with an explosion which could not be accounted for. One person said it was caused by sparks. He took the man who held that view to a colliery where there was some gas coming up a pipe from the workings below. Bunches of sparks were produced by striking a steel pick against ironstone, but they did not succeed in lighting the gas. Afterwards they lighted household gas quite readily by the same means. He had never been satisfied that sparks, ordinary sparks—he was not speaking of electric sparks—would light gas in mines, and hence he did not think they had much to fear from coal-cutters striking sparks on pyrites or anything of that kind. One point which he thought was in favour of machines—was that by their means it seemed possible to do away with the blasting of the coal almost entirely. He understood that Tonge's Hydraulic Cartridge had been found to be quite capable of getting the coal after it had been well holed by a machine coal-cutter.

Mr. Garforth: As to sparks produced in the process of holing I do not remember a case during thirty years where they have caused an explosion. Gas lies near the roof, the cutting is generally done near the floor producing a certain amount of dust, which smothers the sparks that are given off. As regards electric sparks produced at the brushes or commutator I have made some experiments with enclosed electric motors in a highly explosive mixture in a specially constructed chamber on the surface. I used a mixture consisting of 10 per cent. of manufactured gas and 90 per cent. of air. In six recorded experiments we have not had a single mishap with the enclosed electric motors, while in every case with open type electric motors we have been able to ignite the gas surrounding the machine.

Mr. Dickinson: Now and then one sees a spark of greater intensity than ordinary sparks, and also there is the difficulty in the fire damp varying in proportion to the mixture of air, and also in the purity of the gas which sometimes makes it more highly explosive.

Mr. Tonge: referring to the President's remarks on the lighting of gas in mines by ordinary sparks, and also to Mr. Dickinson's, saying there were varying proportions of air and firedamp, and also in the purity of the gas, "which sometimes makes it more highly explosive;" said he would like also to point out the fact that there was occasionally a certain percentage of carbonic oxide (carbon monoxide) present with the carburetted hydrogen; and as this gas ignites at a temperature of 1184° F., which is more than 400 degrees Fahrenheit below the ignition point of firedamp, there can be little doubt but that this is sometimes the cause of gas being fired unexpectedly.

The discussion was adjourned.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL AND MINING SOCIETY.

PART VIII. VOL. XXVIII. SESSION 1902-1903.

The ORDINARY MEETING of the Members was held on Tuesday, 12th May, 1903, in the Society's Rooms, 5, John Dalton Street, Manchester.

Mr. J. ASHWORTH, Vice-President (in the absence of the President), in the Chair.

NEW MEMBERS.

The following gentlemen, having been duly nominated, were elected Ordinary Members of the Society:—

Mr. O. R. JONES, H.M.I.M., 5, Spring Gardens, Chester.

Mr. JAMES RAMSBOTTOM, Church Road, New Mills, near Stockport.

The following Paper on "*Bellinurus Bellulus*" from Sparth, Rochdale, was read by Mr. WALTER BALDWIN, F.G.S.:—

BELLINURUS BELLULUS, FROM SPARTH, ROCHDALE,

By Mr. WALTER BALDWIN, F.G.S.

In a paper read before this Society two years ago on "Prestwichia rotundata," the writer expressed the hope that other palæozoic forms of the king-crab might be discovered at Sparth Bottoms.

Search has indeed been carried on in these beds by several local geologists, but it was only in January of this year that the writer found his desire realised, when he unearthed a fine specimen of Bellinurus bellulus.

The geographical position of Sparth Bottoms, together with its geological horizon has been sufficiently explained* as to render repetition unnecessary here, except merely to state that the strata belong to the early portion of the Middle Coal Measure Period.

On page 152, "Prestwichia rotundata," a bed of fine grained sandstone, about 15 feet in thickness, is mentioned resting on a bed of blue grey shale. This shale contains most beautiful impressions of ferns; species of Sphenopteris, Pecopteris, Neuropteris, and many others being represented, which alas quickly disappear on exposure to the atmosphere. Further excavations have revealed a bed of clay ironstone nodules at about 12 feet from the top of this shale. The bed is a few inches in thickness with nodules containing for the most part fine examples of Carbonicola (anthracosia) acuta whilst a few contain portions of the terminal branches of Lepidodendron elegans, or fragments of ferns such as

*"Prestwichia rotundata," Trans. Manch. Geol. Soc., Part VI., Vol. XXVI. I am much indebted to Mr. S. S. Platt, F.G.S., for particulars which enabled me to give the section of strata passed through in the Coal Pit Shaft at Sparth. This acknowledgment was omitted through inadvertence.—W. B.

Neuropteris gigantea. This bed also yielded the subject matter for the present paper, viz.: Bellinurus bellulus, König, 1820.*

"Bellinurus Bellulus" (König, 1820).
Enlarged ?.

The specimen consists of the head or cephalic shield which is semi-circular in outline and slightly arched; it is broad as compared with its depth. The central portion (the glabella) is prominent and declines towards the circumference: it is about three-quarters of the whole depth of the cephalic shield and is strongly arched by means of two lateral and equidistant ridges or facial sutures springing from the posterior border of the cephalon, these unite anteriorly to form a raised mesial ridge which terminates in a blunt spine

* The original is in the Rochdale Museum and a cast is exhibited in the Manchester Museum.

posteriorly. The mesial ridge is divided by a well marked depression which crosses it at about two-thirds of its length from the posterior border.

There are two minor equidistant and lateral ridges situated on each side of the mesial line. These bifurcate, forming minor arches, and unite with the lateral ridges and with the median ridge just below the well marked depression.

The eyes are situated about half-way up the glabella on the raised lateral margins.

The cephalic shield is surrounded by a flattened margin and has a prominent thickened doublure of the anterior border, which when viewed through a powerful lens exhibits a number of minute granules. It terminates at its posterior angles in long spines.

The cephalon has the following dimensions :—

	Inches.
Greatest breadth of headshield	$1\frac{3}{32}$
Greatest length of headshield from anterior to posterior border (exclusive of spines)	$\frac{16}{32}$
Length of spines, from posterior border	$\frac{3}{16}$
Greatest breadth of glabella	$\frac{3}{8}$
Greatest length of glabella	$\frac{3}{8}$

A comparison of this specimen with the figure of Prestwichia will at once reveal the points of difference. Both the genus Prestwichia and Bellinurus belong to the order of Merostomata and sub-order Xiphosura (sword-tail).

Dr. Henry Woodward has divided these limuloides into two classes, "(*a*) those with movable thoracic segments and anchylosed abdominal ones as 'Bellinurus'; (*b*) those in which the thoracic and abdominal segments are not divided and of which the former appear to be anchylosed as 'Prestwichia.'"

Geological Horizon of Bellinurus.

Bellinurus is of as high an antiquity as the Upper Old Red Sandstone, for Bellinurus Kiltorkensis, Baily, occurs in the Kiltorcan Beds of Ireland, part of the "Yellow Sandstone Series," which pass conformably up into the Lower Carboniferous Shale. Hence the geological horizon of Bellinurus may be given as Upper Old Red Sandstone and Coal Measures.

History.

Bellinurus was first discovered in the "Pennystone" iron nodules of the Coal Measures at Dudley, in Staffordshire, and Coalbrook Dale, in Shropshire.

It was classed among the trilobites as Entomolithus (monoculus) lunatus by Martin; in 1820 König described a specimen, and named it Bellinurus.

Dr. Buckland in 1836, and Professor Prestwich in 1854, figured and described it as "Limulus trilobitoides." It is referred to in the "Catalogue of British Fossils," 1854, by Professor Morris as "Limulus trilobitoides, Buckland."

Mr. G. H. Kinahan, M.R I.A., discovered a specimen in Bilboa Colliery, Queen's County, Ireland, together with some fragments of scattered plant remains and numerous small bi-valve unio-like shells in the same bed of shale. It would thus appear as if Bellinurus were generally associated with unio-like shells and scattered plant remains, and suggests to one's mind that it was an inhabitant of shallow muddy water, and lived in close proximity to the shore line.

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On the motion of Mr. W. SAINT the thanks of the meeting were given to Mr. Baldwin for his paper.

Mr. W. E. GARFORTH exhibited, by means of the oxy-hydrogen light, a large number of photographs taken underground, illustrating the application of coal-cutting machines in various coal seams and the resulting lines of induced fractures in the roof and coal.

THE APPLICATION OF COAL-CUTTING MACHINES AND THE RESULTING LINES OF INDUCED FRACTURES IN THE ROOF AND COAL.*

By Mr. W. E. Garforth, F.G.S.

I may remind you that at the last meeting of this Society when we had the pleasure of listening to the excellent paper given by Mr. Hughes, I suggested that perhaps the photographs which have been taken down a mine in Yorkshire might help to illustrate some of the points which Mr. Hughes introduced and I therefore propose to exhibit some 50 or 60 photographic slides bearing on coal-cutting. At the same time I wish to suggest that if during this exhibition Mr. Hughes would like to personally explain how certain of these specially apply to his paper I shall be glad to give way for the purpose of letting him give his own explanation as I believe what we all desire is to get as much information as possible about coal-cutting.

As a full explanation of these slides may be tedious to you, I think I can give more information in a shorter time by reading a few extracts from the paper I read before the Midland Institute of Mining Engineers some twelve months ago, on "The Application of Coal-Cutting Machines to Deep Mining," and which some of you may perhaps have seen. I must also ask your indulgence if under these circumstances the following explanation appears somewhat disjointed and if I repeat myself in the description as I fear I shall.

From an experience of more than 20 years in working certain seams of coal by coal-cutting machines I think the difficulties experienced in maintaining underground roadways, due to the increased thickness of the overlying strata,

* Excerpts, printed by permission from Part III., Vol. XXIII., of the Transactions of the Institution of Mining Engineers.

may be lessened—that the percentage of crushed coal may be reduced—and that mines formerly looked upon as unprofitable may be worked with advantage.

To obtain these desirable results, certain fundamental laws of Nature which are in full evidence underground, must be more closely recognised and carefully followed; and while the damaging effect of the superincumbent weight

Fig. I.

must on the one hand be guarded against, on the other it should, to a greater extent than hitherto, be utilised by transforming it into a power to replace the use of explosives. By the miner, a weight thus utilised may be looked upon as Nature's lever, somewhat as the farmer looks upon ice as Nature's plough.

History shows that originally mining was conducted on non-scientific lines, and many of its practices were and are still empirical, and the result of its present effeciency, which has required a century for its development, has been obtained at a great sacrifice of human life.

COAL-SEAMS.

It is with the coal-face I wish to deal, as it is thought, after making full allowance for the improvements which

FIG. II.

have been made in the working of mines during the past 30 years, that further improvements may be introduced by retaining the best of all that is good in the older methods; and supplementing them by later mining practices based upon scientific principles.

Before, however, describing certain details connected with the practical working of the coal-face, it is considered necessary to direct attention to some of the physical properties of the coal, roof, and floor, and the effects produced upon the seam by pressure due to superincumbent weight and lateral expansion induced during the process of extraction.

It is hoped that some of the points raised may form the subject-matter for further discussions by the members, and that the investigations of the geologist and physicist, which

FIG. III.

bear on mining, may in the future be more fully utilized for the practical benefit of the miner, who, though he is well aqcuainted with the effects produced under-ground in mining coal, requires fuller information on the exact causes which govern them.

Briefly it may be said, that a piece of coal reveals by its shape the influence of certain Divine laws, which appear more marvellous the better they are understood. The dull, sooty divisions of the coal-seam indicate lines of deposition; the bright continuous cleatings which constitute the face or bord of the coal, are the impress of great earth-movements; while the jointings running at varying angles to the cleatage-planes, show the effect of shrinkages of the strata (Figs. I., II., and III.). In addition to these three natural divisions, artificial lines of fracture may be induced which further alter the shape of the coal (Fig. IV.).

Fig. IV.

From these facts and others, indicated in the illustrations, it will be seen that the straight lines of cleatage are visible indications of natural laws, which have in the past been well known to the miner, and served as a guide in driving narrow and straight roadways or in maintaining a longwall face at any required angle to the cleatage-planes or bord-face.

LONGWALL-WORKING.

When the seam is first cut there is a lateral expansion of the coal, especially in seams where the portion exposed is parallel to the planes of cleatage. While the coal-seam remains untouched, no movement, unless it be an earth-movement, can take place even in deep seams where the weight of the overlying strata nearly approaches the cohesive

FIG. V.

strength of the coal. But, immediately an excavation is made, a movement results, approximately proportionate to the cohesive resistance of the coal and the pressure of the overlying strata.

As the width of the excavation increases, the immediately overlying stratum settles down on the coal-face and pack, and a species of "arching-over" takes place in the overlying stratum, something like a girder, supported respectively by the coal-face and dirt-pack. As the span increases, additional weight is thrown upon the coal-face and the pack-walls, with the result that the former is crushed, which is detrimental, and the latter consolidated, which is desirable for many reasons connected with safety as well as profit. The longer the time to which the face is subjected to such weight, especially if its line be irregular, with projecting pieces of coal (Figs. XIV,,

FIG. VI.

XV., and XVI.), the greater will be the production of low-priced coal; and the quicker a straight fracture is induced, by which the maximum superincumbent weight is thrown on the pack, the larger will be the yield of high-priced coal. If, in addition to such a face-break, other fractures and settlements can be frequently induced, the coal is not only relieved, but the strata immediately above the pack and extending for some distance into the goaf become disintegrated, with a greater tendency to settle down quickly and vertically upon the pack-walls, than where the cohesive strength of the overlying strata is maintained and the weight is thrown forward on the coal-face.

From the foregoing, it will be apparent that the crushing-effect on the coal may be minimized by pushing forward the whole length of the coal-face, and by having the least length to maintain under its influence compatible with the required output. This arrangement can, unless exceptional

Fig. VII.

natural difficulties intervene, be carried out most effectively by having a straight line of face, produced by a straight line of cut, inducing a straight line of fracture in the roof, which is supported by a straight line of timber (Figs. V., XVIII., XIX,, and XX.) This method of working permits of, or leads to, a more systematic use of timber than where the breaks are irregular and the timber is set following these irregularities. In addition to these advantages, there are fewer roads to maintain and less timber, rails, &c., are required (Fig. XXI.) While formerly it was physically impossible to obtain by handworked picks such a rapid advance of face as is now advocated, yet such an advance may be obtained, at the present time, by mechanical appliances actuated by compressed air or electricity.

For some years past, certain coal-faces cut in a perfectly

Fig. VIII.

straight line have been advanced at the rate of 16½ feet per week; and experience has shown that, with certain exceptions due to natural conditions, there is nothing to prevent a greater advance by specially arranging for continuous shifts, so that the coal may be filled immediately after the cut is made. The advance of face requires to be regular both as regards cutting and filling, as opposed to quick filling and leaving the next cut for a longer period, which allows the coal to be crushed and is attended by other disadvantages.

From a careful study of the natural phenomena indicated by the foregoing, and a personal experience gained in working coal-seams from a depth of 240 feet (where pillars of coal left 30 years ago are still standing as efficient support to the main roadways), down to a depth of 3,300

Fig. IX.

feet below the surface, where portions of the coal become crushed to small pieces after a few hours' exposure, the writer is convinced that if deep coal-seams are to be successfully won, a practical acquaintance with certain natural laws and their effects will in future be more essential to colliery-officials and workmen than in the past. Speaking generally, it will be found that in deep, equally with shallow mines, there is a much greater uniformity of conditions than is supposed, and that while coal-seams vary, in depth, thickness, inclination, &c., still the general and main principles connected with their deposition, cleavage, jointings, and lateral expansion, apply almost equally to all seams; and, with certain exceptions, allow the same general method of working to be successfully carried out in deep seams.

When there appears to be a difference between Nature

FIG. X.

and Science, it will be proved, in mining as in other past instances, that the fault does not rest with Nature, and that certain Divine laws now imperfectly understood will in the future be more fully appreciated.

Experience has proved that no system of working can reduce the pressure on the coal remaining to be worked, and this fact becomes more and more apparent as the depth of the coal-seam below the surface increases. Each square foot of coal supports a corresponding area of roof, but when a portion of the coal is removed in the process of mining, then an enhanced weight, over and above what may be termed the natural weight, is thrown upon the remaining portion. For many years, it has been recognised that such complaints as tender coal, bad roof, lifting floor and sudden outbursts of gas were often due to faults of the pillar-

Fig. XI.

system, and with certain exceptions not, as formerly alleged, to the inherent weakness of the coal and adjoining strata.

Formerly it was considered that the longwall could only be carried out when the roof and pavement were good, inclination suitable, &c., yet excessive superincumbent pressure resulting in an excess of small or low-priced coal has compelled its adoption under almost all conditions met with in deep mining. This loss consequent on having to sell a portion of the small or crushed coal at a price so much below the cost of production would have been more severely felt in past years had it not been for the large quantity of the same class of coal required in the manufacture of coke and the mechanical appliances which have been invented to utilize it for raising steam and certain manufacturing purposes. The advantages claimed for the longwall method

Fig. XII.

are too well known to need recapitulation, but amongst others the writer gave the following opinion in May, 1882:— "The straight line of face affords the best lines of fracture, and by allowing the subsidence of the superincumbent weight to be regular and to fall on the goaf, thus taking the pressure from the coal-face, stalls are seldom stopped by weighting-in, and there is less liability to sudden outbursts, as the pent-up gas may be liberated in small quantities and regularly dealt with."*

* *Trans. Midland Inst.*, 1882, Vol. VIII., pages 36 and 37.

The experience of the past 20 years, but especially of the past 10 years, has, however, shewn that in longwall working by hand-holing, there are serious disadvantages, including amongst others:—(1) Under-cutting the back of the holing in an irregular line; and, when an extra depth of holing is necessary to ensure the excavated coal breaking from the solid portion, cutting or slabbing part of the solid face into

FIG. XIII.

small pieces to permit of shoulder-room for the workman (Fig. VI). The projections at the back of the holing act as struts almost as effectively as the sprags in front of the coal-face, especially when assisted by the undermined coal adhering to the roof and the back of the solid coal. The projecting portions are consequently exposed to an excess of crushing-weight, which is further increased by the cut at the back of the excavation being of so small a height that when the overlying weight comes into operation, there is not sufficient space in the holing to avert its immediate effect, and the coal (being usually softer than the roof and floor) suffers by such association. (2) Under-mining one part of the coal-face at a period of time different from the adjoining portion, consequently additional weight is thrown on the remaining portion of the holing-dirt; and this is,

Fig. XIV.—Plan on Line A B of Fig. XVI.,

Shewing irregular line of break due to holing by hand.

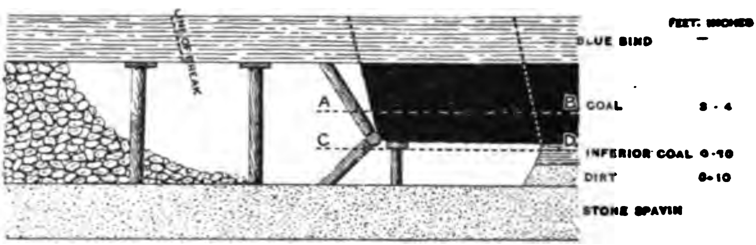
Fig. XV.—Plan on Line C D of Fig. XVI.

therefore, crushed and more easily worked—an advantage to the miner, but gained at the expense of the coal-owner, as a greater percentage of low-priced coal is produced. (3) In order to maintain a large and regular output, an increased length of face is opened out, which becomes subject to the crushing effect of the overlying weight, especially in summer or when trade is bad and short time is worked.

If the coal-face be worked on a curved line, the difficulties previously enumerated are intensified by reason of the projecting angles which cause irregular lines of fracture and prevent a regular settlement of the strata. If it be correct

to work coal by following straight lines, either on the principle of (*a*) plumb-end, (*b*) bord, or (*c*) half-end and half-bord, then the coal-face cannot for the reasons given be advantageously worked at constantly varying curves and angles. When the coal is worked end on, it may be said to have its maximum strength to resist pressure, and allows the deepest excavation to be made before the coal falls, usually in large pieces and with a cubical fracture, even in the smaller pieces. On the other hand, the coal most readily

FIG. XVI.—SECTION ON LINES X Y OF FIGS. XIV. AND XV.



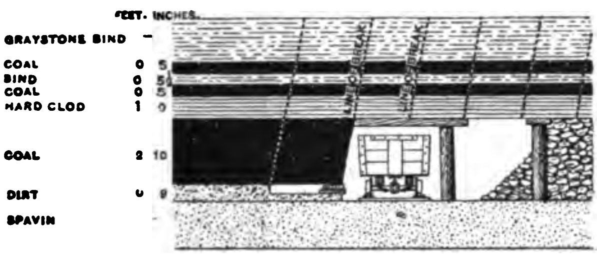
Scale, 8 feet to 1 inch.

falls when worked bord-way, or when the lines of cleatage run parallel with the cutting, in which case friable, slabby, and an increased percentage of fine coal results. A modification of the above system is the working of the seam by end and bord. As the line of break follows the line of the least resistance so the straight line of coal-face may be worked at any angle, as experience gained in working particular seams may require.

Judging by the losses already suffered by the production of small coal, it is natural to expect within the next few years, as deeper seams are worked, that the ill effects of superincumbent weight on a crooked longwall face, will be as well recognised as those which led to the abandonment of the pillar-system.

The writer wishes it to be understood that the suggestions and opinions herein expressed, relate to the general methods of working coal in flat or slightly inclined seams, and that there are exceptions to every rule. For instance, the steepness of a mine, where the end or bord of the coal runs at almost right angles with the line of level, may cause difficulties in the conveyence of coal, or the influence of

FIG. XVII.—SECTION, shewing when depth of undercut is three feet, the line of break is above tub.



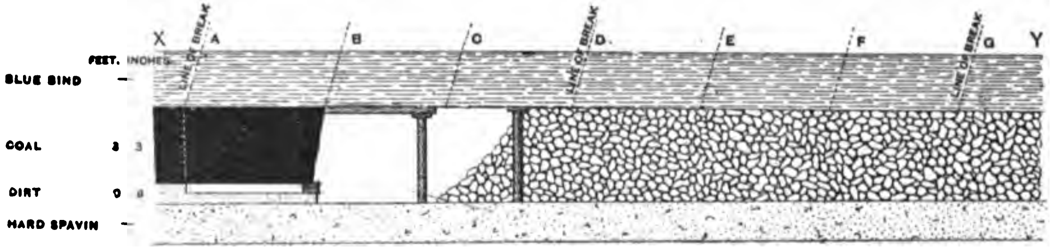
Scale, 8 feet to 1 inch.

faults or other local circumstances may counterbalance the advantages referred to, by preventing the general principles herein suggested from being carried out. At the same time, important advantages are being obtained in certain German mines, where the writer recommended the use of coal-cutting machines in coal seams lying at an inclination of 22 degrees.

MINING WITH COAL-CUTTING MACHINES.

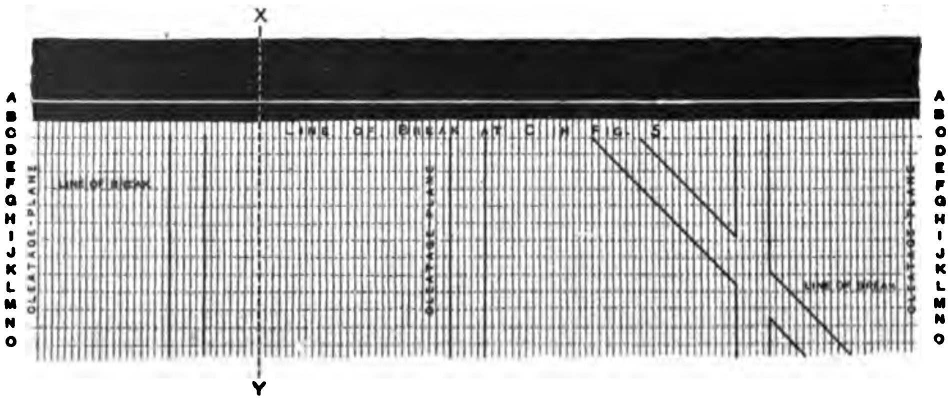
As the longwall system seeks to minimize the crushing effect of the superincumbent weight on the coal, and to replace the pillar-and-stall system, so must the pick as a

FIG. XVIII.—SECTION OF LINE X Y OF FIG. XIX.,
Shewing when the cut is 5½ feet deep, there is sufficient width for tub and bar inside the line of break.



Scale, 8 feet to 1 inch.

FIG. XIX. PLAN, shewing straight line of break due to machine cut.



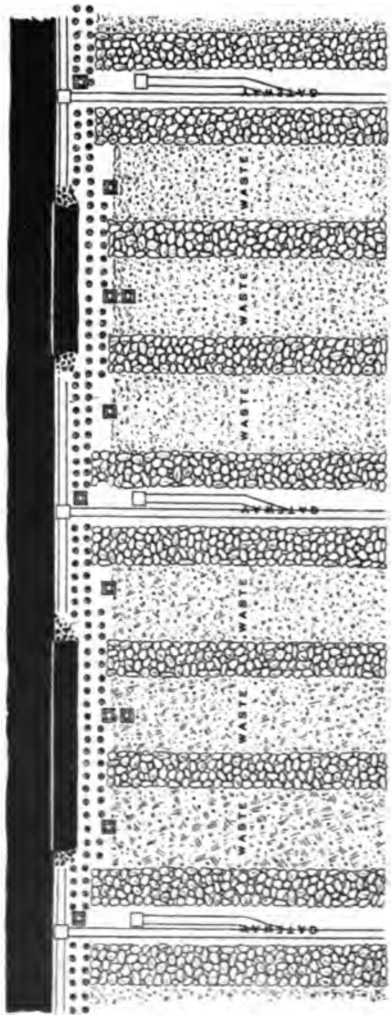
Scale, 60 feet to 1 inch.

holing tool give way to the coal-cutting machine (Figs. VII., VIII., and IX.), with its line of cutting as straight as the rails on which it runs or the cleatage-lines which it professes to imitate. This displacement of the pick for holing will be somewhat akin to those lines of improvement by which the scythe was superseded by the mowing-machine, the oar by the screw-propeller, and the needle by the sewing-machine.

Important changes and improvements have already taken place in other mining operations, for instance, the high-speed fan, in lieu of the ventilating-furnace; mechanical power for the horse; the shielded safety-lamp for the candle; and the same evolution of improvements is now needed in the method of working the coal-face.

The longwall method, which many years of experience has shown to be the only method by which the deep mines of this country can be won, has unconsciously led up to the introduction of coal-cutting by machinery. Without a long straight coal-face, the effectiveness of coal-cutting machines is minimized to a considerable extent. The extra cost of transporting machines from one short face to another, as compared with the advantages now being gained on coal-faces of 1,000 or 2,000 feet, or in one case 4,000 feet in one straight length is considerable. In the thinner seams, the machines cut backward and forward; but in thicker seams, where large outputs are required, a loss arises by waiting for the coal to be filled into tubs. The experience gained in working coal-cutters during the past ten years shews that where a coal-seam, lying at a moderate inclination, can be worked on the longwall system by hand, it can, with certain exceptions, not only be worked with equal facility by machine, but with the additional advantages herein described.

FIG. XX.—PLAN OF LONGWALL COAL-CUTTER FACE.



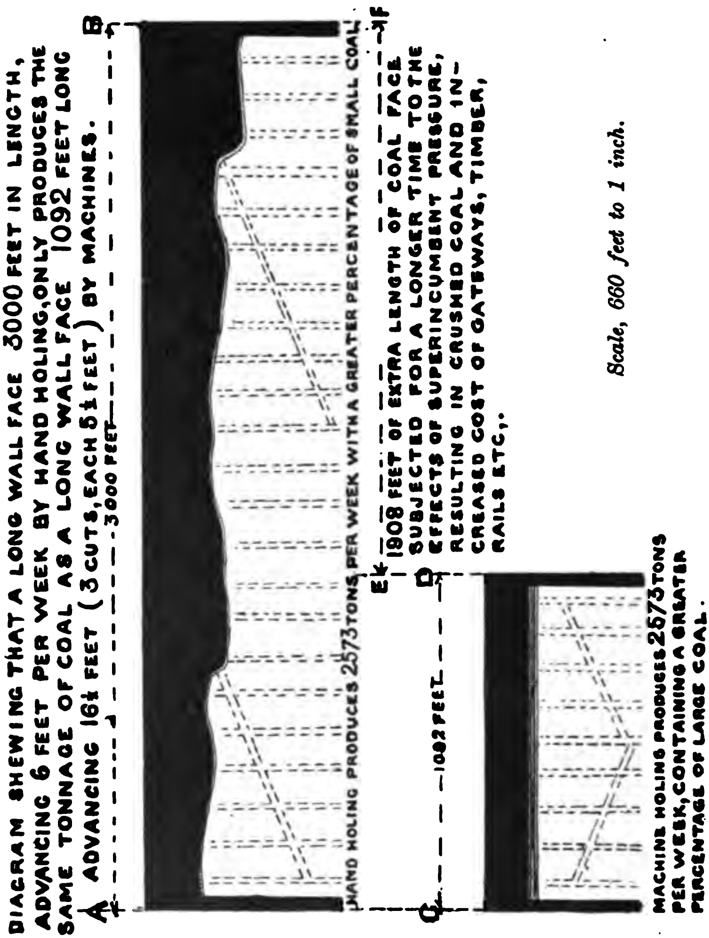
Scale, 60 feet to 1 inch.

Science has been defined to be "the answer made by Nature to the questions put to her by man"; and in no branch of engineering is scientific reasoning more required than in coal-mining, which is largely dependent upon the effect of natural forces.

If a coal-seam be under-cut to a depth of 3 feet, and if, after the artificial supports are withdrawn, the coal does not fall: Nature shews by this answer that the breaking-depth of the seam has not been properly gauged, and the cut requires to be made deeper; or the adhesion between the roof and top of the coal, and the cohesion of the back of the excavated coal and the seam beyond, has yet to be overcome. Trial-cuts with a machine, possessing a deep under-cut wheel, must then be made until the true answer is obtained. The result of such experiments decides the depth of the under-cut, and the exact position where the incision must be made. It also indicates the form of machine, as regards height, width, and other details of construction, which must be governed by the natural conditions of the mine. To attempt to work the mine to suit a particular machine is to court disappointment and loss. Several instances could be quoted where a particular machine has given excellent results in one seam, while the same form of machine has caused inconvenience and loss in another mine, until a special machine had been constructed.

The desire of the miner may be to have a machine of light construction, but experience has shewn that the machine which has to serve as its own foundation must contain the necessary weight to allow sufficient power and strength to be produced, not only to overcome all the natural conditions connected with the seam, but to maintain the proper line of cut, and at the same time to excavate the dirt or coal at a minimum cost. When the roof is of a tender nature and

FIG. XXI.



Scale, 660 feet to 1 inch.

experience shews that a specially quick advance of the whole length of face is needed to "pluck" or "snatch," as it were, the seam from the effect of the overlying strata, it is essential that there should be an excess of power in the air-cylinders or electric motors. The machine also requires to be of the requisite strength, to withstand, not only the resistance due to working, but the sudden and unexpected strains which the natural conditions of the seam demand.

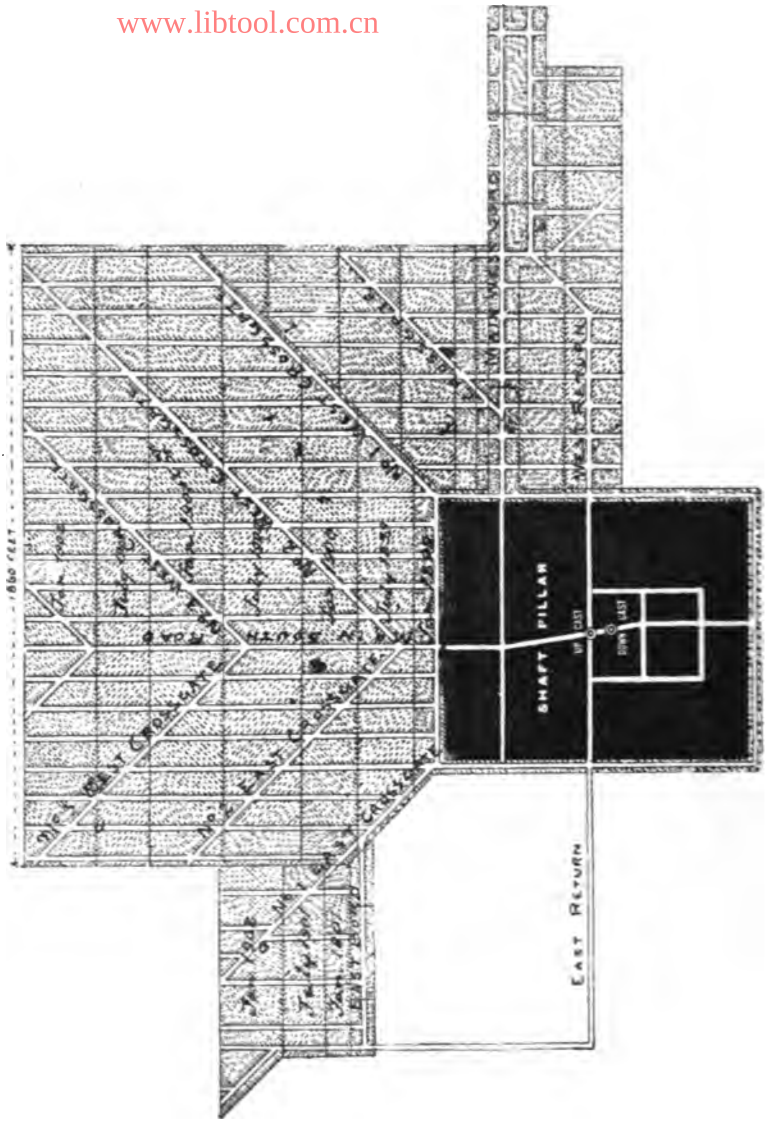
No difficulty has been experienced in training underground workmen to adapt themselves to holing by machine.

The machinemen work in an upright position as compared with the cramped one adopted by men using the pick and lying underneath the coal (Figs. VI. and IX). Over 1,100,000 tons of coal have been got by machine, with four reported accidents, as compared with 315,000 tons got by hand or pick in the same seam for the same number of accidents. The short sprags (Figs. X. and XVIII.) are more easily set by unskilled men, this being partly due to the flat surface made by the machine-cut, as compared with the sloping coal-face made by hand-holing, against which the long sprags have to be skilfully set and properly stamped. It may also be mentioned that the triangular piece of coal, which the miner cuts away to obtain a greater depth of excavation, has to be replaced by a timber-prop (Fig. VI.). Owing to the difficulty in doing this, or want of skill, a great number of accidents have resulted in past times.

If the depth of cut be too small, the timber must be set very near the line of break (Fig. XVII.).

The coal-face is for a longer period more uniformly protected from the action of the superincumbent weight, by allowing each square foot of seam to bear an equal pressure,

FIG. XXII.



PLAN SHOWING THE METHOD OF WORKING A SEAM 3 FT. 3 IN. THICK AT A DEPTH OF 1,500 FT. BELOW THE SURFACE, BY COAL-CUTTING MACHINES, HOLING TO A DEPTH OF 5 FT. 6 IN.

instead of throwing the weight on projecting knobs or pieces of coal.

The thickness of the cut being sufficient to allow of a complete fracture, the excavated coal is removed from the influence of the roof-pressure which latter is duly taken up by settling on the pack-walls (Figs. XI. and XII.). As a consequence of this, a much reduced percentage of small coal is produced, as compared with that holed with the pick.

A straight line of cut worked "end-on" prevents the workmen from slabbing the coal, altering or inclining the coal-face to bord-ways, and it also presents a surface of least resistance to the circulating air.

Assuming an advance of coal-face equal to 16½ feet, with a deep under-cut machine, the timber would in four weeks be set 12 times, whereas with a shallow under-cut machine, the timber, packing, rail-laying, &c., would for the same advance have to be set 21 times. The time thus occupied in setting timber, &c., would be available for filling coal (Figs. XIII. and XVI.), whereby a larger output per man would be obtained, varying from 4½ to 10 tons per man per shift according to the conditions of the mine.

Owing to the lines of break being straight and fewer in number than the irregular and numerous fractures produced by hand-holing, experience has shewn that the stall-gates and cross-gates are maintained with less expense, as the sides of such roads do not slab or easily fall.

In addition to the foregoing, other advantages may be summarized, namely :—(1) Fewer men are required at the coal-face, owing to the output per man being greater; (2) increased and more regular output per man; (3) less arduous labour; (4) better quality of coal; (5) greater tonnage from a smaller area of coal-field; (6) saving in timber; (7) reduced cost of production; and (8) minimum damage to the overlying seams and surface-property by a more regular settlement of the intervening strata; &c.

Mr. ASHWORTH: I am sure, gentlemen, we are all extremely pleased that Mr. Garforth has been with us this afternoon. I think he has paid our Society a very great compliment in coming here to show us these photographs illustrating the action and effects of coal-cutting machines.

Mr. HUGHES: Mr. Garforth's address has been most interesting to us all. I don't think anyone could answer questions on this subject so well as Mr. Garforth, and I should like to hear the matter discussed after the paper has been printed. He has pleased all of us by his exhibition and description of the photographs. I have therefore much pleasure in moving that a vote of thanks be given to him for his communication.

Mr. SMETHURST seconded the motion, which was passed unanimously.

Mr. GARFORTH, in acknowledging the vote, said it was a pleasure to him to take part in the discussion of this important subject, and any information he possessed in regard to it he would gladly give to the Manchester Geological and Mining Society.

ERRATIC AND WATER-WORN STONES FOUND IN FIRECLAY IN THE HARTLEY BANK COLLIERY, HORBURY.

By Mr. Richard Sutcliffe.

The two nodules were found about Christmas, 1900, in the fireclay immediately beneath the Old Hards seam of coal in the south eastern district of the Hartley Bank Colliery, Horbury, in Yorkshire, and the markings on them were made by the coal-cutting machine in displacing them while cutting underneath the coal. Owing to their extreme hardness I need hardly say that they broke the tools of the coal-cutter, and it was owing to this fact that my attention was drawn to them; and I had them brought out of the pit and preserved.

One of them, at least, is distinctly water-worn, and both of them are erratic and apparently of igneous origin.

The men reported having found several others, which they threw in the goaf before calling my attention to them, and which were consequently lost. The whole of them were found in the same locality and in a similar manner, namely, by the coal-cutting machine breaking its cutters against them, and they were not many yards apart; but these were the only specimens preserved, as already stated.

The distinctly water-worn stone weighs 11 lbs., and it lost about ½ lb. through the coal-cutter coming in contact with it. It is well rounded by the action of the water. The smaller one, which is apparently less water-worn, and much flatter in shape, weighs 9½ lbs., and it lost about ½ lb. also through the action of the coal-cutter. This stone appears to have been on its end in the fireclay, as the machine, in cutting horizontally, cut it across its length on a flat surface in a way which it could not have done if the stone had been lying on its side.

I may say that the Old Hards seam, under which these stones were found, is an attenuated extension, in a north westerly direction, of the well known Parkgate seam of South Yorkshire.

Mr. SAINT moved that the thanks of the meeting be given to Mr. Sutcliffe for his communication, and said that some members of the Society took a great interest in discoveries of this kind, and, with Mr. Sutcliffe's permission, he would like to retain the stones for a while, so that they might be seen by members.

Mr. PICKSTONE: I beg to second the motion. I may say I have taken a great interest in these boulders, but I have not seen any before that have been taken from so great a depth below the surface as these two have been. I am quite satisfied they were deposited under similar circumstances to those under which similar stones have been found in the boulder clay: that is to say, the mud in which they were deposited was at the sea bottom, and an ice floe passing over the surface dropped the stones, which were smooth before they were deposited.

Mr. BALDWIN said he thought the stones were probably borne attached to the roots of the trees in flood time. The boulder has the appearance of a quartzite.

Mr. PICKSTONE: They might have been, but I think not in this case. I think they have been carried rolling along and knocking against each other.

Mr. J. ATHERTON: Two somewhat similar stones, much rounded, were found in our Black and White mine, imbedded in the coal, within about twelve inches of the roof. I could not tell what they were nor how they got there. I broke one in order to see what it was composed of, and it appeared to be pure silica. I should be very glad if anyone could give me an idea as to how they became so well rounded, for there was nothing of a like nature in the vicinity.

Mr. J. DICKINSON: It is interesting to have these things brought from different coal seams, inasmuch as it shows the very widespread area in which they exist. I think it is about

50 years since one of these stones was first brought before this Society. I remember one being brought from Dukinfield, and it was followed by one from Bardsley. Then we have had some from Clifton and other places. When they were first brought, they were described by Mr. E. W. Binney as ærolites. We have had them called "erratics," and various other names. To my mind they are simply aggregations of silica in the coal seam.

Mr. BALDWIN: It seems rather incredible to us that there may have been a glacial period during the time of the formation of the coal seams, for it seems so contrary to the character of the vegetation of the coal measure period. When on a visit to the Bacup Natural History Society's Rooms a short time ago, I was shown some similar boulders to these by Mr. George Scott. In the Southern Hemisphere there are traces of glacial conditions in late Carboniferous and in Permo-carboniferous times. I do not consider that we have sufficient evidence to ascribe a glacial epoch or even such a rigorous change of climate that the stones could be carried by ground-ice to Carboniferous Times in the British Isles.

THE INAUGURATION OF A GRANITE MEMORIAL IN LEIGH CEMETERY TO SAMUEL SHORT, ENGINEWINDER, AT ST. GEORGE'S PIT, TYLDESLEY, 4TH MAY, 1903.

By Mr. J. DICKINSON, F.G.S.

I was much interested in reading the account of an incident commemorated by the inauguration of a granite memorial in Leigh Cemetery, to Samuel Short, Enginewinder at St. George's Pits, Tyldesley, who died September 12th, 1902. The unveiling was by Mr. G. H. Peace, one of our members, and was attended by a large representative gathering. The inscription sets forth that on the morning of his decease, when engaged lowering 24 workmen into the mine, he was suddenly overcome by a fatal seizure, but secured their safety by immediately applying the brake. His dying words were "Is the steam brake on?"

This needs not any comment to show the fine character of the man. Yet it may be added that the work of such a person requires constant careful attention. With brief intervals the engine has to be stopped, the engine reversed, and the work done in the opposite direction; the respective loads on each rope are ordinarily a heavy one to be lifted, and the starting to be so gradual as to avoid straining, speed having to be gradually attained, similar to that of a railway train, but to be quickly followed by slackening off after the short run to stoppage, which is usually done with accuracy. This is repeated during the shift, and when men are riding if we could read their minds pleasure floats through as they feel by the slackening that the attendant is at his post to avoid dashing to the bottom or being carried to the pulley. The work is done repeatedly with seldom an accident. Perhaps not any other constantly changing work is done so successfully.

It was some time ago proposed to require by legislation that two men should be in attendance. It was concluded, however, that improvement was scarcely possible, and that in various ways the presence of a second person with divided responsibility was likely to be disadvantageous. All honours, therefore, to the class of whom Samuel Short is representative.

Mr. Ashworth: It is gratifying to find that we have men in charge of winding engines who in times of peril have the presence of mind which this man exemplified. It may be said of him that at his death he saved others. That man is one we can remember with pleasure as showing that the Englishman is still a true man.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL AND MINING SOCIETY.

PART IX. VOL. XXVIII. SESSION 1902-1903.

The ORDINARY MEETING of the Members was held on Tuesday, June 9th, 1903, in the Society's Rooms 5, John Dalton Street, Manchester.

Mr. HENRY HALL, I.S.O., H.M.I.M., President, in the Chair.

NEW MEMBER.

The following gentleman having been duly nominated was elected an Ordinary Member of the Society :—

Mr. ANDREW BURY, 187, Margaret Street, Ashton-under-Lyne.

The following paper on "Gold Mining in the Transvaal," illustrated by specimens and a map of the Witwatersrand District, was read by Dr. W. G. BLACK :—

GOLD MINING IN THE TRANSVAAL.

By Dr. W. G. Black.

Dr. W. G. Black showed a number of specimens of gold ores obtained from the Robinson Gold Mines, Johannesburg, together with a map of the Witwatersrand District, Transvaal. He said: the specimens, now on the table, are not very attractive, nor do they give any idea of the formation in which they were found, they appear to be simply plain stones, so that they do not attract the eye of the visitor or the dealer; but the chemists discovered by analyses that they contained gold. Many people on seeing these specimens are disappointed, because there is no visible gold on the surfaces. It is not the same as you see on examining specimens from Australia, or in the river, or alluvial gold. This gold is contained in chemical combination with the constituents of the rock. It is therefore not visible gold, but contained gold. These specimens were taken from the actual mine itself by a friend of mine, Mr. Robert Mann, who has been engaged for some time in various occupations in South Africa, and he is now connected with the Robinson Deep Gold Mining Company at Johannesburg.

Mr. Joseph Chamberlain, Colonial Secretary, recently visited this mine and descended No. 1 shaft to a depth of 2,500 feet and expressed himself as being greatly pleased with the fact that at that depth the temperature of the air appeared to be cooler than that of the hot atmosphere at the surface.

The beds of conglomerates or reefs in which the gold is found are commonly called "bankets" a name of Dutch origin, meaning a bank or ridge. There are various estimates of the quantity of gold contained in this rock—one ounce per ton, and up to as much as five ounces per ton.

The following is a list of the names of the Reef minerals all of which were obtained from the Robinson Deep Gold Mine, Witwatersrand, Transvaal, by Mr. R. H. Mann :—

No.
1. Hanging Wall or Upper Casing, South Reef.
2. South Reef. Banket conglomerate.
3. Foot Wall, or Lower Casing, South Reef.
4. Hanging Wall or Upper Casing, Main Reef.
5. Main Reef, Banket conglomerate.
6. Foot Wall, or Lower Casing, Main Reef.
7. Spar Seam, Calcite and six small pieces ½ inch and 1 inch.
8. Dyke, Basalt.
9. One Loose Pebble and Crystals.

Mr. C. J. Alford in his book on the geological features of the Transvaal, now out of print, at page 4, says: Underlying the coal formations and exposed at the surface over very considerable areas we find a series of *Sandstones* and *Quartzites* and interbedded with them are masses of Quartzose *Conglomerates*. The latter becoming in some places auriferous, as in the case of the Witwatersrand to a very valuable degree.

These beds vary greatly in thickness, and usually retain very nearly their normal horizontal position, but are occasionally found tilted up to a very high degree of dip, notably in the case of the Witwatersrand.

Mr. Alford also states as follows: on page 18 and succeeding pages of his book :—

"In noticing the geological structure of the part of the country now under consideration, it is with the beds of quartzite and conglomerate which were deposited during period *No. 2*, that we have principally to deal, and the greatest interest necessarily attaches to the conglomerates which form the renowned auriferous *reefs* of the Witwatersrand Gold

Fields, deposited, as we have already noticed, by varying currents of effluent water, they were originally laid down in zones or beds of pebbles, alternating with beds of sand and clayey matter, and would thus be naturally more or less lenticular in structure and very variable in extent.

"The great upheaval and dislocation of these strata caused by repeated irruption of the trappean rocks accompanied by movements of the granitic base, placed them probably altogether or very nearly in their present position; and the subsequent removal of the overlying strata, together with the very general cutting away of the surface during long subsequent periods, has left the edges of these upturned beds in many cases exposed at the surface, forming the outcrops of the present *reefs*.

"As the placing of the surface of the ground in its present horizon is purely incidental, and the beds of conglomerate are many and widely distribnted in the series of sandstone quartzites, consequently the exposure of the edges of those beds which form the present reefs is accidental, and it may be safely assumed that many more beds exist than are now found outcropping at the surface.

"The renowned *main reef* of Johannesburg, and its attendant *leaders* and *reefs*, are the upturned edges of certain of the conglomerate beds which can be followed by their outcrops on the surface east and west of the town for many miles.

"The whole form a series varying from *10 to 200 feet* in thickness, composed of several beds of conglomerate varying in number, separated from each other by a sandstone quartzite, white to red in colour in the upper and oxidised zones and white to blue in depth, carrying in some places traces of granitic clay, mica, and talc, but usually free from the presence of any accessory minerals.

"The distance of these beds from each other, their number, thickness, dip from the surface, and gold bearing value, vary very greatly in their lateral extent.

"The thickness of what is known as the *South reef*, which, as its name implies, lies southernmost in the series, varies from about *six inches* up to *three feet*, and in some places it is very rich in gold, assaying occasionally as high as *ten or twelve ounces of gold* per ton of rock.

"To the north of this occurs in some parts of the series a bed, which has been named the *Middle reef*, which appears to vary from a few inches up to over *two feet* in thickness, and which is also occasionally very rich in gold.

"Still further northward and at a distance varying from *20 to 100 feet* from the south reef, occurs a persistent little bed known as the *main reef leader*, from which hitherto the greatest general results on these fields have been obtained.

"It is usually found from *six inches to two feet* in thickness, and carrying gold in places up to *six or eight ounces* per ton of rock.

"At a short distance further to the northward—sometimes only a few inches—lies a very large deposit, the *main reef*, varying in thickness from about *four* up to as much as *forty feet*, and carrying from a trace of gold up to perhaps an ounce in places. This great mass of conglomerate has been hitherto but little worked upon, its richer though smaller companions offering greater attractions to the miner; it will, however, have its day in the future.

"North of the main reef, at a distance of from twenty to one hundred feet, there lies an almost unexplored and little noticed deposit known as the *north reef*, which, so far as it has been examined, appears to vary from one to five feet in thickness, and to carry gold from a trace up to nearly an ounce per ton of rock. As with the main reef, so with this, its day of importance has yet to dawn when the richer portions of the series have been worked out.

"It must not be assumed that this series of upturned conglomerate beds is by any means absolutely continuous. It appears probable that even the well-known reefs lying south of the main reef are themselves made up of deposits of somewhat different horizons.

"In some parts the individuality of each is much obscured, pebbles of the same nature being disseminated freely through the quartzite partings, which are then often found to carry gold.

"In addition to this normal want of continuity in the beds themselves, we find along the entire series that it is repeatedly faulted and thrown out of line, sometimes to a very great extent.

"The most regular part of the gold-bearing deposits yet known in this district is the line of outcrops which extends for a distance of about twelve miles to the east, and the same distance to the west of Johannesburg. Along this line the beds are faulted repeatedly, but never to a greater distance than about one hundred feet, and their line of east and west strike is very well preserved.

"The *vleis*, or swampy places, appear usually to mark broken ground, and probably the near approach of the igneous rocks, whilst on the higher ground less disturbance is apparent.

"The dip of the beds varies very greatly all along the line, in some places they are nearly perpendicular, and in others the dip does not exceed ten or twelve degrees. It is invariably to the south.

"At a short distance north and south of the reef outcrops the strata of altered sandstone appear never to attain a greater dip than about forty-five degrees south, thus producing, where the reef beds are perpendicular, two lines of unconformability, one north and the other south of the series of reefs. It is probable that the strata contain other beds of conglomerate of a like nature to those now worked, or other portions of the same beds broken off in the general upheaval of the strata, which do not appear at the surface.

"The question of the continuity of the beds in depth is undoubtedly a serious one for the gold miner, and on this two theories suggest themselves at present.

"One is that in depth they will gradually decrease their angle of dip, and turning to the south, continue with their enclosing strata until their normal limits are reached, in which case the lines of unconformability above alluded to would be but a surface disturbance and would disappear in depth.

"Another possible case is that the break up of the strata has been more pronounced than the former would assume it to have been, and that in depth the line of fracture of the beds will be reached, in which case the continuance of the deposit must be looked for amongst the more horizontal portions of the strata to the south of the present line.

"There is also the remote contingency that the original limits of the conglomerate beds are in the present upturned part of the series, and may be reached in depth, but this would involve the assumption of an area of deposition so totally out of proportion in length to breadth, or, on the other hand, a denudation of the surface so vast as to be absolutely incredible.

"Probably both of the first two hypotheses will be found borne out in different parts of the district as the dislocation of the strata has been more or less acute."

The PRESIDENT: I am sure it will be your wish that the thanks of the meeting be given to Dr. Black for his information about the gold mines of the Transvaal. It must be very interesting to the geologists who are here. We have heard, as you know, much about South African gold mines during the last five or six years; indeed we have heard of hardly anything else, I think; and even Mr. Chamberlain himself during his recent visit to the new Colonies seems to have been charmed by colonial eloquence on the subject. Now it seems that the note has changed somewhat. So far as I can judge from the reports sent over they are based on the idea that labour can be had for 7s. 6d. a week, 30s. a month, and that they must have Chinese or some other uncivilised labour. If they do not succeed in getting labour of that kind, I understand 80 or 90 per cent. of the mines will be unprofitable, on account of the immense amount of digging and moving of material they have to do. I beg to move that the best thanks of the meeting be given to Dr. Black.

Mr. J. Dickinson, F.G.S., seconded the motion, and it was adopted.

Mr. Gerrard, H.M.I.M.: Allusion being made to the depth of the mines, it may be interesting to give the depths of some of the deepest on the Rand, as recorded in November, 1902.

Shaft.	Name of Company.	Depth. Feet.
Catlin	Jupiter Gold Mining Co., Ltd.	3752
Howard	Simmer & Jack, West	3408
†Milner	South Geldenhuis Deep	2746
Rhodes	,, ,, ,,	2015
*No. 1 East	Robinson Deep	2601
*No. 2 West	,, ,,	1987½‡
West	Angelo Deep	2468
†Rudd	South Rose Deep	2425
Clement	,, ,, ,,	2392
East	Angelo Deep	2300
†West	Knights Central	2190
West	Volgerstruis Cons. Deep	2400

* These shafts are continued on the incline, the workings being the deepest on the Rand.

† These shafts are being carried forward.

‡ 500 ft. further by slope.

The reef crops out 5614 feet above the sea level; the top of No. 1 East Robinson Deep being 5400 feet above sea level. In connection with No. 1 East Robinson Deep, thermometrical observations recorded at surface, 40° to 68° Fah.; in the mine, 59° to 66°. In a drive, 560 feet out of air current, dry and wet bulbs registered 73°. At the shafts the same instrument registered 66°. At the surface (during a shower of rain) both bulbs registered 54°.

Mr. Sydney A. Smith: I made a professional visit to the Transvaal some time ago, and amongst others went down the Robinson Mine. The shaft or engine brow was driven on the inclination of the main reef series of "banket beds," which dip at an angle of about 35° to the south; the engine brow was some 1000 feet in length from the outcrop, and the vertical depth of the lowest workings in the year 1894 was about 600 feet below the surface. Ultimately, when the downbrow reaches the extreme boundary, its length will be about 2550 feet, and the vertical depth below the surface about 1300 feet. The mine was a very good one and was fitted with the best modern machinery; in fact it was and is one of the largest and richest on the Rand. The machinery, downbrow, and winding plant, appeared to be capable of an output of 1000 tons a day, but at that time they were only winding about 350 tons a day. In my opinion Dr. Black's estimate of the average value of the "banket beds" is incorrect; there are certainly patches where the yield may be found equal to "one ounce and up to as much as five ounces per ton" and even more, but over the "banket beds" worked in the Johannesburg district the gold is well distributed, and may be relied upon as being uniformly dispersed irrespective of the thickness of the beds. The Robinson Mine was producing at that time 25 to 30 dwts. of gold per ton of ore milled. Owing to improved methods of treatment, I believe that more of the lower grade ore is now passed through the mills, and taking an average of the present output of about 30 of the leading mines the yield is about 12 to 15 dwts. of gold actually extracted per ton of ore. The payable gold is found in the matrix only, there being little or no gold in the pebbles. The word "reef" applied to these beds, although generally used, is misleading, as they are not reefs in the sense that mining men generally understand the term as applied to fissure veins; they are conglomerate beds of sedimentary formation lying between beds of quartzite at comparatively moderate inclinations. The word "Banket" as applied to these conglomerate beds is, I believe, derived from the rich plum cake containing almonds and sweets made by the Dutch, which the beds were supposed to resemble in structure. Another item of information, which may be interesting to the members, is the fact that the faults running through these "banket beds" are nearly all *reversed* faults, and in many instances cause overlapping of the payable bed. It is exceptional to find the displacement caused by the faults such as we usually have in our coal mines in England. I don't think I saw three faults that were not *reversed* during the time I was in the district of the Rand.

The following paper "On a Fossil Polyzoa, from the Mountain Limestone, Castleton," was read by Mr. J. BARNES, F.G.S. :—

ON A FOSSIL POLYZOA, FROM THE MOUNTAIN LIMESTONE, CASTLETON.

By Mr. J. Barnes, F.G.S.

The fossil is only a very small one; it is not a very important animal, but it is an interesting one inasmuch as it is the first that has been found in England, and probably in Europe.

Polyzoa. Enlarged ?.

Specific Characters. Polyzoum small, circular in section, with nine to eleven elongata narrow five rod like rays, which are slightly broader near the base, and appear to be directed downwards and outwards. These rays are not equidistant or exactly symmetrical, and appear to be smooth on the under surface. Greatest diameter from extremities of opposite rays, 7 mm. diameter of the circular central portion 1·25 mm.

OBSERVATIONS. A piece of limestone with two specimens was obtained at Castleton some time ago, which has been kept for identification. My attention was called to similar organisms from the Carboniferous of North America which have been named Evactinopora by Meek & Worthen, Geol. Illinois, Vol. III., p. 501.

It will be well to quote the diagnosis of the genus as given by these authors. "Polyzoum free, consisting of a few large, more or less thickened and solid calcareous plates or laminæ radiating from an imaginary vertical axis, so as to present, in a transverse section a star-shaped or cruciform outline. Rays thickest and most dense on the under and outer edges thinner and penetrated on each side by the pores within. Each apparently divided along the middle by a thin lamina separating the inner ends of the pores of the opposite side. . . . . . . Pores small, regularly arranged on quincunx and separated by spaces equalling or exceeding their own breadth." Three species were described, all much larger and more robust than the English example. It is unfortunate that the samples before us are not free and the pores are not visible, but I think there can be little hesitation in referring the specimens to *Evactinopora*, *E.* Castletoniensis has more rays than any of the American species. The type Ev. radiata having eight, the others six and four respectively.

Mr. Ollerenshaw: I should like to ask Mr. Barnes if he has discovered any other similar fossils near Castleton?

Mr. Barnes: I have not. This fossil has been in my possession for about 18 months. It has been left over until I could find someone who could tell me something about it.

Mr. J. Tonge proposed a vote of thanks to Mr. Barnes for his paper, and said the Society was indebted to Mr. Barnes for many other valuable contributions.

The motion was seconded by Mr. Dickinson, and passed unanimously.

COAL-CUTTING BY MACHINERY.

The discussion on "Coal-cutting by Machinery" was resumed.

Mr. HUGHES said: At the meeting held on April 21st, the President referred to the question of the quality of the "slack" or small coal produced by coal-cutting machinery. He expressed the opinion that the "slack" made by machine-holing was almost worthless as compared with "slack" produced by hand holing. Presumably he referred to holing in the coal in both cases. It is quite true that the "slack" produced by the machines is fine slack, but it is questionable whether there is not as much fine slack made by hand-holing although it is mixed with nuts. With a machine holing a depth of 3 feet 6 inches, and making an incision of say 4 inches, the excavation amounts to 3½ cubic feet per lineal yard. A collier when hand-holing would make a "balching" of say 18 inches to cut 3 feet 6 inches deep, and the height of the holing at the back would be about 2 inches or equal to 9 cubic feet of excavation per lineal yard.

Assuming a mine in each case 3 feet thick, the machine when holing in the coal would produce 11 per cent. of fine slack, whereas by hand-holing nearly 30 per cent. of the same seam would be made into nuts and slack, and in my opinion there is a large proportion of fine slack made by the latter process. Mr. Hall assumed that two-thirds of the holings by hand would make nuts; that may be so, but a great deal would depend upon the collier, the nature of the coal &c. It is not often that machines are allowed to hole in the coal. The dirt must be very hard indeed if the machine with its cutting picks properly arranged on the cutter wheel will not cut in it,—but the machine is sometimes put to hole in some part of the coal which is better made into slack, than to be sent away either as nuts or cobbles When machines are holing in the dirt, it is of the utmost importance to see that the fine dirt is cleaned from the holings, otherwise the slack will become mixed with it and serious complaints will be received from the consumers. We have never received any complaints of the quality of the slack produced by the machines holing in the coal.

The President also referred to the question of machines holing in the dirt as compared with hand-holing in the same. With hand-holing in dirt to a depth of say four feet, a collier would make a balching of 18 inches or more, and, in a seam of two to three feet in thickness it would be difficult to find stowage room for the holing-dirt in addition to the dirt from the gate road rippings. On the other hand, a machine makes an incision of only about four inches for this depth of cut, hence the minimum quantity of dirt would have to be removed. Obviously the greater the height of the holing the better the coal can be broken up and removed when got down. Assuming we have a coal face 200 yards long which is to be holed four feet deep, eight men with two machines would be able to cut that distance and clean the dirt away during the night, and most of the coal would be down ready for the men to commence filling the waggons in the morning; but it would require a much larger number of men to cut the same length and depth by hand and make ready for the filling operations.

In reply to the question whether a machine could hole in dirt so hard that a man could not hole in it with the pick, I may say machines would cut fairly well in hard dirt in which it would be unreasonable to expect a man to hole. I know of a seam of coal about two feet thick with very hard underclay, and the manager was determined the holing should not be done in the coal. The dirt was too hard for hand holing, and therefore blasting the dirt out with explosives in properly arranged shot holes was tried, but this method was found to be far too expensive, and a Diamond coal-cutting machine arranged to cut to a depth of five feet or five feet six inches was substituted with satisfactory results.

The PRESIDENT said he thought Mr. Hughes must be wrong when saying that in a mine three feet thick the machine in holing makes 11 per cent. of fine slack, while by hand-holing nearly 30 per cent. was made. I will ask Mr. Hughes whether he has taken into account the fact that some deduction must be made in the case of hand-holing for nuts and coal?

Mr. HUGHES: Yes. I think there is at least 11 per cent. of fine slack contained in the 30 per cent. of the runnings made by hand-holing.

The PRESIDENT: You only get twice as much slack with a man as compared with a machine, and in one case you have it all fine slack, and in the other you have from one-third to two-thirds of nuts or round.

Mr. GERRARD: Plus the same amount of small slack.

The PRESIDENT: I think Mr. Hughes has claimed too much in favour of the machine.

Mr. GERRARD: I remember you touched upon that point very strongly—the comparison of the amounts of slack produced by man and the machine. You also touched on another point, on which I hoped to get from Mr. Hughes some corroboration. If there is a saving of 9d. a ton by machine-cutting, and the saving may be as much as 1s. 9d., how is it that there are not more machines in operation? You made two very good points and spoke very forcibly upon them. Mr. Hughes has given us some further information which does not appear to be quite conclusive.

Mr. Hughes: I can only say the figures I gave are accurate, and that if any member wishes to see the machines at work he can do so.

Mr. Robinson: I am disposed to agree with the President on the question of slack percentages. I think from machines we get fine dust for which colliery people will take 2s. 6d. a ton as against 5s. for rough slack. Yet, I think it likely that machines for coal-cutting will be more generally adopted in the future. I have had experience with machine-cutting in the dirt, where the men having gone out of the mine before clearing the dirt from the holing, on returning the next day found the cut closed by pressure and the dirt so hard that it required to be reholed That was the case in a seam with a hard floor, but it is important to know what we can do in the case of a seam with a soft floor? I believe it costly to clear up the loose dirt after the machine. The machine rakes the stuff out to some extent, but it does not clear it all away and leave a clean floor; and unless the dirt is cleared out of the "cuts" the slack will get mixed with it and is then unsaleable. To my mind Mr. Hughes's figures stating the cost of getting are altogether too big, and I gather from them that it would not pay to apply machines in a seam where the coal can be got by hand for 2s. a ton? When opening out a new mine and men are difficult to manage no doubt it would be an advantage to introduce machines. The conditions of mining vary so much in different counties. In some parts of Lancashire we meet with faults and steps which prevent the use of machines, while in Yorkshire there are excellent mines comparatively free from faults and steps where coal-cutting by machines can be adopted without much trouble. The question of the cost of electricity as compared with compressed air is one I should like to hear discussed. I find some managers prefer to use compressed air for driving coal-cutting machines, but others say electricity is more economical and so long as we can get a machine made gas proof, I fancy there is not very much objection to the use of electrical machines. I have tried one that was electrically driven, and as long as the cover was kept on it was all right and appeared to be safe enough. I should like someone to give us the approximate cost of power as between electricity and compressed air. If there is not much difference I think we had better use compressed air for coal-cutting purposes in the mines.

The PRESIDENT: One point which Mr. Robinson mentioned was most important. The question as to whether electricity was any great advantage over compressed air. I know we have had a Committee sitting for many months trying to make out what ought to be done in the mines, and their chief difficulty is as to whether electricity shall be allowed at the coal face or not. It may possibly be quite safe in main fresh-air roads, but it is a very serious matter to allow it at the coal face, and that must appeal to every manager who happens to have charge of dangerous seams. Now, if it can be shown there is no great advantage in having electricity as compared with compressed air, it is really not worth our while allowing electricity to be used at the working faces if there is no commercial advantage in it. We have two gentlemen here to-day who can give us some information on this question, and we ought to take advantage of their presence. Mr. Hughes has the best installation of coal-cutting machines in Lancashire, and they are driven by compressed air. On the other hand, Mr. Garforth, from Yorkshire, has perhaps the best installation of machines in that county, and I believe the whole of his machines are driven by electricity.

Mr. Garforth: No. Twenty by compressed air and two by electricity.

Mr. Gerrard: We have Mr. Alfred Tonge working machines with electricity, so that you have one on each side.

The President: I think it is a very important point and if the gentlemen named will give us information thereon it will in my opinion be very valuable.

Mr. Robinson: If we could have it as clearly as the other figures it would be very useful to those who are hesitating as to which power to adopt.

Mr. Alfred J. Tonge: I had not noticed this paper was down for discussion till this morning. I hurriedly put up a few notes I had prepared for another occasion, but I fear they will not be of much use in comparison with the notes which Mr. Hughes has given in his paper. It is true we have electrical coal-cutters working at Hulton Collieries, seven or eight in all, and we find the cost of stores is higher than that given by Mr. Hughes. It varies very much according to the seam we are cutting in. We have not a seam that we can cut at the rate of 60 yards in 60 minutes, as Mr. Hughes did in one of his experiments. If we did that we should have fusing up or some other calamity happening to the machine. The extent our machines can travel is from 1 foot to 1 foot 3 inches per minute, which means probably 20 yards per hour. So that has a great deal to do with the cost of repairs. For instance, where we travel quickest the cost of repairs is the lightest, and where we can only travel slowly, owing to the hardness of the dirt, the cost of repairs is heaviest. The cost of repairs to the machine where the holing is hard is 4¼d. per ton, and in another mine it does not amount to one half-penny per ton.

Mr. SAINT: Is the type of the machine the same in both cases?

Mr. TONGE: Yes. In another mine the cost of repairs is 2d. per ton of coal; but occasionally we put a new wheel on a machine and the cost of a new wheel adds another 6d. to the cost of tonnage in that quarter. On an average the cost of repairs is nearer 2d. per ton than the one penny of which Mr. Hughes spoke. That is not allowing anything for depreciation or the cost of the power. I don't think Mr. Hughes allowed for depreciation. I should like to say I quite agree with Mr. Hughes in regard to the way he has calculated the slack, though I cannot agree that the slack is of equal quality. We have a mine where the slack was rendered absolutely useless by the use of a coal-cutter. According to my notes, prepared, as I say, for another purpose, I find our proportions of large coal got by machines is nearer that of the hand-got coal than that stated by Mr. Hughes. The cost of cutting in one of our mines, including electrical cost and wages and filling out, is 2s. 7½d., where 3s. 0½d. is the average cost of hand-got coal, but that does not cover depreciation. In another mine the cost was 2s. 10¼d. against 2s. 11½d. In another it was 3s. as against 2s. 11¾d. In our seams therefore we do not find that we can undercut them very much cheaper with machines than by hand, but we do get an advantage in the larger yield of round coal from the seam. I have no experience apart from what I have seen at other collieries of compressed air. I understand electricity is slightly cheaper in the cost. Speaking of the safe use of electricity in mines, we are working electric machines right on the face of the coal. I have had the pleasure of being present at Mr. Garforth's experiments when he demonstrated the possibility of working an enclosed machine in an explosive mixture for a considerable length of time. At the end of one hour it had not exploded, so that by taking the necessary precautions I do not see any reason why electrically driven machines should not be put to work at the coal face.

Mr. GARFORTH : If I were to try to give you a description of the reports that I have had during the last seven or eight years respecting the working of 220 machines, you would find them so conflicting that you could not make up your mind which to believe. The machine which is suitable for one mine is unsuitable for another. As regards electricity, you know I have been giving evidence before the Home Office Committee, and I can only repeat the answers I then gave. Some persons favour electricity on account of repairs, and others on the ground of economy. The reports are most conflicting, but the collieries which use both electricity and compressed air have for the last twelve months been ordering more electrical than compressed air machines.

The PRESIDENT : What about the small coal?

Mr. GARFORTH : In addition to the quantity of coal cut by machine as compared with hand-holing, I may point out that by hand-holing an irregular line is cut at the back of the holing—it may be only an inch, or perhaps not more than a pick point. The consequence is, when the superincumbent weight comes in operation the coal is crushed thus causing a larger percentage of small coal, whereas when working by machine a clean cut is produced at the back of holing five inches in height. With the line being perfectly straight a complete fracture is obtained so that the whole body of coal falls over and relieves the pressure on the roof, besides being stronger when put in the tub than when it has been subjected to a great crushing weight. As to wages, I may say that when we were working a five feet cut and introduced a five feet six inches cut, which gave a wider face for the men to fill at, all other conditions being exactly the same, the men increased their wages 10d. a day. But as I said when I spoke here a month ago, there are a great many interesting points in connection with the working of coal—superincumbent weight—percentage of small—the question of temperature—also questions bearing on geology and cost of production. At present we are interested in the question of cost, and this discussion will be useful to us in working thin seams in depressed times as well as good seams in good times.

The PRESIDENT: I think the meeting has lasted long enough, but we should, I think, bring this question up again. As things stand at present, compressed air power seems to be most favoured. The gentleman who has been using electricity only saves 2d. or 3d. a ton, while he who uses compressed air saves 9d. to 15d. a ton. Mr. Garforth said that people were ordering electrical coal-cutters in preference to compressed air. Well, people do very foolish things sometimes, and are always disposed to like novelties. Electricity is a very interesting kind of study, and men seem rather to like anything connected with electricity, and that possibly may be the reason why they are ordering more of these electrical coal-cutters. Mr. Robinson raised a point which I think is very important. We will assume it should happen in Mr. Garforth's pit where he gets all his coal with coal-cutters, in a year or two's time he will not have any colliers at all; he will only have labourers.

Mr. ROBINSON: I contend that there are many mines altogether unsuited for machines. We have tried the machines in several of the mines at Haydock, and have found that our men can do as much work as the machines can.

MEERSCHAUM CLAY.

Mr. JOSEPH DICKINSON, F.G.S., mentioned that many sources have been credited with the supply of the clay used in making the much prized meerschaum pipes; and that recently he had seen a notice that the chief supply is obtained at Brusa, in Asia Minor, where it is found as a white earth. Numerous small holes are said to be dug till they come to a bed of red clay, in which the meerschaum lies in isolated kidney-shaped pieces, usually about the size of a walnut and rarely larger than an apple.

His principal reason for the mention was that he had many times seen apparently identical deposits in the red ground accompanying the stratified iron ore of County Antrim, most of which seemed to be wasted, the only use so far as the miners stated being as a healing plaster. It is a beautiful clay, and he hoped that the mention may call attention to the possibility of its suitableness for other useful purposes.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

PART X. VOL. XXVIII. SESSION 1903-1904.

The ANNUAL MEETING of the Members was held on Tuesday, October 13th, 1903, in the Society's Rooms, Queen's Chambers, 5, John Dalton Street, Manchester.

Mr. HENRY HALL, I.S.O., H.M.I.M., President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society, namely :—

Mr. M. R. AROKSAMY, 175, Oxford Street, Secunderabad (Deccan), India.

Mr. GEORGE BENTLEY, Bradford Colliery, Manchester.

Mr. THOMAS F. RITSON, Manager, Bamfurlong Collieries, near Wigan.

THE ANNUAL REPORT OF THE COUNCIL AND TREASURER'S STATEMENT.

REPORT OF THE COUNCIL,

For the Session 1902-3.

Your Council in presenting the Sixty-fifth Annual Report, as prescribed by Rule XIII. of the Society, have pleasure in congratulating the members on the continued prosperity which the Society enjoys.

During the past session sixteen new members have been elected.

Five members have resigned and the names of nine have been removed from the list under Rule XII.

Your Council regret to record the loss of two members by death—Thomas Ward, F.G.S., and George Wild. They were both very old and useful members—Mr. Ward* was a member of nearly twenty years standing, and Mr. Wild,† who was an honorary member, had been connected with the Society thirty-six years.

The Society now consists of 227 members, as follows :—

Honorary Members	8
Life Members	11
Ordinary Members	208
Total	227

The number of meetings held in the Society's Rooms, 5, John Dalton Street, Manchester, during the past session was nine. The attendance was very good.

The President, Mr. Henry Hall, I.S.O., H.M.I.M., in delivering his Inaugural Address, took for his subject

* See note by Mr. J. Dickinson, Part VI., Vol. XXIII., p. 146.
† Do. do. Part VII., Vol. XXIII. p. 166.

"Industrial Education," a subject which, at the present time occupies the minds of a considerable number of "thinking" people.

During the session papers and short communications have been presented before the Society on geological subjects by Mr. J. Barnes, F.G.S., Mr. W. Baldwin, F.G.S., Dr. W. G. Black, Mr. J. Dickinson, F.G.S., and Mr. W. Pickstone; and on mining subjects by Mr. W. E. Garforth, Mr. James Grundy, Mr. Owen Hughes, and Mr. A. Dury Mitton. Mr. Mark Stirrup, F.G.S., read his Report as Delegate at the meeting of the British Association held in Belfast, 1902.

Numerous specimens of fossils, flint implements, and minerals were exhibited by Mr. W. Baldwin, Mr. J. Barnes, and Dr. W. G. Black.

A list of the papers and short communications read before the Society during the session is appended.

Mr. J. Tonge was appointed by the Council to act as the Society's delegate at the British Association's meeting held at Southport in September.

On Saturday, 20th June, an Excursion was made to the Wirral Peninsula under the leadership of Mr. W. Pickstone. About twenty members and their friends took part in it and spent a most enjoyable day, leaving Manchester by the 12-30 p.m. train for Hoylake, *via* Liverpool and Seacombe. On arrival at Hoylake the party was driven along the promenade to inspect the submerged forest at Leasowe. The drive was continued and the party set down near the Royal Hotel, Hoylake. At this point an inspection was made of the recently uncovered ground, in which certain reeds referred to by Mr. Pickstone in his paper read before the Society on the 13th January, 1903, came under observation. This vegetation in Mr. Pickstone's opinion, supports his view of recent subsidence of the shore line.

An animated discussion took place showing a great diversity of opinion. A short walk from this point along the shore brought the party to Hilbre Point where a section of New Red Sandstone (Pebble Beds) was examined. The drive was then continued to West Kirby and thence to Thurstaston Common. Here the large New Red Sandstone Rock supposed to be dedicated to the god "Thor" was inspected. This rock is described by the late Mr. G. H. Morton in his book on the "Geology of the Country around Liverpool" as the "Thorstone, a projecting mass of rock supposed to have been formed by the excavation of the surrounding sandstone by the Danes, but more probably by sub-ærial denundation."

The thanks of the Society is tendered to the authors of the various communications read during the session.

The Library Committee appointed by your Council last year have met frequently during the Session and have arranged for the Society's transactions to be catalogued under a card system, having three heads—authors, subject, geographical. This work is now in a forward state and when completed it should prove useful, embodying, as it does all the matter brought before the Society since its inception (1838). It is also proposed to catalogue the whole of the books in the Library in a similiar way. This work will necessarily involve considerable expenditure, and some contributions to a special fund, created for the purpose of meeting the expenditure, have already been received. Your Council returns thanks to those members who have contributed towards this object, and also to those who have promised to contribute. They would be pleased to receive presents of books on Mining and Geological subjects, and make a special appeal to those interested in the work of the Society to give donations to the fund opened to carry out this work, which your Council think of vital importance to the welfare and advancement of the Society.

The papers read during the Session show no falling off in their scientific and practical value. It is to be hoped that more members will be induced to prepare papers to be read before the Society, and so help to keep up that standard of scientific efficiency for which the Society is noted.

Your Council also wish it to be known that they intend to make a special effort during the next Session to secure new members, and invite the hearty co-operation of the members towards that end. Colliery Owners, Lessors, Lessees, Agents, Managers, Surveyors, Mining Engineers, and all interested in the science of geology or the art of mining are eligible for membership.

Members are requested to pay their subscriptions as soon after they fall due as possible, and so avoid a considerable amount of loss by waste of time and expense. All cheques should be crossed (and Co.) and made payable to the Honorary Treasurer, G. H. Hollingworth, at the Rooms of the Society.

The financial statement prepared by the Treasurer and appended, shows the Society to be in a prosperous condition.

In conclusion, your Council would make reference to the important change in the Society's name—from "Manchester Geological Society" to "Manchester Geological and Mining Society." It is hoped that the change will have the effect of increasing the interest of the Members generally in the work of the Society. They would also refer to the change in the crest of the Society, which has been made from an ammonite circled by a scroll, to an ammonite above two picks, from which hangs a miner's safety lamp, all being circled, as hitherto, by a scroll bearing the Society's new title :—"Manchester Geological and Mining Society."

TREASURER'S STATEMENT.

The following statement was presented by the Treasurer :—

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

BALANCE SHEET, 30TH SEPTEMBER, 1903.

Dr. LIABILITIES.	£	s.	d.	ASSETS. *Cr.*	£	s.	d.
To Outstanding Accounts :—				By £600 Birkenhead Railway Consolidated Preference Stock Guaranteed (at £124)	744	0	0
J. B. Cornish	0	4	6	,, £733 Lancashire and Yorkshire Railway 3% Consolidated Preference Stock (at £88¾)	650	10	9
Manchester Corporation	0	9	2	,, Library and Furniture	500	0	0
J. Roberts & Sons	0	18	6	,, Cash in Bank	99	19	8
	£1	12	2	,, Cash in hands of Secretaries	0	14	8½
,, Balance in favour of the Society	2013	12	6½	,, Arrears of Subscriptions, £47 10s., say	20	0	0
	£2015	4	8½		£2015	4	8½

ABSTRACT OF THE ACCOUNTS, 1902-3.

Dr. RECEIPTS.				£	s.	d.
1902.						
Sept. 30.—To Balance in Bank				130	15	11
,, ,, Secretary's hands				0	11	11½
1903.						
Sept. 30.— ,, Members' Subscriptions :—						
Current	175	10	0			
Advance	4	10	0			
Arrears	24	10	0			
				204	10	0
To Dividends :—						
Birkenhead Railway	22	12	0			
Lancashire and Yorkshire Railway	20	14	2			
				43	6	2
,, Bank Interest				1	7	2
,, Hire of Rooms				5	0	0
,, Sales of Transactions				1	7	9
				£386	18	11½

PAYMENTS. *Cr.*	£	s.	d.
1903.			
Sept. 30.—By Rent, Wages, and Expenses of Rooms	111	7	11½
,, Printing Transactions	121	11	0
,, Circulars and Stationery	17	11	0
,, Postages, &c.	18	15	3
,, Reporters	9	9	0
,, Library	4	8	4
,, Sundry Expenses, Insurances, &c.	3	2	5½
,, Balance in Bank	99	19	8
,, Balance in Secretaries' hands	0	14	3½
	£386	18	11½

The investments of the Society consisted of £600 Birkenhead Railway Consolidated Guaranteed Stock and £733 Lancashire and Yorkshire Railway 3 per cent. Consolidated Preference Stock. The Certificates for these are deposited at the Williams Deacon and Manchester and Salford Bank, St. Ann's Street, Manchester, and were inspected by us this 12th day of October, 1903.

(Signed) GEORGE H. WINSTANLEY.

Audited and found correct,

GEO. H. HOLLINGWORTH, Hon. Treas.

GEO. H. WINSTANLEY, Auditor.

LIBRARY FUND.

Dr.	£	s.	d.	*Cr.*	£	s.	d.
1902.				1093.			
Oct. 17.—To Lees Knowles	5	0	0	July 22.—By Library Bureau Ltd.	3	10	6
,, 18.— ,, Joseph Dickinson	5	0	0	Sep. 30.— ,, Balance	7	11	3
Dec. 20.— ,, Bank Interest	0	0	9				
1903.							
Jan. 7.— ,, G. B. Harrison	1	1	0				
	£11	1	9		£11	1	9

Mr. HALL invited comment on the Report and Balance Sheet but none was offered.

Mr. JOHN RIDYARD then moved, Mr. HARRISON seconded, and it was resolved that the Report and Statement of Accounts be approved.

ELECTION OF OFFICERS.

The officers and members of the Council for the ensuing year were elected as follows:—

Mr. J. GERRARD, in moving the appointment of Col. Hollingworth for the office of President, said he had the greatest possible pleasure in so doing. Col. Hollingworth had done so much for the Society in the past—having filled every office except that of President—and of all the members of the Society he knew no one more entitled to fill that honourable position.

Mr. J. DICKINSON: I have much pleasure in seconding the proposal.

The CHAIRMAN, in putting the resolution, which was carried unanimously, said Col. Hollingworth had been a most useful member of the Society and had proved an excellent treasurer.

On the motion of Mr. LIONEL B. WELLS, seconded by Mr. W. S. BARRETT, the following gentlemen were unanimously elected to be Vice-Presidents: Messrs. A. Dury-Mitton, Assoc.M.Inst.C.E., George Peace, John Ashworth, C.E., and G. B. Harrison, H.M.I.M.

Col. G. H. Hollingworth, F.G.S., was re-elected to the office of Honorary Treasurer.

Messrs. William Saint, H.M I.M., and James Tonge, junr., F.G.S., were re-appointed Honorary Secretaries.

On the proposition of Mr. Ridyard, seconded by Mr. J. S. Burrows, the following gentlemen were elected members of the Council, namely: Messrs. H. Stanley Atherton, John Gerrard, H.M.I.M., D. H. F. Matthews, H.M.I.M., Owen Hughes, W. W. Millington, P. Lee Wood, E. O. Bolton, W. Ollerenshaw, William Pickstone, Sydney A. Smith, Assoc.M.Inst.C.E., Alfred J. Tonge, and L. B. Wells, M.Inst.C.E.

The Past-Presidents continue, under the Society's Rules, *ex-officio* members of the Council.

Messrs. J. Barnes, F.G.S., and Geo. H. Winstanley, F.G.S., were re-elected Honorary Auditors.

Col. Hollingworth then took the chair and delivered the following address :—

THE PRESIDENT'S ADDRESS.

By Col. Geo. H. Hollingworth, F.G.S., M.Inst.M.E.

My first duty on assuming the office of President of our ancient and learned Society is that of thanking you for the distinguished honour that you have done me in electing me to the office. I shall endeavour with your assistance to do my duty in that position. I have in turn filled every position in the Society, and I venture to hope that the Society if not better for the selection may at any rate be no worse, but may continue to follow a career of usefulness and prosperity.

It has been customary for the President on his election to address some remarks from the chair upon some subject dealing with the past, present or future of the Society, or upon some geological or mining subject. I am afraid that the few remarks that I am about to make will hardly do justice to the occasion.

Last year the President Mr. Henry Hall, H.M.I.M., dealt with the subject of education, a subject which has since then been an angry question in the country, but as regards that branch which more particularly concerns the Society, viz., technical education there continues to be great progress made, although I can scarcely say that I am satisfied that there is yet any satisfactory educational course provided for the embryo mining engineer, the difficulty seems to be largely that a combination of practical experience with a scientific training is so essential to the mining engineer, and that the practical experience must be gained at an early age, otherwise the taste and liking for the rough work is likely to be lost. Perhaps the Birmingham course and that at our own Victoria University (which is under the direction of Mr. James Tonge, junr., one of our members) may be so arranged as to meet the want.

Mining practice in the future will certainly require a more scientific training than in the past, the problems to be solved increase in complexity, as time advances and difficulties increase. There are increases in the costs and increased use of machinery with greater depths of the mines, difficulties with skilled and unskilled labour, complex geological problems to work out,—these and many other things will add to the technical requirements of the mining engineer, and will entirely prevent the use of the old processes of trial and error as being too expensive for continuance.

The Manchester Geological and Mining Society has now been established 65 years, and in that period has done the very best work in furthering the interest of Geology and Mining in the district and very many valuable papers have been communicated and geological records made. There is still much good work to be done.

The Society by adding the word "Mining" to its title during the past year has only recognised *i.e.* only announced to the public—that mining forms an important if not essential part of the work of the Society which was founded in the year 1838 "to collect and diffuse Practical and Theoretical knowledge respecting Geology and Mining."

There is a feeling amongst some practical members (and some who are not members) that the Society does not fill the place it might occupy as the Mining Institution of the district, but having taken the step of adding "Mining" to its title, I hope that it will take further steps with a view of being in reality the Mining Institute for Lancashire, Cheshire and the neighbourhood.

Important questions will probably have consideration during the present Session with a view to increasing the popularity as well as the usefulness of the Society to geologists and engineers, amongst which will be the question of the federation of the Society with its contemporaries in other districts, a course which has many things to recommend it, whilst it may have also some drawbacks.

The Society as it stands is flourishing, it has a considerable membership, (which may I feel sure be increased) and it is in a sound—indeed very good—financial position; and the matter of funds need not prevent enterprise. It has attained its present position on a very small annual subscription—less, I believe, than that of any similar institution in the country, and I think no one would object to increase it if such should be required.

It is very desirable that during the current session we should have a series of papers read before the Society, worthy to compare with those previously recorded in its transactions; as although most of the leading principles of the science of geology and the art of mining are now well established, there are many subjects upon which information is desirable, and we have by no means arrived at the place where it is convenient to rest.

Amongst such subjects I may briefly indicate the following:—

One of the most interesting and important problems of the present day is the question of the depth beneath the surface to which it is practicable to work our coal and other mines? At what depth will physical conditions preclude the working? How soon will the limit of temperature be reached, and what is that limit? How does the pressure of the strata effect the working of the mines and the quality of the produce? And what are the prospects of future discoveries and inventions by means of which these conditions may be modified?

Valuable evidence upon these subjects has recently been given before the Royal Commission on coal supplies by some of our members as well as others, and we may hope that their further experience and conclusions may be communicated through our Society, which has its home in a district where are worked several of the deepest mines in the country.

In connection with deep mines—the subject of the extension of the coal bearing strata, under the newer formations, gains additional interest, and information upon the prospects of finding the regular coal seams beneath the red sandstones of South Lancashire and Cheshire will be much sought after in the immediate future.

Much information has already been recorded; but very much more is required before it will be prudent to embark on colliery enterprise very far from the present coal workings.

And, again, in the same connection, the correlation of the upper series of the coal measures, in the Lancashire and particularly of the Manchester coalfield, has never been satisfactorily made out. A section of the strata, down to and connecting with the Worsley 4 feet Mine or the Ince Yard Mine, would be a valuable contribution to the geology of the Manchester district, and would materially help the Mining Engineer to calculate the probability of workable coal being obtained in the southern districts.

Amongst other subjects, which I need hardly name, are the new developments which are constantly taking place in electricity, coal-cutting machinery, and other mechanical appliances, in shaft sinking, lighting, and in testing for gases, and particularly a practical means of testing for carbonic oxide gas—one of the most dangerous of all mine gases—would be welcomed.

I conclude by asking all the members to join in making the coming session of the Society a successful one, by communicating the results of their observations, experience, and information for the general good.

VOTES OF THANKS.

The PRESIDENT (Col. HOLLINGWORTH) moved a vote of thanks to the officers who had served the Society during the past year.

Col. LEES KNOWLES, M.P.: I have much pleasure in seconding that proposition. I have been called upon somewhat unexpectedly to take part in to-day's proceedings, for though one of the oldest members of the Society I seldom have the opportunity of attending these meetings. Nevertheless I have had its interests at heart, as my father was formerly a President of the Society and I am associated as a trustee of the Society with one of his oldest friends and the oldest member of the Society—I allude to Mr. Dickinson, formerly Her late Majesty's Senior Chief Inspector of Mines.

The resolution was passed.

Mr. W. S. BARRETT moved that the thanks of the meeting be given to the President for his address. This was seconded by Mr. HENRY HALL, and carried.

Mr. HALL said that no doubt this question of education was the one which we had to consider most, but he thought now we were getting all these big technical schools established the difficulty of mining engineers gaining a scientific knowledge of their profession will be greatly removed. There was ground also for believing that good will come from the Act of Parliament that was passed recently whereby anyone who has attended lectures at certain colleges may count the time spent at such lectures as part of the time of study for a manager's certificate. He thought the effect of that would be that young mining engineers will spend more time at the college than they have hitherto done, and by that means we shall secure what we have been seeking.

A PROPOSED DINNER.

Mr. PICKSTONE suggested that it might be an advantage to have established an annual social meeting, which would include some dining; not necessarily an expensive affair, but to bring the members together under circumstances other than around the table at the monthly meetings. If it would be well to bring the subject formally before the meeting he would move that arrangements be made for such a meeting and for dining together.

Mr. J. DICKINSON: I believe that I am the senior member of this Society, and, of course, in my time the Society has twice met at a dinner, once at the Albion Hotel and once at what was the Clarence Hotel, where the Post Office now stands. On the latter occasion we had a band of music and did the thing in considerable style. We had also with us some leading men. Indeed on both occasions we had some very important persons present with us, amongst them being Mr. James Heywood and the late Mr. J. T. Woodhouse, Mr. Fereday Smith, Professor Ramsay, of the Geological Survey, and others. I am not much of a dining out man myself, but I shall be glad to second Mr. Pickstone's proposal.

Col. Lees Knowles: I think there is a precedent for something of the kind, in the fact that the Geological Society of London have an annual dinner at the time when they elect their officers.

Mr. Gerrard remarked that perhaps the change in the Society's title might serve as an excuse for having a dinner. He would suggest that they try the experiment of one such convivial meeting.

The President: It is moved that we have a dinner. I don't think the recommendation went further than that. There was no proposal that the dinner be an annual affair.

The resolution was then adopted:—"That there be a dinner, and that the arrangements for the same be left in the hands of the Council."

LIST OF PAPERS AND SHORT COMMUNICATIONS

WHICH HAVE BEEN BROUGHT BEFORE THE

SOCIETY DURING THE SESSION 1902-03.

1902.		
October.	Grundy, James, H.M.I.M. in India. "Mineral Produc-in India."	
November.	Hall, Henry, I.S.O., H.M.I.M. "Industrial Education."	
	Stirrup, Mark, F.G.S. "Report of the Delegate to the British Association Meeting held at Belfast, 1902."	
December.	Dickinson, Joseph, F.G.S. "Heaton Park Borehole, near Manchester, with Notes on the surroundings."	
	Mitton, A. Dury, Assoc.M.Inst.C.E. "Coal-cutting by Machinery."	
1903.		
January.	Baldwin, Walter, F.G.S. "Some Prehistoric Finds from Ashworth Moor and Neighbourhood."	
	Barnes, J., F.G.S. "A Calcareous Sandstone from Bamberg, Bavaria, Germany."	
	Pickstone, William. "Recent Geological Changes in the Peninsula of Wirral, Cheshire."	
February.	Dickinson, Joseph, F.G.S. "Finding Mineral Veins by Electricity."	
March.	Pickstone, William. "Our Underground Water Supply."	
April.	Hughes, Owen. "Coal-cutting by Machinery."	
May.	Baldwin, Walter, F.G.S. "Bellinurus bellulus" from Sparth, Rochdale.	

May. Garforth, W. E. "The Application of Coal-cutting Machines and the resulting lines of induced fractures in the roof and coal."

June. Barnes, J., F.G.S. "A Fossil *Polyzoa* from the Mountain Limestone, Castleton."

NEW MEMBERS.

Bury, Andrew	Orrell, G. H.
Clark, William	Owen, R.
Edmondson, R. H.	Pilkington, Lionel
Edmondson, J. H.	Ramsbottom, James
Evans, James	Rogers, William
Jobes, R. Anderson	Rushton, Arthur
Jones, O. R., H.M.I.M.	Sutcliffe, W. H., F.G.S.
Marshall, Eustace	Wasley, J. C., M.E.

MEMBERS DECEASED.

Ward, T., F.G.S.	Wild, G.

MEMBERS RESIGNED.

Nelson, W., Jun.	Walshaw, J.
Marshall, H. S.	Handsley, R.

Thompson, F. W.

MEMBERS REMOVED FROM LIST.

Clark, G.	Leah, R.
Gresley, W. G., F.G.S.	Lomax, J.
Guy, J. G.	Maxwell, F.
Jackson, A.	Rhodes, J. R.

Settle, Miles.

The complete list of the Council for the ensuing year is as follows :—

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COL. G. H. HOLLINGWORTH, F.G.S., M.INST.M.E.

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GEORGE PEACE. | GEO. B. HARRISON, H.M.I.M.

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JOHN GERRARD, H.M.I.M. | P. LEE WOOD.
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W. WRENCH LEE.

PAST PRESIDENTS OF THE SOCIETY.

Presidents Deceased are signified by *Italics*.

Year of Election.	
1838-39-40	*Egerton, The Rt. Hon. Francis, M.P.*
1841-2-3, 49-50-1	*Heywood, James, F.R.S., F.G.S.*
1843-4-5, 55-6-7	*Egerton, Sir Philip de Malpas Grey, Bart, M.P.*
1845-46-47	*Moseley, Sir Oswald, Bart.*
1847-48-49	*Thicknesse, Ralph, M.P., Wigan*
1851-52-53	*Black, James, M.D., F.G.S.*
1853-54-55	*Ormerod, G. W., M.A., F.G.S.*
1857-8-9, 65-6-7	*Binney, E. W., F.R.S., F.G.S.*
1859-60-61	*Kay-Shuttleworth, Sir, J.P., Bart., M.P.*
1861-3, 77-8, 87-8	Dickinson, Joseph, F.G.S.
1863-64-65	*Knowles, Andrew.*
1867-8-9, 84-5	*Greenwell, G. C., F.G.S., M.Inst.C.E.*
1869-70-1, 82-3	*Aitken, John, F.G.S.*
1871-2-3, 88-9	*Knowles, John, M.Inst.C.E., J.P.*
1873-74	*Knowles, Thomas, M.P.*
1874-5, 6-7, 86-7	Dawkins, Prof. W. Boyd, M.A., D.Sc., F.R.S.
1875-76	Smith, R. Clifford, F.G.S.
1878-79	*Forbes, John Edward, F.G.S.*
1879-80	Earl of Crawford and Balcarres, F.R.S.
1880-81	Shuttleworth, Lord, of Gawthorpe.
1881-82	*Gilroy, George, M.Inst.C.E.*
1883-84	Pilkington, Edward, J.P.
1885-86	*Ormerod, Henry Mere, F.G.S.*
1889-90, 1902-3	Hall, Henry, I.S.O., H.M.I.M.
1890-91	Burrows, John S., F.G.S.
1891-92	Tonge, James, F.G.S., Assoc.M.Inst.C.E.
1892-93	*Peace, Maskell William, F.G.S.*
1893-94	Saint, William, H.M.I.M.
1894-95	Watts, William, F.G.S.
1895-96	Winstanley, Robert, C.E.
1896-97	Stirrup, Mark, F.G.S.
1897-98	Ridyard, John, F.G.S.
1898-99	*Livesey, Clegg, J.P.*
1899-1900	Barrett, W. S., J.P.
1900-01	Greenwell, G. C., F.G.S., M.Inst.C.E.
1901-02	Barnes, J., F.G.S.

APPENDIX TO THE REPORT.

ADDITIONS TO THE LIBRARY, 1902-1903.

To September 30th, 1903.

Barnsley.—Midland Institute of Mining, Civil, and Mechanical Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Belfast.—Natural History and Philosophical Society. Report and Proceedings for Session 1901-02. *From the Society.*

Birmingham.—South Staffordshire and East Worcestershire Institute of Mining Engineers. Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Birmingham.—British Geological Photographs (set of twenty-two Platinotypes, mounted). Part 2. *Purchased.*

Bradford.—Annual Report (32nd) of Libraries and Art Museum Committee.

Bristol.—Naturalists' Society. Proceedings. New Series, Part 3, Vol. IX.

Cambridge.—Museum. 37th Annual Report Museums and Lecture Rooms' Syndicate for 1902. *From the Woodwardian Museum.*

Cardiff.—Naturalists' Society. Report and Transactions for 1901-2. Vol. XXXIV.-V. *From the Society.*

Cardiff.—South Wales Institute of Engineers. Proceedings. Nos. 2, 3, 4, 5, Vol. XXIII. No. 1, Vol. XXIII., and Alphabetical and District Lists of Members. *From the Institute.*

Chester.—32nd Annual Report of Chester Society of Natural Science and Literature for 1902. List of Lepidoptera found in the counties of Cheshire, Flintshire, Denbighshire, Carnarvonshire, and Anglesea. *From the Society.*

Chesterfield and Midland Counties Institute of Engineers.—Proceedings. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Dublin.—Royal Dublin Society. Proceedings. Part 5, Vol. IX. Scientific Transactions. Parts 14, 15 and 16, Vol. VII. (2nd Series). Part 1, Vol. III. Economic Proceedings. Vol. I. Part 3. *From the Royal Irish Academy.*

Edinburgh.—Royal Physical Society. Proceedings. 1900-01.

Edinburgh.—Royal Society. Proceedings. Vol. XXIII.

Edinburgh.—Geological Society. Transactions. Part 2, Vol. VIII., and Special Part.

Glasgow.—Natural History Society. Transactions. Part 3, Vol. V. Parts 1 and 2, Vol. VI.

Hamilton.—Mining Institute of Scotland. Transactions. Included in the Transactions of the Institution of Mining Engineers. *From the Institution.*

Hanley.—North Staffordshire Institute of Mining and Mechanical Engineers. Proceedings. See Transactions of the Institution of Mining Engineers.

Hertford.—Hertford Natural History Society and Field Club. Transactions. Parts 5 and 6, Vol. XI. *From the Society.*

Kensington.—Free Library. Annual Report, 1901-2. Catalogue No. 1.

Leeds.—Literary and Philosophical Society. 82nd Annual Report, 1901-2.

Leeds.—Yorkshire Naturalists' Union. Transactions. Nos. 26, 27, 1901; Nos. 28, 29, 1902.

Leeds.—Yorkshire Geological and Polytechnic Society. Proceedings. No. 3, Vol. XIV.

Leicester.—Literary and Philosophical Society. Transactions. Parts 1, 2, 3, Vol. VII. *From the Society.*

Liverpool.—Geological Association. Annual Report, 1901-2.

Liverpool.—Science Students' Association. Annual Report, 1902-3.

Liverpool.—Geological Society. Proceedings. Part 2, Vol. IX.

Liverpool.—Public Libraries and Art Galleries. 50th Annual Report, 1902.

London.—British Association for the Advancement of Science. The President's Address and the Sectional Addresses. Reports for 1902. Photographs of Geological Interest in the United Kingdom. 13th Report of the Committee. *From the Association.*

London.—British Museum. Natural History Department. "Southern Cross Collections," 1902.

London.—Geological Magazine. (New Series.) Decade IV. Nos. 10, 11, 12, Vol. IX. Nos. 1-9, Vol. X. *Purchased.*

London.—Geological Survey. Summary of Progress, 1902.

London.—Geological Society. Quarterly Journal. No. 232, Vol. LVIII. Nos. 233, 234, 235, Vol. LIX. Geological Literature added to the Geological Society's Library, 1902, and List of the Geological Society. *From the Society.*

London.—Geologists' Association. Proceedings. Parts 7, 8, 9, 10, Vol. XVII. Parts 1, 2, Vol. XVIII. List of Members of the Geologists' Association. *From the Association.*

London.—Institution of Mechanical Engineers. Proceedings. Nos. 2, 3, 4, 5, 1902, and List of Members, 1902. No. 1, 1903. *From the Institution.*

London.—Iron and Coal Trades' Review. Nos. 1805 to 1817, Vol. LXV., Nos. 1818 to 1843, Vol. LXVI., Nos. 1844 to 1856, Vol. LXVII.

London.—Iron and Steel Institute. Journal. No. 2, 1902. and No. 1, 1903. Rules and List of Members. *From the Institute.*

London.—Palæontographical Society. Vol. LVI., for 1902. *Purchased.*

London.—Royal Society. Proceedings. Nos. 467 to 476, Vol. LXXI. Nos. 477 to 481, Vol. LXII. *From the Society.*

London.—The Colliery Guardian. Nos. 2179 to 2191, Vol. LXXXIV. Nos. 2192 to 2217, Vol. LXXXV. Nos 2218 to 2230, Vol. LXXXVI.

London.—The Mining Journal. Nos. 3502 to 3514, Vol. LXXII. Nos. 3515 to 3540, Vol. LXXIII. Nos. 3541 to 3553, Vol. LXXIV.

Manchester.—Association of Engineers. Transactions. 1901.

Manchester.—Literary and Philosophical Society. Memoirs and Proceedings. Parts 1, 2, 3, 4, 5, Vol. XLVII. *From the Society.*

Manchester.—Geographical Society. Journal. Nos. 4 to 12, Vol. XVIII. and Supplement. Nos. 1 to 3, Vol. XIX. *From the Society.*

Manchester.—Field Naturalists' Society. Report and Proceedings for the year 1902 (43rd year).

Manchester.—The Owens College Museum. Report for the year 1900 and 1901. Publication. Nos. 39, 40, 41, 42, 43, 44, 45, 47, 48. *From the College.*

Newcastle-upon-Tyne.—Institution of Mining Engineers. Transactions. Nos. 5, 6, Vol. XXI. Nos. 5, 6, Vol. XXII. No. 6, Vol. XXIII. Nos. 1, 2, 3, 4, Vol. XXIV. Parts 1, 2, 3, Vol XXV. *From the Institution.*

Newcastle-upon-Tyne.—North of England Institute of Mining and Mechanical Engineers. Transactions. Included in the Transactions of the Institution of Mining Engineers; Annual Report, 1901-2; 1902-3. Report of the Committee upon Mechanical Coal-cutting. Part 1. Longwall Machines. *From the Institute.*

Norwich.—Norfolk and Harwich Naturalists Society. Transactions. Part 4, Vol. VII.

Salford.—The Fifty-fourth Annual Report of Libraries, Museum, and Parks Committee for the Borough of Salford, 1901-2.

Stafford.—North Staffordshire Field Club. Annual Report and Transactions, 1902-3. *From the Club.*

Wigan.—Science and Art of Mining. Nos. 4 to 26, Vol. XIII. Nos. 1 to 3, Vol. XIV.

BOOKS, PAMPHLETS, AND REPORTS.—ENGLISH AND FOREIGN.

Mines and Quarries. Parts 3, 4, 1901; Parts 1, 2, 1902; also H.M. Inspector's Report of Mines and Quarries for the S. W. District for 1902. Report to His Majesty's Secretary of State for the Home Department on the circumstances attending an explosion which occurred at Maclaren Colliery (No. 1 Pit), Aberlysswg, on the 3rd September, 1902, by S. T. Evans, K.C., M.P., and J. S. Martin one of His Majesty's Inspectors of Mines. *Presented by Mr. J. S. Martin.*

Chart of Fossil Sheels. Found in connection with the seams of Coal and Ironstone in North Staffordshire by Wheelton Hind, M.D., F.G.S., and J. T. Stobbs, F.G.S. *Presented by Dr. Hind.*

Rain and Dust Fall in Edinburgh in 1902 (Pamp) Dr. W. G. Black, F.R.C.S. (Ed.), F.G.S. (Ed.) *Presented by the Author.*

Paper.—"Influence of Winds upon Climate during the Pleistocene Epoch," and "A Sketch of the Later Tertiary History of East Anglia." *Presented by the Author, F. W. Harmer, F.G.S.*

Four Papers.—"Etudes Géologiques sur le Terrain Quaternaire du Canton de Vaud (Suisse)." "Sur les Causes de la Duparition des Ancieus Glaciers des Vosges." "La Eruption Volcaniques, a propos du recent disastre de la Martinique." "L'Activissne." *Presented by the Author, Professor Stanislas Meunier, Paris.*

Cape of Good Hope.—Annual Report of the Geological Commission, 1900. *From the Commissioners.*

Washington.—Papers from the Smithsonian Report for 1900-1. "A Century of Geology" by Professor J. Le Corte. "Evolutional Geology" by Professor J. W. Sallas. "Emigrant Diamonds in America" by Professor W. H. Hobbs. "Bogoslof Volcanoes" by C. Hart Merriman. "The Mutation Theory of Professor De Vries" by Charles A. White.

Paper.—"The Cheesewring, Cornwall, and its Teachings." *Presented by the Author, Professor Ed. Hull, LL.D., F.R.S., F.G.S.*

"Times Atlas" purchased.

Adelaide.—"Contributions Nos. 12, 13, to the Palæontology of South Australia." Report on the White Range Gold Mines. *Presented by the Government Geologist.*

Queensland Government Mining Journal. Vol. XXXIV. The Year Book of Queensland. Slater's Almanac, Queensland, for 1903. *Presented by the Agent-General for Queensland.*

Mineral Resources of New South Wales. *Presented by the Agent-General for New South Wales.*

India.

Calcutta.—Memoirs of the Geological Survey of India. No. 3, Vol. XXXII.; No. 3, Vol. XXXIII.; No. 2, Vol. XXXIV.; No. 1, Vol. XXXV.; and General Report of Geological Survey, April 1st, 1901, to March 31st, 1902. *From the Director of the Survey.*

Australia.

Adelaide.—Royal Society of South Australia. Transactions. Part 1, Vol. XXVII. *From the Society.*

Melbourne.—The Australian Mining Standard. Nos. 719 to 737, Vol. XXVIII.; Nos. 738 to 753, 755 to 763, Vol. XXIX.; Nos. 764 to 771, Vol. XXX. *From the Editor.*

Sydney.—Mineral Resources of New South Wales, and Annual Report of the Department of Mines and Agriculture for the year 1901. *From the Hon. the Minister of Mines.*

Canada.

Halifax.—Mining Society of Nova Scotia. Journal. Vol. VI.

Halifax.—Nova Scotian Institute of Science. Proceedings and Transactions. Parts 3, 4, Vol. X.

Hamilton.—Hamilton Association. Journal and Proceedings for 1901-1902. No. 18. *From the Association.*

Houghton, Michigan.—Michigan College of Mines. Year-Book, 1902-1903.

New York.—Compressed Air Information by W. L. Saunders, M.Am.Inst.C.E. *Presented by the Publishers.*

Ottawa.—Geological Survey of Canada. Annual Report, 1899. Vol. XII., and Maps. Contributions to Canadian Palæontology. Part 2, Vol. III.

Ottawa.—Geological Map of Manitoba (Western sheet), No. 783. Geological Map of the Dominion of Canada. *Presented by the Director Geological Survey.*

Ottawa.—Map of the Dominion of Canada. *Presented by the Agent General.*

St. John, New Brunswick.—Nataral History of New Brunswick. Part 1, Vol. V. *From the Society.*

Toronto.—Canadian Mining Institute. The Volcanic Origin of Natural Gas and Petroleum, by Eugene Cost, E.M. *Presented by the Author.*

Victoria, B.C.—Anuual Report of the Minister of Mines. Province of British Columbia, 1902. *Presented by John Gerrard, H. M. I. M.*

U. S. America.

Baltimore.—Maryland Geological Survey. Garrett County and Cecil County, with Maps.

Baton, Rouge. La.—Geological Survey of Louisiana. Report, 1902.

Cambridge.—Harvard College. Bulletin of the Museum of Comparative Zoology. No. 7; Vol. XXXVIII.; Nos. 4, 5, 6, 7, 8, Vol. XXXIX.; Nos. 3, 4, 5, 6, Vol. XL. Annual Report of the Museum of Comparative Zoology for 1901-1902. Geological Series. Nos. 1, 2, 3, Vol. VI. *From Alex. Agassiz.*

Carolina, N.—Elisha Mitchell Scientific Society Journal. Part 2 (17th year). Parts 1, 2, Vol. XVIII. Parts 1, 2, Vol. XIX.

Chicago.—Field Columbian Museum. Report Series, No. 2, Vol. II. Zoological Series, Nos. 7, 8, 9, Vol. III. *From the Museum.*

Colorado Springs.—Colorado College Scientific Society. College Studies. Vol. X.

Denver.—Colorado Scientific Society. Proceedings, 1897-1900. Vol. VI., pp. 55-108. Vol. VII.

Des Moines.—Geological Survey of Iowa. Vol. XII. *From the Director of the Survey.*

Lima.—Map of Peru. *Presented by the Minister for Foreign Affairs.*

Madison.—Wisconsin Geological and Natural History Survey. Bulletin. No. 8.

Minneapolis.—The American Geologists. Nos. 1, 5, Vol XXIX., Nos. 3, 4, 5, 6, Vol. XXX.; Nos. 1, 2, 3, 4, 5, 6, Vol. XXXI.; Nos. 1, 2, 3, Vol. XXXII. *Purchased.*

Missoula.—University of Montana. Bulletin, No. 10.

New York.—Brooklyn Institute of Art and Sciences. Bulletin, Parts 2, 3. Vol. I.

New York.—The American Museum of Natural History. Bulletin No. 1, Vol. XVIII. List of Papers Published in the Bulletin and Memoirs. Vols. I. XVI., 1881-1902; also Annual Report for 1902. *From the Museum.*

New York.—American Institute of Mining Engineers. Transactions. Vol. XXXI. Pamphlets. List of Members, Officers, Rules, &c., 1902.

New York.—Stone. No. 3, Vol. XXV. *Presented by the Publisher.*

Philadelphia.—Franklin Institute. Journal. Nos. 4, 5, 6, Vol. CLIV.; Nos. 1, 2, 3, 4, 5, 6, Vol. CLV.; Nos. 1. 2, 3, Vol. CLVI. *From the Institute.*

Philadelphia.—Academy of Natural Sciences. Proceedings. Parts 2, 3, Vol. LIV.; Part 1, Vol. LV. *From the Academy.*

Philadelphia.—American Philosophical Society. Proceedings. Nos. 170, 171, Vol. XLI.; No. 172, Vol. XLII.; and Memorial Volume I.

Scranton, Pa.—Mines and Minerals. Nos. 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, Vol. XXIII.; Nos. 1, 2, Vol. XXIV. *From the Editor.*

Springfield (Mass.)—Museum of Natural History Report, 1901-02.

Topeka.—Kansas Academy of Science. Transactions. 1899-1900. Vol. XVII.

Washington.—Smithsonian Institute. Annual Report of the Institute, 1900.

Washington.—Geological Survey. 22nd Annual Report, Parts 1, 2, 3, 4. Bulletins, 191, 195, to 207. Monographs, Nos. 41, 42, 43. Professional Paper, Nos. 1-8. Standard Topographic Maps, 122. Folios, 72 to 90. Mineral Resources in the United States, 1901. *From the Director of the Survey.*

Washington.—Map of the United States. *Presented by F. Boughton Weeks, Esq.*

Wyoming.—Mining in the Grand Encampment Copper District. Carbon and Albany Counties, Wg. Presented by the State Geologist.

FOREIGN.

Berlin.—Gesellschaft für Erdkunde: Zeitschrift, Nos. 6, 7, 8, 9, 10, 1902. Nos. 1, 2, 3, 4, 5, 1903.

Berlin.—Zeitschrift der Deutschen Geologischen Gesellschaft, Nos. 2, 3, 4, Vol. LIV.; No. 1, Vol. LV.

Berlin.—Zeitschrift für Pracktische Geologie. No. 1.

Bruxelles.—Societe Royale Malacalogique de Belgiqūe. Annales, Vol. XXXVI.

Caen.—Sociètè Linnèenne de Normandie (5th Series), Vol. V. *From the Society.*

Dresden.—Naturwissenschaftliche Gesellschaft "Isis." January—June, 1902.

Essen. Ruhr.—Jahresbericht des Vereins für die bergbaulichen, Interessen im fechs bervergamtsbezeck Dortmund, für das Jahr, 1902. I. (Allegmeines). I. Teil. I. (statistiches) Teil.

Freiburg.—Naturforschenden Gesellchaft, Berichte. Vol. XIII.

Iglo.—Jahrbuch des Ungarischen Karpathen-Vereines. No. XXX.

Halle A/S.—Mittelungen der Vereins für Erdkunde zu Halle A/S. 1902-3.

Kazan.—La Societe des Naturalistes de l'University de Kazan. No. 4. Vol. XXXIV., No. 5. Vol. XXXV., Nos. 1-6, Vol. XXXVI.

Keiff (Russia).—La Société des Naturalistes. Memoirs. Nos. 1, 2, Vol. XVII.

Lausanne.—Société Vaudoise. Bulletins, No. 144, 145, 146. Vol. XXXVIII.

Lille—Société Géologique du Nord. Annales, Vol. XXX., XXXI.

Lima.—Cuerpo del Ingienuros de Minas de Peru. Böletin. Nos. 1, 2.

Mexico.—Sociedad Científica "Antonio Alzate." Memorias Y. Revista. Nos. 5, 6, Vol. XIII. Nos. 1, 2, 3, 4, 5, 6, Vol. XVII. Nos. 1, 2, Vol. XVIII. No. 1, Vol. XIX.

Mexico.—Institute Geologies des Mexico Boletins. No. 16.

Montevideo.—Annales del Musco Nacional. No. 1, Vol. IV.

Naples.—Rendicenti dell' Accademia della Scienze Fisiche e Mathematiche. Parts 8, 9, 10, 11, 12, Vol. VIII. (3rd Series). Parts 1, 2, 3, 4, 5, 6, 7, Vol. IX. (3rd Series).

Paris.—Société Gèologique de France. Bulletin. No. 5, Vol. I. (4th Series). Nos. 2, 3, 4, Vol. II. (4th Series).

Paris.—Commercial Geographical Society. Bulletin. No. 10-12, Vol. XXIV.

Pisa.—Societa Toscana de Scienze Naturale. Vols. XIII.

Rome.—Atti della Reale Accademia dei Lincei. Rendiconti. Nos. 6, 7, 8. 9, 10, 11, 12, 2nd Series, Vol. XI. Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 1st Series, Vol. XII. Nos. 1, 2, 3, 4, 5, 2nd Series, Vol. XII. Rendiconto.—Dell' Adunanza Del, 7, Geugno, 1903.

St. Petersburg.—Comité Geologique. Bulletin. Nos. 7-10, Vol. XX. No. 1, 4, Vol. XXI. Memoirs. No. 4, Vol. XV.; Nos. 1, 2, Vol. XVII.; No. 3, Vol. XVIII.; No. 1, Vol. XIX.; No. 2, XX. Verhandlungen. Vol. XL.

St. Petersburg. Material for Russian Geology No. 1, Vol. XX.

St. Petersburg.—Geologique Du Cabinet De Sa Majésté Travaux de la Section. No. 2, Vol. III. Vol. V.

Stockholm.—Académie Royale Suédoise des Sciences. Bulletin. Nos. 1, 2, 5, 9. Memoirs 32, 34.

Stockholm.—Bihang Fill Krongl Svenska Velenskaps Akademiens Handlingar. No. 1, Vol. XXVII.; No. 2, Vol. XXVIII.

Tōkyō (Japan).—Imperial University. Journal of the College of Science. No. 1, Vol. XIX.; No. 2, Vol. XVIII.

Toluca, Mex.—Boletin Meteorologico, Organo Oficial de la Red Meteorologico del Estado. Nos. 1, 2, 3, Vol. IV.

Upsula.—Geological Institution. Bulletin. No. 10, Part 2, Vol. V.

SOCIETIES WITH WHICH THE SOCIETY EXCHANGES ITS TRANSACTIONS, AND INSTITUTIONS AND JOURNALS TO WHICH A COPY IS SENT FREE.

I.—ENGLAND.

London ....British Association for the Advancement of Science, Burlington House, London.

British Museum, the Superintendent, Copyright Office.

British Museum Library, Natural History Department, Cromwell Road, Kensington.

Geological Society, Burlington House, W.

Geological Survey, Jermyn Street, S.W.

Geologist Association, University College, Gower Street, W.C.

Institution of Mechanical Engineers, Storey's Gate, St. James' Park, Westminster, S.W.

Iron and Steel Institute, 28, Victoria Street, S.W.

RoyalInstitution of Great Britain, Albemarle Street.

Royal Society, Burlington House, W.

Public Library, Kensington, High Street, W.

Manchester ......The Manchester Association of Engineers, Grand Hotel, Aytoun Street.

Field Naturalists' Society.

Free Library, King Street.

Literary and Philosophical Society, 36, George Street.

Manchester Geographical Society, 16, St. Mary's Parsonage.

Victoria University.

Barnsley........Midland Institute of Mining Engineers.

Birmingham ....South Staffordshire and East Worcestershire Institute of Mining Engineers, Colmore Chambers, 3, Newhall Street.

Bradford ......Public Free Library, Bradford, Yorkshire.

Bristol ....Naturalists' Society, Clifton.

Cambridge ......Geological Museum, University.

University Library.

Philosophical Society, The Museum, University.

Cardiff ....Cardiff Naturalists' Society, 44, Londoun Square.

South Wales Institute of Mining and Mechanical Engineers, Park Place, Cardiff.

Chester .... Society of Natural Science, Grosvenor Museum.

Chesterfield ....Chesterfield and Midland Counties Institution of Engineers (G. A. Lewis, Secretary, Albert Street, Derby).

Cornwall. ......Royal Geological Society, Penzance.

Royal Institution, Truro.

Essex ....Essex Field Club, Passmore-Edwards Museum, Romford Road, Stratford, Essex.

Exeter ....Albert Memorial Museum.

Hanley ....North Staffordshire Institute of Mining and Mechanical Engineers (F. R. Atkinson, Secretary, Shottle Hall, near Derby).

Leeds ....Philosophical and Literary Society.

Yorkshire Naturalists' Union (John Waddington, Hon. Librarian, Blackman Lane, Leeds).

Geological Association, Mechanics' Institution, Cookridge Street.

Yorkshire Geological and Polytechnic Society, the Museum, Leeds.

Leicester ....Literary and Philosophical Society.

Liverpool ......Free Library and Museum.

Geological Association, Free Library, William Brown Street.

Geological Society, Royal Institution.

Science Students' Association, Royal Institution, Colquitt Street.

Newcastle-on-Tyne Institution of Mining Engineers.

North of England Institute of Mining and Mechanical Engineers.

Newcastle-under-Lyme ...... North Staffordshire Naturalists' Field Club (Secretary, W. Wells Bladen, Stone, Staffordshire).

Norwich ....Norfolk and Norwich Naturalists' Society.

Oxford ....Bodleian Library.

Radcliffe Library.

North Shields....Public Free Library.

Rochdale........Literary and Scientific Society, 105, Freehold Street.

Salford ....Royal Museum and Library.

Southampton ....Hampshire Field Club, Harley Institution.

Warwick........Natural History Society.

Watford, Herts ..Herefordshire Natural History Society and Field Club (Daniel Hill, Hon. Librarian, Herga, Watford, Herts).

Wigan ....Free Library.

Mining School.

II.—Scotland.

Dundee ....Free Library and Museum.

Edinburgh ......Advocates' Library.

Edinburgh Geological Society.

Royal Society.

Royal Physical Society.

Glasgow ....Geological Society.

Natural History Society.

Hamilton ......Mining Institute of Scotland.

III.—Ireland.

Dublin ....Royal Dublin Society.

The Library, Trinity College.

Belfast ....Natural History Society, the Museum.

IV.—Australia.

Adelaide ....Royal Society of South Australia (W. C. Rigby, 74, King William Street, Adelaide).

Melbourne ......Geological Society of Australasia, Colonial Mutual Chambers.

Public Library of Victoria.

Australian Mining Standard.

Sydney ....Free Public Library.

Australasian Association for the Advancement of Science, University.

Royal Society of New South Wales, 37, Elizabeth Street.

Department of Mines. — The Government Geologist.

V.—Canada.

Halifax, Nova Scotia ...... Nova Scotian Institute of Science.

Hamilton, Ont. .. Hamilton Association.

Montreal .... Library of Canadian Mining Institute, Room 4, Windsor Hotel, Montreal.

M'Gill University (The Principal).

Ottawa .... Geological Survey of Canada (Director, Museum, Sussex Street, Ottawa).

St. John, N.B. .. Natural History Society of New Brunswick.

Toronto .... Canadian Institute, 58, Richmond Street, E.

VI.—India.

Calcutta .... Geological Survey of India.

VII.—United States.

Baltimore ...... The Maryland Geological Survey (The State Geologist, John Hopkins University).

Boston .... Free Library.

Cambridge, Massachussetts ...... Museum of Comparative Zoology, Havard College.

Chapel Hill, North Carolina .... The Elisha Mitchell Scientific Society.

Chicago .... The Chicago Academy of Science.

Field Columbian Museum, Zoological Series.

Colombus ...... Ohio, Geological Survey of. (The State Geologist.)

Denver, Col. .... Colorado Scientific Society.

Indiana ....Department of Geology and Natural Resources (W. S. Blatchley, Esq., State Geologist).

Illinois ....Illinois Mining Institute, Springfield, Ill.

Field Columbian Museum, Chicago.

Michigan ......Michigan Mining School, Houghton.

Minneapolis ....Geological and Natural History Survey of Minnesota.

New York ......American Institute of Mining Engineers (Secretary), R. W. Raymond, 99, John Street, New York City).

American Museum of Natural History, Central Park.

Philadelphia ....Academy of Natural Sciences.

Franklin Institute.

Pennsylvania Geological Survey.

American Philosophical Society, 104, S. Fifth Street.

Rolla, Mo.......Missouri Geological Survey.

Scranton, Pa ....Editor of "Mines and Minerals.

Washington ....Library of the U.S. Geological Survey.

Smithsonian Institute.

Wisconsin ......Wisconsin Academy of Science, Arts, and Letters, Madison.

Wyoming ......Historical and Geological Society.

VII. Foreign Societies.

Berlin ....Deutsche Geologische Gesellschaft.

Gesellschaft für Erdkunde. Wilhelmstrasse, 23, S.W.

Brussels ....Société Royale Malacologique de Belgique.

Buenos Ayres....Officiana Nacional de Commercie.

Caen ....La Société Linnéenne de Normandie.

Christiana .....Royal University of Norway.

Dresden ....Naturwissenschaftliche Gesellschaft Isis.

Halle, A/S .....Verein für Erdkunde.

Die Kaiserliche Leopold. Carol. Deutsche Akademie der Naturforscher.

Helsingfors......La Commission Gèologique de la Finlande. (Secretary, Dr. J. J. Sederholm, Boulevardsgatan 29.)

Iglo, Hungary ..Societé Hongroise de Carpathe.

Kazan, Russia ..La Société des Naturalistes de l'Université de Kazan.

Kieff, Russia ....La Société des Naturalistes.

Lousanne (*Suisse*).Société Vaudoise des Sciences Naturelles.

Lille ....Société Geologique du Nord.

Mexico ....Sociedad Cientifica "Antonio Alzate."

Naples ....Accademia della Scienza Fisiche e Mathematiche.

Paris ....La Sociètè Gèologique de France.

La Société de Spéléologie. 7, Rue des Grands Augustins.

Pisa ....Società Toscano di Scienze Naturali, Museo di Storia-Naturale.

Rio de Janeiro ..Museo Nacional.

Rome ....Reale Academia dei Lincei.

St. Petersburg . . Académie Impériale des Sciences.
Comité Géologique.

Société Impériale Mineralogique.

Stockholm . . . . . . Académie Royale Suedoise des Sciences.

Turin . . . . Académie Royale des Sciences.

IX.—SCIENTIFIC JOURNALS, &c.

Iron and Coal Trades Review, 165, Strand, W.C.

Mining Journal, 46, Queen Victoria Street, London.

Colliery Guardian, 30 and 31, Furnival Street, London, E.C.

Science and Art of Mining, 27, Wallgate, Wigan.

Stone, F. W. Hoyt, 45, Broadway, New York.

LIST OF MEMBERS.

OCTOBER, 1903.

The Names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	Names and Addresses.
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.A.
1897	Allen, Edward, M.E., Willow Bank, Hale, Bowdon, Cheshire.
1898	Allen, Robert, River Cottage, Lower Broughton, Manchester.
1803	Aroksamy, M. R., 175, Oxford Street, Secundarabad (Deccan), India.
1893	Ashworth, John, C.E., 8, King Street, Manchester. *Vice-President.*
1878	Ashworth, Thomas, 42, Deansgate, Manchester.
1877	Atherton, James, 13, Mawdsley Street, Bolton.
1895	Atherton, H. Stanley, 13, Mawdsley Street, Bolton. *Member of Council.*
1878	Atkinson, W. N., H.M. Inspector of Mines, Barlaston, Stoke-on-Trent.
1897	Baker, Godfrey, Pendlebury, Manchester.
1901	Baldwin, Walter, F.G.S., 218, Yorkshire Street, Rochdale.
1900	Banks, Thomas, 60, King Street, Manchester.
1895	Barnes, J., F.G.S., South Cliff House, 301, Great Clowes Street, Higher Broughton. *Past President. Hon. Auditor.*
1875	Barrett, W. S., J.P., 64, The Albany, Old Hall Street, Liverpool. *Past-President.*

Year of Election.	Names and Addresses.
1891	*Bell, Thomas*, J.P., 15, The Valley, Scarborough.
1903	Bentley George, Bradford Colliery, Bradford, Manchester.
1881	Black, W. G., F.R.C.S. Ed., F.G.S. Ed., 2, George's Square, Edinburgh.
1898	Boden, Peter, Butterworth Hall Colliery, Milnrow, Rochdale.
1889	Bolton, Edgar O., Burnley Collieries, Burnley. *Member of the Council.*
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., The Collieries, Accrington.
1902	Bouchier, C. F., Strangeways House, Platt Bridge, near Wigan.
1886	Bramall, Henry, M.Inst.C.E., Pendlebury Collieries, Pendlebury, Manchester.
1900	Brancker, Richard, 11, Old Hall Street, Liverpool.
1902	Brewerton, Joseph, Civil and Mining Engineer, 97, Bridge Street, Manchester.
1877	*Broeck, Ernest Von den*, 32, Place de l'Industrie, Brussels.
1900	Burke, Harry.
1878	Burrows, John S., F.G.S., Green Hall, Atherton, Manchester. *Past-President.*
1903	Bury, A., 187, Margaret Street, Ashton-under-Lyne.
1887	Campbell, W. M., Sutton Heath Collieries, St. Helens, Lancashire.
1901	Champ, Henry, c/o Messrs. S. & J. Watts & Co., Portland Street, City.
1901	Chapman, C. H., 293, Liverpool Road, Salford.
1898	Clark, Robert F., Bickershaw Collieries, Leigh, Lancashire.
1903	Clark, William, Garswood Coal and Iron Co., Park Lane, Wigan.
1894	Clarke, Robert, 42, Deansgate, Manchester.
1894	Cole, Robert H., Endon, Stoke-on-Trent.
1901	Coleman, W. H., 299, North Road, Clayton, Manchester.

Year of Election.	Names and Addresses.
1901	Cotterill, W. B., Hazlehead, near Sheffield.
1878	Cowburn, Henry, 253, Westleigh Lane, Westleigh, near Manchester.
1883	Crankshaw, Joseph, F.G.S., 11, Ironmonger Lane, London.
1879	Crawford and Balcarres, the Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1900	Davidson, Robert, 2, Park Lane West, Pendlebury, Manchester.
1869	Dawkins, Professor W. Boyd, M.A., D.Sc., F.R.S., F.G.S., F.S.A., A.M.I.C.E., The Owens College, Manchester. *Past-President.*
1900	Deane, Adam, Stopes Colliery, Little Lever, Bolton.
1877	*De Rance,* C.E., F.G.S., 32, Carshalton Road, Blackpool.
1898	Dickinson, Archibald, 199, Brunshaw Road, Burnley.
1856	Dickinson, Joseph, F.G.S., Hon.M.I.M.E., South Bank, Sandy Lane, Pendleton. *Past-President. Trustee.*
1889	Dobbs, Joseph, Coolbawn House, Castlecomer, Co. Kilkenny.
1898	Douglas, Ernest, Pemberton Collieries, Wigan.
1898	*Eagle, George, 37, Brown Street, Manchester.
1903	Edmondson, J. H., Garswood Hall Colliery, Wigan.
1903	Edmondson, R. H., Garswood Hall Colliery, Wigan.
1878	Ellesmere, the Right Hon. the Earl of, Worsley.
1895	Ellis, Thomas Ratcliffe, Solicitor, King Street, Wigan.
1897	Ellis, W. T. Wood, M.Inst.M.E., M.S.A., 34, Strand, London, W.C.
1900	Elce, Abraham, jun., Colliery Manager.
1884	Elce, George, Altham Colliery, Whalley Road, Accrington.
1902	Evans, J., Britannia Works, Cross Street, Salford.

Year of Election.	Names and Addresses.
1895	Evans, Robert, Mining Engineer, Olive Bank, Royton, Oldham.
1897	Evans, Walter, J.P., M.E., Royton, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1891	Finch, John, 4, Wellington Terrace, Lichfield Road, Sutton Coalfield.
1901	Flatters, A., F.R.M.S., 16, Church Road, Longsight.
1891	Fletcher, Arthur, 8, St. Andrews, Ainsworth Road, Radcliffe.
1896	Fletcher, Leonard R., Atherton Collieries, Atherton, Manchester.
1868	Fletcher, Thomas, Wheatfield, Bolton.
1873	Garforth, W. E., F.G.S., Snydale Hall, near Pontefract.
1893	Garside, Edward, B.Sc., Assoc.M.Inst.C.E., Town Hall Chambers, Ashton-under-Lyne.
1902	Garton, Walter, Brookside, Bickershaw, Wigan.
1874	*Geikie, Sir Archibald*, D.Sc., LL.D., F.R.S., 10, Chester Terrace, Regent's Park, London, W.
1892	Gerrard, John, H.M. Inspector of Mines, Worsley, Manchester. *Member of the Council.*
1903	Gillott, J. W., Lancaster Works, Barnsley.
1882	Glover, B. B., 41A, Victoria Buildings, Manchester.
1898	Glover, J. W., M.E., 41A, Victoria Buildings, Manchester.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1874	Greenwell, G. C., M.Inst.C.E., F.G.S., Beechfield, Poynton, Cheshire. *Past-President.*
1879	Greenwood,* John, c/o The Globe Spinning Company, 1, Marsden Street, Manchester.
1892	Gregson, G. Ernest, 11, Chapel Street, Preston.
1877	Grundy, H. T., Colliery Surveyor, Radcliffe.

Year of Election.	Names and Addresses.

1888	Grundy, James, Inspector of Mines in India, F.G.S., Middle Road, Calcutta, India.
1881	Hall, Henry, I.S.O., H.M. Inspector of Mines, Rainhill, Prescot, Lancashire. *Past President.*
1898	*Hall, Levi J., Morland House, Birch Vale, near Stockport, (Furness Vale Collieries, Stockport.)
1877	Harris, George E., M.E., Assam Railway and Trading Co., Limited, Margerita, Assam, India.
1894	Harrison, George B., H.M. Inspector of Mines, 278, Worsley Road, Swinton, Manchester. *Vice-President.*
1892	*Haworth, Denis, Oswaldtwistle Collieries, Accrington.
1897	Heather, Frank, 47, Mosley Street, Manchester.
1900	Henshaw, A. M., Talk-o'th'-Hill Collieries, Staffordshire.
1902	Hewitt, J., 114, Bell Green Lane, Ince, Wigan.
1889	Higson, Charles H., 106, Eccles Old Road, Pendleton, Manchester.
1876	Higson, John, F.G.S., 18, Booth Street, Manchester.
1900	Hinnell, Leonard H., Civil Engineer, 26, Corporation Street, Manchester.
1897	Hobson, Bernard, M.Sc., F.G.S., The Owens College, Manchester.
1877	Holding, William, Cossall Colliery, near Nottingham.
1878	Hollingworth, Col. George H., F.G.S., 37, Cross Street, Manchester. *President. Hon. Treasurer.*
1899	Hollingworth, David, Chemist, Gas Works, Stretford, Manchester.
1895	Holroyd, W. F., F.G.S., 49, Half Edge Lane, Eccles.
1897	Howsin, Evelin G., Huntroyd Estate Office, Padiham.
1894	Hughes, Owen, Rose Hill House, Hindley, near Wigan. *Member of the Council.*
1874	*Hull, Professor Edward,* M.A., F.R.S., 20, Arundel Gardens, Notting Hill, London, W.

Year of Election.	Names and Addresses.
1895	Hutchinson, John William, The Lewis Merthyr Consolidated Collieries, Ltd., Hafod, near Pontypridd.
1878	Jackson, Charles G., Rookwood, near Chorley.
1902	Jobes, R. A., 13, Douglas Terrace, Carley Road, Southwick-on-Wear.
1883	Jobling, Albert, 91, Rectory Road, Burnley.
1883	Jobling, Henry, 91, Rectory Road, Burnley.
1884	Jobling, John, Manager, Cliviger Colliery, Burnley.
1882	Johnson, William, Abram Colliery, Wigan.
1903	Johnson, William Henry, B.Sc., 24, Lever Street, Manchester.
1903	Jones, O. R., H.M. Inspector of Mines, 5, Spring Gardens, Chester.
1897	Keen, James, Hindley Green, Wigan.
1893	Kenrick, James P., 8, St. James's Square, Manchester.
1879	*Kinahan, G. H.*, M.R.I.A., Woodlands, Fairview, Co. Dublin.
1901	Knight, Henry, Manager, Rose Bridge and Ince Hall Collieries, Wigan.
1889	Knowles, John, Brynn Mount, Westwood, Lower Ince, Wigan.
1887	*Knowles, Col. Lees, M.A., LL.D., F.G.S., M.P., Westwood, Pendlebury. *Trustee.*
1898	Krauss, John Samuel, B.A., Stonycroft, Knutsford Road, Wilmslow, Cheshire.
1898	Landless, Richard, Bank Hall Colliery, Burnley.
1902	Latham, Daniel, Surveyor, Rose Bridge and Ince Hall Collieries, Wigan.

Year of Election.	Names and Addresses.
1898	Laverick, John H. W., Pye Hill, Jacksdale, near Nottingham.
1890	Law, J. Illingworth, Waterfoot, Manchester.
1902	Lea, Walter, Collins Green Colliery, Earlstown.
1884	Leech, A. H., Brinsop Hall Colliery, Wigan.
1897	Lees, Frederick, The Rookery, Ashford, Bakewell.
1899	Leigh, Oswald B., The Towers, Didsbury.
1898	Livesey, John, Rose Hill Colliery, Bolton.
1887	Lord, James, Hill House, Rochdale.
1898	Lowe, Henry, Moss Colliery, Ince, near Wigan.
1881	Macalpine, G. W., Parkside, Accrington.
1902	Machin, Thomas H., Hyde Lane Colliery, Hyde, Cheshire.
1901	McKay, William, Carlton Villa, Park Road, Hindley, Wigan.
1897	Makepeace, H. R., H.M. Inspector of Mines, 12, Compton Road, Wolverhampton.
1903	Marshall, Eustace, The Larches, Wigan.
1892	Matthews, D. H. F., H.M. Inspector of Mines, Hoole, Chester. *Member of Council.*
1893	Matthews, E. L., Belvedere Street, Withington Street, Pendleton, Manchester.
1896	Matthews, Thomas, Imperial Iron Works, Belvedere Street, Withington Street, Pendleton, Manchester.
1873	*Martin, Joseph S.*, H.M. Inspector of Mines, The Vikings, 16, Durdham Park, Clifton, Bristol.
1892	Miller, Arthur, Broad Oak, Hurst, Ashton-under-Lyne.
1892	Millington, W. W., Hardman House, Hollinwood, Oldham. *Member of Council.*
1892	Mills, David, Bradford Street, Farnworth.
1895	Mitton, A. Dury, Assoc.M.Inst.C.E., 50, Victoria Buildings, Manchester. *Vice-President.*
1895	Mort, Arthur, B.Sc , Sharigh, Baluchistan.

Year of Election.	Names and Addresses.
1878	Nall, Simon, Firgrove, near Rochdale.
1898	Naylor, Alfred, Shirebrook Colliery, Mansfield.
1897	Noar, T. Lamb, Rossendale, Fairhaven, Lytham.
1900	Ollerenshaw, W., Manager, Denton Colliery, Denton, Manchester. *Member of the Council.*
1903	Orrell, G. Harold, M.E., Swallowfield, Horwich.
1903	Owen, Richard, Messrs. Pearson and Knowles' Collieries, Wigan. *Vice-President.*
1876	Peace, George, Monton Grange, Eccles.
1883	Peace, George Henry, M.Inst.C.E., Monton Grange, Eccles.
1897	*Pickup, P. W. D., Rishton Colliery, Rishton, near Blackburn.
1900	Pickstone, William, 8, St. Paul's Road, Kersal, Manchester. *Member of Council.*
1879	Pilkington, Charles, The Headlands, Prestwich, Manchester.
1873	Pilkington, Edward, J P., Clifton Collieries, near Manchester. *Past-President.*
1899	Pilkington, Lawrence, South Garth, Eccles Old Road, Pendleton.
1903	Pilkington, Lionel, Haydock Collieries, St. Helens, Lancashire
1877	Place, W. H., Hoddleston Collieries, Darwen.
1887	Platt, Samuel Sydney, M.Inst.C.E., F.G.S., Moss House, King's Road, Rochdale.
1891	Prestwich, Joseph, Elm Bank, 72, Eccles Old Road, Pendleton, Manchester.
1903	Ramsbottom, James, Church Road, New Mills, Stockport.
1897	Reid, Alexander, Pekin Syndicate Limited, Shanghai, China.
1897	Richardson, Isaiah, Blainscough Collieries, Coppull, near Chorley.

Year of Election.	Names and Addresses.
1860	Ridyard, John, F.G.S., Hilton Bank, Little Hulton, Bolton. *Past-President.*
1900	Ridyard, George, M.E., Shakerley Collieries, Tyldesley.
1893	Rigby, John, Highfield, Winsford, Cheshire.
1903	Ritson, Thomas F., Manager, Bamfurlong Collieries, near Wigan.
1897	Ritson, W. A., 44, Woodlands Street, Cheetham, Manchester.
1889	Robinson, John, Haydock Collieries, St. Helens.
1903	Rogers, W., 311, Wigan Road, Bolton.
1892	Roscoe, George, Peel Hall Collieries, Little Hulton, Bolton.
1898	Roscoe, Thomas, Peel Hall Collieries, Little Hulton, Bolton,
1895	Rothwell, Samuel, 21, Chorley New Road, Bolton.
1903	Rushton, A., Moss Hall Collieries, Coppull, near Wigan.
1895	Ryans, Joseph, Colliery Manager, Arigna Mines, Carrick-on-Shannon.
1887	Saint, William, H.M. Inspector of Mines, Kersal Bank, Higher Broughton, Manchester. *Past-President. Hon. Secretary.*
1902	Salisbury, S., 62, Ayres Road, Brooks' Bar, Manchester.
1888	Scarborough, George Edward, Colliery Manager, Newton and Meadows Collieries, Wigan.
1887	Scott, Frederick W., Atlas Works, Reddish, near Stockport.
1889	Scott, William B., Eversley Cottage, Middleton.
1891	Scowcroft, Thomas, J.P., Redthorpe, Bromley Cross, near Bolton.
1899	Selby, John B., Atherton House, Leigh, Lancashire.
1882	Settle, Joel, The Hill, Alsagar, Stoke-on-Trent.
1899	Shaw, Alfred, Bersham Colliery, Wrexham.
1887	Shuttleworth, Lord, of Gawthorpe, Burnley.
1884	*Simpson, W. W., Winkley, near Whalley, Blackburn.

Year of Election.	Names and Addresses.
1864	*Smethurst, William, F.G.S., Brynmair, Dolgelly, North Wales.
1902	Smethurst, W. A., Garswood Hall Collieries, Brynn, Wigan.
1881	Smith, John, Bickershaw Collieries, Westleigh, near Manchester.
1873	*Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell. *Past-President.*
1888	Smith, Sydney A., Assoc.M.Inst.,C.E., 1, Princess Street, Albert Square, Manchester. *Member of the Council.*
1903	Speakman, Charles, Rosehaugh, Clitheroe.
1886	Speakman, Harry, Bedford Collieries, Leigh, Lancashire.
1881	Squire, J. B., Assoc.Inst.C.E.. F.G.S., M.I.M.E., 20, Victoria Street, Westminster Street, London, S.W.
1880	Stirrup, Mark, F.G S., High Thorn, Stamford Road, Bowdon. *Past-President.*
1902	Stocks, F. W., F.S.I., The Hermitage, Middlewich.
1882	Stopford T. R., Ashton Green Collieries, St. Helens, Laucashire.
1891	Sutcliffe, Richard, Horbury, near Wakefield.
1903	Sutcliffe, W. H., F.G.S., Shore Cottage, Littleborough.
1899	Tansley, A. E., Springfield House, Coppull, Chorley.
1899	Tatham, Roger.
1901	Taylor, John, 51, Park Road, Darwen.
1889	Taylor, William, 51, Park Road, Darwen.
1892	Thompson, James, 248, Chorley Road, Westhoughton, Bolton.
1897	Tickle, James.
1893	Timmins, Arthur, A.M.I.C.E., F.G.S., Argyll Lodge, Higher Runcorn.
1891	Tonge, Alfred J., Hulton Colliery, near Bolton. *Member of Council.*

Year of Election.	Names and Addresses.
1873	Tonge, James, F.G.S., Assoc.M.Inst.C.E., Albany Chambers, Mawdsley Street, Bolton. *Past-President.*
1898	Tonge, James, Jun., F.G.S., Westhoughton, near Bolton. *Hon. Secretary.*
1886	*Trafford, Sir Humphrey Francis de, Bart., F.G.S., 18, Arlington Street, London, W.
1895	Travers, T. W., Mining Engineer, Spring Bank, Broad Oak Park, Worsley.
1896	Turner, Robert, Jesmond House, St. Helens.
1876	Unsworth, John, Scot Lane Collieries, Wigan.
1887	Walkden, Richard, Colliery Manager, 26, Watery Lane Terrace, Springvale, Darwen
1882	Walker, T A., Pagefield Iron Works, Wigan.
1902	Wall, Captain Arthur, Coed Mawr Hall, Tal-y-Cafn, Wales.
1882	Wall, Henry, Rowbottom Square, Wallgate, Wigan.
1893	Wallwork, Jesse, Bridgewater Collieries, Walkden, near Bolton.
1888	*Walmsley, Oswald, 2, Stone Buildings, Lincoln's Inn, London.
1897	Walton, Thomas, Exors. of Col. Hargreaves, Colliery Offices, Bank Parade, Burnley.
1892	Ward, Alexander Haustonne, Raneegunge, Bengal, India.
1903	Wasley, John C., M.E., 184, Saltwell Road, Gateshead.
1880	Watts, William, F.G.S., Underbank Hall, Deepcar, near Sheffield. *Past-President.*
1897	Wells, Lionel B., M.Inst.C.E., 5, John Dalton Street, Manchester. *Member of the Council.*
1890	*Whittaker, William,* B.A., F.R.S., F.G.S., Freda, Campden Road, Croyden.

Year of Election.	Names and Addresses.
1891	Whitehead, J. J.
1898	Widdowson, J. H., 19, Brazennose Street, Manchester.
1880	Williams, Sir E. Leader, M.Inst.C.E., Manchester Ship Canal Company, Spring Gardens, Manchester.
1897	Winstanley, George H., F.G.S., 42, Deansgate, Manchester. *Hon. Auditor.*
1876	Winstanley, Robert, C.E., 42, Deansgate, Manchester. *Past-President.*
1886	*Wood, Guy.
1897	Wood, John, M.E., Barley Brook Foundry, Wigan.
1897	Wood, Percy Lee, Clifton and Kersley Coal Co., Ltd., Clifton, Manchester. *Member of the Council.*
1895	Wordsworth, T. H., New Moss Colliery, Audenshaw, near Manchester.

SUBSCRIBERS.

Stechert & Co., 2, Star Yard, Carey Street, London, W.C.

Eyre & Spottiswoode, 5, Middle New Street, London, W.C.

Cornish Brothers, Ltd., 87, New Street, Birmingham.

Members are requested to communicate to the Hon. Secretaries all changes of address, also any omissions, or corrections required in the list.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL AND MINING SOCIETY.

PART XI. VOL. XXVIII. SESSION 1903-1904.

The ORDINARY MEETING of the Members was held on Tuesday, 10th November, 1903, in the Society's Rooms, 5, John Dalton Street, Manchester.

Colonel GEO. H. HOLLINGWORTH, F.G.S., President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society:—

Mr. J. W. GILLOTT, Lancaster Works, Barnsley.

Mr. WILLIAM HENRY JOHNSON, B.Sc. (Lond.), 24, Lever Street, Manchester.

Mr. CHARLES SPACKMAN, Rosehaugh, Clitheroe.

CONGRATULATIONS TO SIR LEES KNOWLES, BART.

Mr. JOSEPH DICKINSON, F.G.S., called attention to the honour which was conferred by the King on Col. Lees Knowles, M.P., on the occasion of His Majesty's birthday. He said: Allow me to express my gratification, which is also likely to be yours, on the announcement of His Majesty the King's pleasure to bestow the honour of a Baronetcy on Colonel Lees Knowles, M.A., LL.M., F.G.S., F.Z.S., D.L., M.P., and one of the members and co-trustee with myself of this Manchester Geological and Mining Society. His application is never ceasing, always doing something useful, with his heart and hand in a long list of good works—not the least of which is a rifle range, with structural screens, backed by high permian sand, on his land at Pendleton, which is likely to save the Salford Volunteers many a long journey for practice, and may possibly be similarly available for the Manchester Volunteers. Shortly before this meeting began the Council passed a vote of thanks to him for kindly presenting this Society with sixty parts of the transactions of the Institute of Civil Engineers. I have much pleasure in moving: "That the congratulations of this Society be given to Colonel Lees Knowles on the honour which His Majesty is about to confer upon him."

Mr. PEACE seconded, and the resolution was cordially adopted.

Mr. W. J. SUTTON, F.G.S. (America), read the following paper on "The Geology and Mining of Vancouver Island":—

THE GEOLOGY AND MINING OF VANCOUVER ISLAND.

By Mr. W. J. Sutton, F.G.S. (America),
Victoria, British Columbia.

Comparatively little is yet known regarding the Geology of Vancouver Island, owing to the mountainous character of the interior, and the dense growth of vegetation, making it almost impenetrable.

It is interesting to note, its geographical position on the north-west coast of America being so very similar to that of the British Isles on the north-west of Europe. The climate is identical, owing to similar meteorological conditions. We have the influence of the Pacific Ocean, with its Japan current, striking our coast line, as you have the Atlantic, with its Gulf Stream, so materially affecting your climate.

We have a large portion of the population, of English birth, who have brought their manners and customs with them, and it may be truly said that there is no place outside of England to-day more characteristically English than the City of Victoria at the present time. So that we might with good reason, like Max O'Rell, speak of Vancouver Island and its people as "John Bull, Jr., and his Island."

Vancouver Island is about three hundred miles in length, with an average width of about seventy miles. Its mountains, with the Queen Charlotte group of islands to the north, form a partially submerged range of mountains, which have been called by the Geological Survey of Canada the Vancouver Range. It forms the extreme western portion of the great

Cordilleran system of Western America, comprising four great mountain ranges, *i.e.*, the Rocky Mountains, the Gold Range, the Coast Range, and the Vancouver Range.

The Rocky Mountains are composed principally of stratified rocks (largely carboniferous).

The Gold Range of mountains is composed principally of gneisses, schists and gold bearing slates, and comprise the archean axis of that portion of North America.

The Coast Range of mountains is composed almost entirely of granite with small included areas of gneiss and mica schist (usually highly garnetiferous).

The Vancouver Range is very variable in character, being composed of slates, quartzites, and schists, with local areas of crystalline limestone, and large areas of volcanic rocks comprising diabases, gabbros, and large quantities of clastic volcanic material.

The Vancouver range does not form a continuous range, but is very much broken up into detached ranges and isolated peaks with very deep intervening valleys, making it very rugged over the greater portion of the interior of Vancouver Island. Standing on one of these elevated snow-capped peaks the scenery is grand beyond description. The higher ranges run from four to eight thousand feet in elevation, and on the northerly slopes are covered with perpetual snow.

The mountains are heavily clothed with timber up to an elevation of about four thousand feet, above which the timber becomes very small and scrubby.

The timber is almost entirely coniferous, the most abundant tree being the Douglas fir. We have also red cedar, spruce, and hemlock of commercial importance; with alder, maple, oak, yellow cedar, balsam, arbutus, and white pine over small areas.

The oldest rocks on Vancouver Island have been tentatively placed in the carboniferous period, although I am inclined to think that we shall yet find some strata lower down in the geological scale. The oldest fossil-bearing strata so far found have been the detached areas of limestone, which is almost invariably highly crystalline with all vestiges of organic life destroyed. Along with this absence of fossils we have the sedimentary rocks of the earlier period very much broken up and penetrated by volcanic intrusions, thus making the determination of the geological succession a very difficult problem indeed.

Bearing this in mind, the following is given as a broad generalization of the geological succession on Vancouver Island :—

Tertiary period,
Cretaceous period,
Jurassic period,
Triassic period,
Carboniferous period.

Commencing with the oldest formation, we have a series of slates, argillites, quartzites, and schists, with small local areas of highly crystalline limestone, which are placed in the carboniferous period.

Before the close of this period of sedimentation there appears to have been some extrusion of volcanic material along the sea coast, thus making no sharp line of separation with the following period of active vulcanism which has been placed in the Jura-Triassic. This comprises an immense quantity of volcanic material, making a total of many thousands of feet in thickness. This volcanic series extends from one end of Vancouver Island to the other, and must have been one of the most terrific outbursts of explosive vulcanism in geological times, as the amount of ash and agglomerate extruded during this period amounts to thousands of feet in thickness. I have fonnd it extremely difficult to ascertain the thickness of this elastic volcanic material, as it is intimately incorporated with contemporaneous volcanic flows. The bulk of this eruptive series is composed of diabase, and is very similar in composition and character to the basic volcanic flows of the copper-bearing series of Northern Michigan and Wisconsin, which has been definitely determined as pre-cambrian. Under the microscope one would take them to belong to the same petrographical province. During the Cretaceous period there was a gradual subsidence with the deposition of a large thickness of sediment, principally sandstone, with interbedded coal seams. Sometime after the close of the Cretaceous period, probably during the early miocene, we had another volcanic disturbance on Vancouver Island.

Along the Beaufort Range, near Union, the Cretaceous strata have a vertical displacement of about two thousand feet. During this disturbance comparatively little volcanic material was ejected. It was of a trachytic character, and of limited extent. One of these flows is of special interest in the neighbourhood of the coal mines at Union, where a seam of bituminous coal has been converted by it into a fair grade of anthracite. This flow covers an area of about 1,000 acres, and is about 100 feet thick. It is a quartz andesite or dacite.

The focus of disturbance during this period appears to have been to the north of Vancouver Island as we find a much greater eruption in the Queen Charlotte Islands, where a large flow of basalt quickly followed the outflow of trachyte and trachytic breccia.

During the middle Tertiary we had a small off shore deposit formed, along the west coast of Vancouver Island.

It now forms a narrow fringe of friable sandstone extending from Sooke Harbour to Cape Beale. In the neighbourhood of Victoria we have beautiful evidences of glacial action owing to the tough durable eruptive rocks having retained the grooving remarkably well, with numerous exposures all over the city.

Considerable boulder clay has been deposited over different portions of the Island during the Glacial period. More particularly in Comox district.

The whole of what is now the Gulf of Georgia and Straits of Fuca must have been filled by an immense glacier which wrapped Vancouver Island with its icy mantle, and having its outflow to the north and south of the Island.

I can thus only briefly sketch the geology of the Island. With regard to mining I may say that coal mining is at present the principal mining industry on Vancouver Island.

The output per annum is in the neighbourhood of one million tons. This is mined by two colliery companies—The Wellington Colliery Company, with head-office at Victoria, and The Western Fuel Company (formerly The Vancouver Coal Company), with head-office at Nanaimo. The coal is a first-class bituminous coal, having about the following composition:—

	Per cent.
Volatile matter	30 to 40
Fixed carbon	55 „ 65
Ash	6 „ 8

There are two workable seams of coal, separated by about 300 ft. of intervening strata, principally sandstone. The seams vary from 3 ft. to 7 ft. in thickness. The lower seam lies near the base of the coal formation (Cretaceous), in fact it is sometimes found resting on the underlying basic igneous rocks, showing that the coal began to be deposited soon after a level surface had been formed along the coast. The lower seam is, as a rule, the thickest bed and cleanest coal, and usually a free burning coal, only coking slightly.

The upper seam is a strong coking coal. The Wellington Colliery Company have a large coking plant at Union Wharf. The coke is mostly made from washed screenings. The coal is washed by an elaborate system of jigs, and coked in bee-hive ovens.

The mining has been done principally by means of inclines on the dip of the bed, which is frequently exposed along the rim of the coal basin.

The usual dip of the coalbeds is about fifteen degrees, but they are frequently faulted and disturbed. In the neighbourhood of Nanaimo the coal mines extend for a considerable distance under the sea.

The principal market for the coal is the San Francisco market, although the local consumption has greatly increased during recent years. A local demand for coke has been created by the erection of two smelters on the island.

These smelters have been built to handle the product of the copper ores of the North-west coast. The mining of copper and gold ores comes next in importance to coal mining.

The most important output at present is from the mines on Mount Sicker, about fifty miles from Victoria. I may especially mention the Tyhee and Lenora mines. The ore is principally chalcopyrite, carrying a little gold and silver in a compact barite gangue. It occurs in the form of lenses along a highly schistose zone formed by dynamic metamorphism.

The country rock was originally granitic in character, cut by intrusive basic eruptives. These have been converted into sericitic and chloritic schists, along a zone about half-a-mile in width, with a vertical schistosity and strike of about North 75° West. This belt appears to cut across Vancouver Island, but has not yet been thoroughly explored.

The ore from the Tybee mine is taken by an aerial tramway to the Esquimalt and Nanaimo railway, and thence by rail a short distance to the Company's Smelter at Ladysmith, which is also the shipping port for the Wellington Collieries from their mines at Extension.

The Ladysmith smelter handles about 125 tons of ore per day, converting it into a high grade copper matte, which is shipped to an American converter and refining plant.

The ore from the Tybee mine is taken by a narrow guage railway to the Crofton smelter, a distance of about ten miles. The Crofton smelter is capable of handling about 300 tons daily. They have also a converter, and the product consists of 98% blister copper. There are a large number of occurrences of copper ore throughout the extent of Vancouver Island, which may be said to be only in the prospect stage.

Most of these prospects are contact deposits formed near the contact of limestone and acid eruptives.

The ore of these contact deposits is principally chalcopyrite and bornite, associated with pyrite, pyrrhotite, and magnetite. The associated gangue minerals are garnet, epidote, chlorite, ilvaite, and clinochlore.

Some of these contact deposits are almost entirely phyrrhotite, others entirely compact magnetite, containing over 60 per cent. of metallic iron, and sufficiently free from sulphur to be suitable for the manufacture of iron and steel. Some of this ore has been mined at Texada Island, and shipped to a small blast furnace at Port Townsend, in the State of Washington, where a good pig-iron has been made from it. The possibilities in favour of iron manufacture may be said to be very promising, owing to the fact that all the materials required in the process can be obtained close to the seaboard.

Considerable placer gold was found on Leech River some years ago, and most of the mountain streams show "colours," but at present very little is being taken out. Beyond the copper and iron ores, no other mineral of economic importance is being mined at present.

Quite a number of minerals have been found in small quantities. I may mention cinnabar, native arsenic, stibnite, realgar, galena, sphalerite, and native copper.

I look forward to considerable development in the way of copper and gold mining on the Island, as the numerous prospects indicate a field of great possibilities.

The PRESIDENT: I think we are very much indebted to Mr. Sutton for his very interesting paper, and following the usual course, I will thank some one to move a vote of thanks to Mr. Sutton.

Mr. DICKINSON: I have much pleasure in moving a vote of thanks to Mr. Sutton for his interesting description of the geology and mining of Vancouver Island. I have not myself had an opportunity of being there, but I have heard something about it, and I should like, after the vote has been passed, Mr. Sutton to tell us whether any of the basaltic rocks are inter-stratified, or imperfectly stratified, with any of the coal measures similar to what we have found in Scotland. He spoke of one of the mining operations extending to where the coal was changed into anthracite. It is quite common in Scotland, where the coal comes near to one of these basaltic rocks, to find it deprived of its volatile matter and formed into anthracite. I should like to know, therefore, whether any of the basaltic beds do override the coal measures.

Mr. J. Tonge: I have pleasure in seconding the motion. I wish Mr. Sutton would tell us what the relative value of the coal found in the Cretaceous beds and the semi-anthracite coal was. He has given us an idea by stating the amount of carbon in each. To what extent has anthracite coal been found?

The resolution was adopted.

Mr. Sutton: I thank you for your vote of thanks. In regard to the questions, I may say the area covered by this anthracite is about 1000 acres. It is merely a local flow, about 100 feet in thickness, and there is about 50 feet of sandstone between the flow and the coal. We have not mined any of the coal yet. An incline is being run into the Anthracite seam, and we expect to be mining coal from it next summer. The difference in value will be, I think, about two dollars a ton—that is if it retains the character which is expected from the borings that have been made.

Mr. Ashworth: I have been very much interested in listening to what Mr. Sutton has said about Vancouver Island. I wish he would tell us how the coal in one place which he has described compares with that which is found further west.

Mr. Sutton: You are treading on tender ground, because I am an employee of the Wellington Colliery Company.

Comparisons are said to be odious, but I may say that the coal further west, to which Mr. Ashworth refers, has up to date been a little better than our coal; but before I came away I learned that its quality was declining, in that it was becoming more mixed with other substances, so that before long I think they will have to wash their coal. The coke we make is made out of the washed coal. We do not make any with coal taken direct from the mine. But taking it all in all there is not a great difference in the qualities.

The PRESIDENT: Will you tell us the thickness of your coal seams?

Mr. SUTTON: They vary from three feet to seven feet. Our best seams run about five feet, and we work them down to about 2½ feet. That is the thinnest we can work to a profit at the present time. We pay the highest wages out there, I believe, of any colliery in the world—averaging about four dollars for a working day of eight hours.

Mr. ASHWORTH: Are the coal companies' and the mining companies' properties largely held by American syndicates, or are there many English mining companies in Vancouver?

Mr. SUTTON: That is one of the things we want you in this country to consider. We want our own people to take up these things more than the Americans. I am pleased you have put that question, for I felt very sorry to learn that an English colliery company that had been at work for thirty years had recently sold out to an American company. It is with great regret I have to state that though the bulk of the coal measures are held by a Scotchman, the Americans are coming rapidly to the front in various enterprises. A Scotchman, whose father went out many years ago has managed to obtain possession of the bulk of the coal areas.

Mr. Ashworth: I think that is a point for us to consider. Mr. Sutton and others who come from Canada, or British Columbia, want to encourage the people of this country to take a more special interest in the development of the mineral wealth of British Columbia and Vancouver Island. That was my impression when I went all through British Columbia, through the kindness of the Canadian Pacific Railway Company. I found that so many of the Americans were getting the pick of the minerals, and not only was that the case with respect to the minerals, but they were also acquiring much valuable agricultural land in the North-West. If we wish to be Imperialistic, it is very important that we should send our money there direct instead of passing it through New York, and I believe if our mining magnates and others would invest their money direct in that country instead of through the several exchanges, they might reap a small percentage to begin with, and the ultimate result would be beneficial to themselves and the country.

Mr. Sutton: That brings up a question which I have often considered. Englishmen wish to have things brought to them instead of, like the Americans, going out and looking for them. Americans are alive to the necessity of sending out agents in advance. These agents are on the alert for good things, and when any new discovery is made they quickly seize it for the benefit of their patrons. Then the Americans sometimes unload on the British public. I would urge you to form your companies beforehand and send a good man out, and let him look around and be ready to pick up any good thing that presents itself. The Le Roi Mine was a good mine, but the British public paid too much for it. It was beginning to look a bit dubious, so its owners thought it time to load it on to British capitalists, and they did so at a high price. It is a good mine: I have nothing to say against it. Still too high a price was paid for it.

Mr. SYDNEY A. SMITH: Is there much inducement to British people to invest when the product only yields 2 dollars a ton and wages are 4 dollars a day?

Mr. SUTTON: The anthracite coal will yield an *extra* profit of two dollars a ton over that of the bituminous coal. That was what I meant to say. The selling price varies from 3½ to 4 dollars a ton on board ship, and is retailed at about 6½ dollars a ton.

The PRESIDENT again acknowledged the Society's indebtedness to Mr. Sutton, and assured him that the members of the Society would willingly assist him in any enquiries he wished to make in this country.

Mr. JAMES TONGE, F.G.S., the Society's Delegate read the following report on the Meeting of the British Association held at Southport, September, 1903:—

REPORT OF THE SOCIETY'S DELEGATE TO THE MEETING OF THE BRITISH ASSOCIATION, HELD AT SOUTHPORT, SEPTEMBER, 1903.

By Mr. James Tonge, F.G.S., Assoc.M.Inst.C.E.

I have to thank the Council of this Society for doing me the honour to appoint me their delegate to the British Association this year; due partly, I think, to the state of health of our esteemed member, Mr. Mark Stirrup, who has worthily represented the Society on so many occasions.

I think it has been Mr. Stirrup's aim when he has reported to this Society, generally, to direct attention more particularly to the geological work of the British Association. And this would seem most fitting.

I do not know whether the members may expect me to follow in the beaten path; but I ventured to suppose that for once they may pardon a little change and accept a brief review of the general character of the 1903 meetings, and especially of the fine address on Higher Education with which the President of the Association, Sir Norman Lockyer, opened the meetings. Because not only have we for the past few months been engaged in fierce controversy about the supposed decline in our trade, its cause and cure (some asserting that we want Protection and others Education), but the present occupant of our Presidential Chair, and his predecessor, have both made Higher Education as regards Mining the chief point in their addresses; and without any reference to Tariffs have shewn a Higher Education in Mining to be an absolute necessity for this country. And doubtless the same necessity exists in respect to all industries as well as to mining, though perhaps not in all cases in an equal degree. That this necessity has been long acknowledged both by scientists and leaders of industry is well known. But no serious attempt has been made to supply the want. Sir Norman applies himself to the task.

Using his position as President of so influential a body as the British Association he makes an urgent appeal to them, and through them to the British Government, to "wake up" and like our Continental neighbours and America, to spend more money on Scientific Education.

In Professor Dewar's Presidential Address last year he uses these words: "To my mind the really appalling thing is not that the Germans have seized this or the other industry, or even that they may have seized on a dozen industries. It is that the German population has reached a point of general training and specialised equipment which it will take us two generations of hard and intelligently directed educational work to attain. It is that Germany possesses a national weapon of precision which must give her an enormous initial advantage in any and every contest depending on disciplined and methodised intellect."

Sir Norman Lockyer evidently thinks the same.

The President's Address.

Sir Norman chose as the title of his address: "The Influence of Brain Power on History." He borrowed the title, as he himself told us, from a great teacher, Captain Mahan, of the U.S. Navy, who wrote a book on "The Influence of Sea Power on History." And throughout his address the President kept two points well to the front: 1st, that if it was necessary for us to spend money in providing as much sea power as any other two nations, either in times of peace or war, it was still more necessary that we should provide money to produce brain power, the equivalent of battle ships. 2nd: That as the nation in the old days trusted to private and local effort to provide the navy, but found it to be unequal to the task, so the nation having for long trusted too much to private and local enterprise for its Higher Education must recognise the necessity for the State taking the matter up.

"But," he asked, "where are we to-day as compared with our Continental neighbours and with the U.S.A.? Men of science, leaders of industry, the chiefs of our political parties all agree that our present want of Higher Education—in other words, properly equipped Universities—is heavily handicapping us in the present race for commercial supremacy, because it provides a relatively inferior brain power, and this is leading to a relatively reduced national income.

The facts shew that we cannot depend upon private efforts to put matters right. How about local effort? Anyone who studies the statistics of modern municipalities will see that it is impossible for them to raise rates for the building and up-keep of universities. Already they are high in many places. The buildings of the most modern university in Germany have cost a million. For up-keep the yearly sums found chiefly by the State for German universities of different grades, taking the incomes of seven out of the 22 universities as examples, are as follows:—

	£
1st Class:—	
Berlin	130,000
2nd Class:—	
Bonn, Gottingen	56,000
3rd Class:—	
Konigsberg, Strasburg	48,000
4th Class:—	
Heidelburg, Marburg	37,000
	£271,000

The President then proceeded to draw a comparison between ourselves and our competitors in reference to universities, looking upon them as the measure of our production of brain power, as battle ships are the measure of our sea power.

"Are they," he asked, "equal in number to those of any other two of our competitors?"

"In the United Kingdom we had until quite recently 13. Of these one is only three years old, and another is still merely an examining board. In Germany there are 22 universities, in France 15, in Italy 21, in the United States it is difficult to say precisely, but in title there are 134. Among these there are 46 with more than 50 professors and instructors, and 13 with more than 150."

Sir Norman contends that we want eight new Universities. To build and equip these we want £8,000,000; and afterwards we want £400,000 a year to maintain them. To do this we should set aside £24,000,000. "But what," he asks, "is that?"

The moment the nation was aroused, chiefly by Captain Mahan's book on "The Influence of Sea Power on History," it voted £21,000,000 on warships to be spent during the next five years.

And if we voted 24 millions from the 16 thousand millions which Sir R. Giffen says we are worth, what is that compared with the interest it would pay?

It is obvious that the power of a nation for war, in men and arms and ships, is one thing; its power in peace struggles is another. In the latter the source and standard of national efficiency are entirely changed. To meet war conditions there must be equality or superiority in battleships and army corps. To meet the new peace conditions there must be equality or superiority in Universities, scientific organization, and everything which conduces to greater brain power.

We have found that it is not now as in the old days. Trade no longer follows the flag; it follows brains, and our manufacturers are too apt to be careless in securing them. In one chemical establishment in Germany 400 Doctors of Science, the best the Universities can turn out, have been employed at different times in late years.

In the United States the most successful students in the higher teaching centres are snapped up the moment they have finished their course of training and put in charge of large concerns, so that it has become a saying, "Youth is the pass-word for promotion."

In Britain, on the other hand, apprentices who can pay high premiums are preferred to the well educated, and the old rule of thumb processes to new developments.

Dealing with research as being now acknowledged to be the most powerful engine we possess for education, and showing how in other countries this is being more and more recognised by the State, he quoted Mr. Balfour, the President-elect of the British Association for next year.

Mr. Balfour said: "I do not believe that any man who looks round the equipment of our universities or medical schools, or other places of education, can honestly say in his heart that we have done enough to equip research with all the costly armoury which research must have in these modern days. We, the richest country in the world, lag behind Germany, France, Switzerland, and Italy. Is it not disgraceful? Are we too poor or are we too stupid?"

Sir Norman suggests the formation of a Scientific National Council, such as was unanimously recommended by a Commission presided over by the Duke of Devonshire over a quarter of a century ago. These recommendations have, like many others, been utterly ignored. Germany has such a Council. Even Lord Curzon in India has seen the necessity of such a Council, and has made a beginning in the interests of that country.

The President, in conclusion, said: "I have done what I feel to be my duty in bringing the present condition of things before you. It is now your duty, if you agree with me, to see that it be put right. You can if you will."

Turning to the work of the various sections it seemed somewhat strange that so many of the presidents should have fixed upon the one subject of the neglect of England as compared with other countries to encourage Higher Technical Education.

In the Geological Section the President, Professor W. W. Watts, took for his subject "The functions of Geology in Education and practical life."

He strongly insisted upon the necessity for field work following closely upon laboratory and museum work, and assured his hearers that he had noticed in his own students that though on first going into the open to study geology many shewed quite a repugnance to it, so soon as they began to see its beauty, its law and order—the sequence of the rocks, the connection between surface features and rock structure—they seldom failed to become intensely interested. To use the President's words, "they came into the field a rabble of larky boys; before they left it they had begun to develop into men."

The President claimed that no class of men got to know the country so well and so intimately as the geologist—for whereas the topographer just transferred his field work to paper and had done with it, the geologist was bound to keep all the main results of his surveys stored in his mind to use in connecting them with future work.

Professor Watts then went on to advocate the use of the geologist in a business with which I entirely disagree.

He said: "Why not scatter such men in every quarter of the globe, particularly where any trouble is likely to arise? They are cheap enough, they will waste no time, and they will be so glad of the chance for research that they will not be hard to satisfy in the matter of pay and equipment. Thus you will acquire a corps of guides ready wherever and whenever they are wanted; and when trouble arises they may do a great deal by means of their intimate knowledge of topography to save millions of money and thousands of lives, and to prevent the irritating recurrence of the kind of disaster with which we have become sadly familiar within the last five years."

Now whilst I greatly deplore these disasters, I protest against employing an army of geologists to help to get us out of difficulties when we have got in, a debasing of science for such a purpose. Far better to have a few representatives sitting all the year round studying how the troubles may be avoided.

The President was on safer and far better ground when he dealt with Geology in its economic aspect, and pointed out that Geology served a useful purpose not only in the winning of coal, iron, oil, and other useful minerals; but in many other departments of engineering as well as in agriculture. Under most of these headings he gave examples shewing the great utility of theoretical and practical Geology combined.

In the latter part of his address the President dealt with our coal supplies, and expressed the hope that the results of the Coal Commission would be to direct attention to the present waste of coal, and suggest means for greater economy in its use.

He concluded a very interesting and valuable address in the following words: "To sum up, I consider that the time has come when geologists should make a firm and consistent stand for the teaching of their science in schools, technical colleges, and universities. Such an extension of teaching will, of course, need the expenditure of time and money; but England is at last beginning to wake up to the belief, now an axiom in Germany and America, that one of the best investments of money that can be made by the pious benefactor or by the State, is that laid up at compound interest, 'where neither rust nor moth doth corrupt,' in the brains of its young men."

So Professor Watts thinks, evidently. And if he had said this was his opinion and the opinion of the British Association doubtless he would have been correct. But that England *is* awake to this idea is more than I can yet dare to think, judging by recent events. I fear England would prefer to go on building battleships and recruiting soldiers.

It was natural that the geology of the district where the meetings were held should receive attention, and several papers were read; amongst them one by Mr. Harold Brodrick, on Martin Mere, an ancient lake on the north side of the Wigan to Southport railway. In the 16th century, he said, it was about four miles in length by two in breadth, occuping a hollow in the boulder clay plain of south-west Lancashire: a place which, Mr. Brodrick thought, extended as far westward, at the close of the glacial period, as the Isle of Man. The lower portions of the peat of the Martin Mere basin contain trunks of gigantic oaks and Scotch firs. Near the surface of the peat no less than fifteen dug-out canoes had been found at various times in the area of Martin Mere; and many others had been found on the sites of other lakes in the districts of Ainsdale and Formby. Since 1693 artificial drainage has been resorted to with more or less success, and it is now only after excessive rainfalls that any large area lies under water.

Mr. J. Lomas, F.G.S., read a most instructive paper on "The Geology of the country around Southport," in which *he* also mentioned the probability of the West Lancashire boulder clay plain having formerly extended to the Isle of Man, and that the Irish elk found in the Isle of Man crossed by this lost land.

At various places along the coast, meres, with peat and tree trunks, were found below high water level, as at Leaseowe in Cheshire.

In Section D., Zoology, the President, Professor Sydney Hickson, complained of the very slight recognition that had been made by the State of the valuable services rendered by Zoologists to this country.

He devoted a considerable portion of his introductory remarks to the good work done in Zoology in this country during the past twenty years, but, as he showed, almost entirely through private enterprise; and contrasted the scanty Government aid received in this country with that given in Germany, France, Belgium, Holland, and particularly in the United States.

One striking sentence in his address, comparing our position in Biology, was this: "There are many in this country who have gained a high position as men of science, and whose opinion is frequently quoted as authoritative on questions affecting science in general, who are more ignorant of the first principles of the science of Biology than the Dutch schoolboy of fifteen years of age."

Professor Hickson quoted most interesting cases where a knowledge of Biology had produced remarkable results in improving the health and sanitary conditions of towns.

He devoted a very considerable part of his address to the engrossing subject of the natural variations of plants and animals, and the problem of the hereditary transmission of characters from generation to generation.

In regard to the *weight* of human beings, he thought there could be no doubt that artificial variation (or variation through the influence of environment) predominated over the natural or inherited. But in *stature*, he held that artificial variation was less predominant. Still, he thought many who inherited a tendency to shortness of stature might be tall by reason of environment and favouring conditions. And some born of tall parents might, by unfavourable circumstances, stop short in stature.

The Geographical Section was one of extreme interest and pleasure, both from the character of the President's address, which was devoted to Terrestrial Magnetism in relation to Geography, and the graphic descriptions of Lieutenant Shackleton, of the experiences of himself and his crew in their winter quarters under Mount Erebus. The effect of his plain, unvarnished, yet thrilling tales upon his audience was to keep them delighted from beginning to end.

In the Anthropological Section Mrs. Stopes, of Hampstead, discussed some paleolithic implements, and also some saw-edged paleolithic flakes and implements found by the late Mr. Stopes at Swanscombe, Kent.

At the York meeting in 1881, she said, when Mr. Stopes shewed his carved pectunculus from the Red Crag as the first recorded trace of pleistocene man, Professor Prestwich stated that *he* had found a bone in the same series which seemed to have been sawn in two, but that as he had thought it was impossible that man should have existed at that period he had pronounced against the saws. Here, however, were both men and saws associated in the pleistocene period.

A most interesting report was presented by the committee appointed to explore Irish caves. It dealt chiefly with the visit to the Edendale caves, in county Clare, last year. At 15 feet from the mouth of one of these caves a projection in the side of the road had been worn smooth, as if by the constant passing in and out of some animal. One system of caves here was found to be very prolific in remains of animals now extinct in Ireland, and in human relics of different periods, with bones of man and domestic animals, and much charcoal.

So extensive were some of these caves, and so abundant in remains of animals and man, the explorers had named them "The Catacombs."

But of all the papers read at the sectional meetings, and the addresses of the Presidents, none were so full of interest as those in the Mathematical section.

The President, Professor Vernon Boys, after referring to the distinguished scientists gone from the Association during the past year, having finished their work, at once fixed the attention of his packed audience by launching into a short account of the greatest discovery of the past year—greatest, as he said, not only because of its intrinsic importance and revolutionary possibilities, but for the excitement it has raised amongst the general public.

Professor Boys concluded this part of his address as follows: Unlike old-fashioned chemicals, which, when they are formed, have all their properties properly developed, radium and its salts take a month before they have acquired their full power (so Dewar tells us), and then, for anything we know to the contrary, proceed to manufacture heat, emanations, three kinds of rays, electricity, and gases for ever. For ever; well, perhaps not for ever, but for so long a time that the loss of weight in a year calculated, I suppose, rather than observed, is next to nothing. Professor Rutherford believes that thorium or uranium, which act in the same kind of way, but with far less vigour, would last a million of years before there was nothing left, or at least before they were worn out; while the radium, preferring a short life and a merry one, could not expect to exist for more than a few thousand years.

In this time one gramme of radium would evolve one thousand million heat units, sufficient if converted into work to raise five hundred tons a mile high; whereas a gramme of hydrogen, our best fuel, burned in oxygen, only yields thirty-four thousand heat units, or one thirty-thousandth part of the output of radium. I believe that this is no exaggeration of what we are told and of what is believed to be experimentally proved with regard to radium; but if the half of it is true the term "the mystery of radium" is inadequate—the "miracle of radium" is the only expression that can be employed.

The foregoing are just a few points noted in the various addresses and papers read and discussed.

On the whole it may be said, I think, the Sectional Meetings were fairly well attended.

Besides these there were three public lectures given, which were very well attended, and evidently much appreciated. "Man as artist and sportsman," by Dr. Munro; "The old chalk sea and some of its teachings," by Dr. Arthur Rowe; and "Martinique and St. Vincent: the eruptions of 1902," and there can be no doubt that these lectures would be both interesting and instructive to the audiences.

The one question which the delegates of societies such as ours were expected to take special interest in and give attention to was the relation of the Corresponding Societies to the Association; and how they could best promote the interests of science unitedly.

Very interesting papers were read at the two Conferences of the Corresponding Societies, followed by animated discussions; the substance being perhaps embodied in the resolution passed at the close of the first meeting as follows:—"That, as urged by the President in his address, it is desirable that scientific workers and persons interested in science should be so organized that they may exert permanent influence on public opinion in order more effectively to carry out the third object of this Association, originally laid down by the founders, viz., to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress, and that the Council be asked to take steps to promote such organizations."

In accordance with this resolution the Corresponding Societies were urged to appoint committees, to be named the "British Association Sub-Committees," such committees to report to, and keep in communication with, the British Association, and, through that body, with each other, that so the work done by the societies individually may be all brought together.

The President moved a vote of thanks to Mr. Tonge for his report.

Mr. Pickstone: I beg to second the motion. I think Mr. Tonge has placed before us some wise words, partly his own and partly the words of others, and if they are true—if they represent fairly the position we are in before the world—well, we are in a sorry position. Individually we know something of trade, but it seems that as a nation we have not been doing right by ourselves, and I hope we shall do right in the not distant future. It seems to be absolutely necessary to bring us at least a few decades nearer the standard of education that Germany is said to occupy to-day scientifically before the world.

The resolution was adopted, and the meeting terminated.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

PART XII. VOL. XXVIII. SESSION 1903-1904.

The ORDINARY MEETING of the Members was held on Tuesday, 8th December, 1903, in the Society's Rooms, 5, John Dalton Street, Manchester.

Colonel GEO. H. HOLLINGWORTH, F.G.S., President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society :—

Mr. HENRY H. CAMPBELL, Mining Engineer, 444, Produce Exchange Buildings, Manchester.

Mr. GEORGE GRAHAM, Sylvan Avenue, Brooklands, Cheshire.

ABRADED COAL.

A NEW THEORY OF THE FORMATION OF COAL.

Mr. Henry Hall, H.M.I.M., I.S.O., exhibited some abraded coal which had apparently been reformed into solid coal in the course of two or three years. He said: The history of these samples is as follows: For some three or four years water had been wound in tanks at a colliery near Prescot, and emptied at the surface into a wooden trough, which again emptied itself through a hole at the bottom, so that the trough was one instant full and the next empty, setting up a steady, wave-like motion. The result of this action has been that a minature coal seam a sixteenth to a quarter of an inch thick has formed on the vertical sides of the trough. The explanation of this phenomenon seems to be that the water contained fine coal dust abraded off the seam below, which was deposited by the wave-like motion already referred to. But what is most remarkable—I know of no previous instance of it—is that a perfect seam of coal has been formed, hard, bright, and crystalline in character, precisely the same as the thin pipers or bands of bright coal met with underground, and this without either pressure or the passage of time. It seems to me that this phenomenon opens up a wide field for inquiry for geologists. We have been accustomed to think that the formation of a coal seam occupied perhaps millions of years, accompanied by heat and pressure. Now I think you will agree there is no appearance of compressed fuel about the samples you have before you. It is rather one of growth, as if the particles of coal dust dissolved or mechanically mixed in the water had still within them some vegetable life. It is clear, at any rate, that coal may be abraded by water and reformed again into a solid seam of pure coal in the course of half a dozen years, if the circumstances are favourable. I wish to mention in reference to this matter that there was a good deal of ochre coming up in the water from time to time, and the coal and the ochre seem to have separated themselves from each other, the coal forming a coal seam, and the ochre forming what you have often seen, a seam of ochre. It is rather remarkable that in, I think, all the coalfields in England, whenever you find coal you find iron in connection with it. In Staffordshire the iron seams and the coal seams alternate very largely. And I think it is the same in every coalfield. The two things seem to have come together in nature, as they now seem to go together in the every-day world. I submit, with a good deal of respect, that instead of coal seams being formed on the site of forests by process of vegetable decay, time, pressure, and heat, the substance forming coal has more likely been dissolved or mechanically mixed in water and deposited in the same way as any other part of the earth's crust. At any rate I am satisfied in my own mind that it is possible, and probable indeed, that there was no coal seam formed, as it were, in bulk.

The PRESIDENT: We have to thank Mr. Hall for bringing before us a very interesting phenomenon. It opens up a wide field for speculation and discussion, and I will ask some one to move a vote of thanks to him for bringing the matter before us.

Mr. J. RIDYARD: I have pleasure in moving a vote of thanks to Mr. Hall for his communication.

Mr. ALFRED J. TONGE seconded, and the motion was adopted.

Professor BOYD DAWKINS, F.R.S.: Perhaps I may open the discussion on the principle of being perhaps the rashest man here. I think we have to thank Mr. Hall for having brought before us an extremely novel and bold view of accounting for the coal seams by an experiment he has observed taking place in a wooden trough which has been the receptacle of water, I take it, from a coal pit.

Mr. Hall: From a coal shaft.

Professor Dawkins: Quite so, and I believe the circumstances under which this coal, or this carbonaceous material was formed, were these: That this trough was alternately filled and emptied—how many times a day? ("once in a minute," Mr. Hall said). That is to say it was filled and emptied, so that the coal dust which would be in the water would have the opportunity of being collected by pure mechanical action on the sides of the trough. Well, it seems to me, that those being the conditions under which this accumulation of carbon was formed in that box, it is a very large order indeed to argue from that as to the conditions of the formation of coal seams which occupy thousands of square miles, and which were formed under totally different conditions. It seems to me this is one of those speculations which are interesting in themselves, and show an amount of daring which a great many of us would not face. I for one would feel inclined to believe in the conclusion of scientific men who preferred to take the evidence as it is presented by the constitution of the coal seams themselves, and of the associated deposits, rather than go to this trough to upset the whole of the evidence which has hitherto been presented by the study of the coal seams themselves. I think this Society would prefer to go to the seams themselves for information as to how they were made rather than to this trough which was filled and emptied once a minute. At all events, the physical conditions on the surface of the earth which such a view involves are a serious objection to

Mr. Hall's theory. But there is another point which strikes me, and that is, that these samples were formed of coal-dust. The coal was in the seam before it was reduced to dust, and collected again on the sides of this trough. I say, therefore, we don't get any further towards accounting for the accumulation of the seams of coal by referring to this trough.

It seems we have here a phenomenon of extreme interest. It is this, that when you have finely-divided particles of certain substances, there is a tendency for those minute particles, under certain conditions, to collect together and assume a solid shape. For instance, take nuggets of gold. Take the visible gold in a quartz vein. It was originally accumulated in very minute particles in crystals of iron sulphide. Then the iron sulphide crystal has been dissolved away, and then you have these particles collected together to form a solid lump of gold. While obliged to Mr. Hall for having brought this very interesting case of consolidation before us, I for one have the greatest possible difficulty in following him, and in citing the conditions of deposit as an explanation of the formation of seams of coal, which have been in all cases formed on a surface which is traversed by roots and rootlets, and which is distinctly a surface of growth,—something which has been formed, as we know by its physical structure, by the decomposition of plants on the surface of the ground. I had hesitation in breaking the ice and beginning this discussion, but no doubt I shall be followed by many gentlemen who will probably take a totally different view.

Mr. Mark Stirrup, F.G.S.: I should like to say a word or two, and there is one point which Professor Boyd-Dawkins has not referred to, and I think it is one that is very important—that is with regard to the age of the coal. I think our friend opened his remarks by saying there was no necessity really to consider the coal measures were of that geological age, that vast age, we suppose them to be, but that, seeing these samples of coal had been formed in this trough, the coal measures may be of a much more recent date than geologists assume. The coal measures we know to be of very great age from other evidence. The position in which they are found in the strata of the earth is strong evidence of how and when they were formed, while their fossil flora indicates a Palæozoic origin. No doubt the coal measures are of a vast age, how old it would be useless to attempt to say, whether millions or thousands of millions of years. But the illustration Mr. Hall has brought before us will not upset the geologist's view of the coal measures period.

Mr. JOHN ASHWORTH: We must all feel very grateful to our friend Mr. Hall for bringing these specimens before us. I think Mr. Hall spoke strongly in the same way that Ruskin did—so as to get somebody to answer him. The great interest of this phenomenon to my mind is this, that the coal was formed on the vertical sides of the trough. The coal dust was brought there by the agency of the water which filled the trough every minute. While the process of filling and emptying was going on this coal was forming itself on the sides and the ochre was also separated. That point is extremely interesting—the coal dust separating itself from the ochre and both forming themselves into separate substances at the same time. It is interesting, without going into the question of the age of coal, to have such an interesting specimen brought before our notice.

Mr. J. DICKINSON, F.G.S.: The specimens we have had before us show that not only has crystallisation taken place in this miniature coalfield, but that there are lines of cleavage running through, similar to what we find in many of our coal seams. There is one point which I think should strengthen what Professor Boyd-Dawkins said, that is, that the rootlets are almost invariably found below the coal seams in this country. But under the coal seams I have seen in Savoy and the Mount Cenis tunnel, when it was being driven, there were not any rootlets. I should like Mr. Hall to explain, if he can, how his stratification with the ochre is compatible with the absence of rootlets. How anyone who has seen coal seams *in situ*, and marked their varying stratification, can reconcile those appearances with the present view held by geologists is more than I can understand.

Mr. James Tonge, F.G.S.: Much surprise seems to be felt because this is a solid body of coal. I don't think any members who have watched in collieries the deposit of oxide of iron on the sides of vessels, whether in horizontal or vertical positions, can be surprised; the oxide of iron cements itself against the sides of vessels and becomes hard and solid, so that it takes blows with a hammer to detach pieces. I imagine that this piece of coal has been formed in a similar manner. It has been by the force of its own cohesion and not by any pressure. As the water has risen and fallen, the coal and oxide of iron have caught and remained on the side, and that process has continued until, as in this case, a solid accumulation of considerable thickness has been formed. Of course I may have taken a wrong view, but it seems to me that is the way this coal has been formed.

The President: In that case would you not expect to have it mixed instead of being in layers, as it is here?

Mr. Gerrard: Do you mean the consolidation has been effected by the oxide of iron?

Mr. Hall: With respect to what Professor Boyd-Dawkins said, that it was a big jump from this experiment to the question of the formation of the coal seams, I quite admit that, but, as the old adage says, an ounce of fact is worth a ton of theory. Here we have an example, which we have seen with our own eyes, of how a coal seam has been formed, but the general theories about the formation of coal are theories pure and simple. Nobody has any chance of knowing actually whether they are true or false, but in the case I have adduced we have had a coal seam actually formed, and presenting exactly the same appearance as those that we are familar with. I cannot explain the phenomenon, I admit, but I think it is worth a good deal of consideration as a little fact that we can see and that we know all about. I should like to point out to Professor Dawkins that the constant ebb and flow of the water in the trough represented to my mind the action of the sea—a wave-like action. Hence, if you have this vegetable matter washed to and fro by the waves, is it not likely that it formed itself into seams just as this has done on a small scale? Mr. Dickinson, I think, mentioned a difficulty about the accepted theory concerning the formation of coal that has always troubled me. I have never yet been able to explain it myself, nor have I heard anyone else explain it thoroughly. The old theory is that coal seams are on the site of forests. They cannot explain where the forests grew. In some cases you have a thin seam of coal, and a little higher up a thick seam, and lower down a still thinner seam. You can understand that the trees forming the thick seam got their roots in the three feet of clay beneath, but further down you have a thin band, an inch thick, and below that again another band, perhaps half an inch thick, with only a thin layer of earthy matter between the two. I cannot for the life of me see where those forests got their roots that formed these thin layers of coal, whereas it is easily explained if you accept the view I have set forth. I was very much struck with this formation, and I am quite sure the more you look at those little bits of coal the more you will be struck by them. You will be struck by the texture of the coal, the crystallization of it, how it became solid. We know that many people make compressed fuel, using an immense amount of pressure, and adding pitch to it, but they get nothing like that which I have shown. You can see it is compressed fuel in the one case, but here you have a substance which if you examine it by a magnifying glass you cannot tell the difference between it and the best Arley coal. The texture is the same. The impression on my mind is that this vegetable matter is not dead, but that it is still living.

The following paper on "A Machine for Testing Miners' Safety Lamps" was read by Mr. William Henry Johnson, B.Sc.:—

A MACHINE FOR TESTING MINERS' SAFETY LAMPS.

By Mr. William Henry Johnson, B.Sc.

The invention of the miner's lamp by Davy and Stevenson was of such great importance to miners and colliery owners that it may be said to mark an epoch in the history of coal mining.

No one, I think, will dispute that it has been the means of saving thousands of lives, and that without this invention many collieries could not be worked.

Year by year improvements have been made in the lamp to render it safer in presence of gas, but, I regret to say, explosions due to faulty lamps are still numerous, and though attended by serious loss of life and of valuable property, yet very little has been done to ensure an efficient test of each lamp before it is taken down the mine.

It is acknowledged that many colliery explosions are due to the faulty construction of the lamps themselves, or to some oversight on the part of the lamp-house men, and they will ever be liable to recur unless the lamp-house man is assisted by a mechanical tester arranged on scientific principles.

In the Report of the Accidents in Mines Commission for the year 1886, great stress is laid on the necessity of testing each lamp before it goes down the pit, yet strange to say, this matter has hitherto received little or no attention.

On page 88 of this report, headed "Practical Testing of Lamps," we read:—

"In examining a safety lamp, even one of simple con-
"struction, it is very easy to overlook, in fitting up the parts,
"small errors, which entirely deprive the lamp of its power

"of isolating the flame. With the object of detecting any "imperfect lamps which have escaped notice in the ordinary "inspection, it is usual at some collieries to test every lamp "in gas before it is allowed to go down to enter the pit. "At other collieries lamps are only tested occasionally."

Since this report was published, the daily testing of lamps has been practically abandoned. In fact I am not aware of any colliery except those furnished with this patent lamp tester where lamps are now daily tested.

The report continues as follows:—

"With the safer and more complicated lamps it is still "more difficult to detect by the eye defects in adjustment, "indeed in many cases important parts cannot be seen after "the lamp has been put together.

"During our course of experiments, explosions have been "traced to imperfections so small that we have had some "trouble in finding them, even when certain of their "existence.

"We consider it, therefore, absolutely necessary that such "lamps should be regularly tested in an explosive mixture "before they are allowed to descend the shaft.

"The gas tests hitherto applied consist either in raising a "lighted lamp into a vessel (open below) in which the air is "more or less viated by a stream of gas. or by passing a "lighted lamp through a ring of burners from which "unlighted gas is escaping; neither of these methods of "making the test is trustworthy. An imperfect lamp will "pass through it and be extinguished by the pure gas above "it, without producing an explosion, and too slow in its "action to allow of the delivery of lamps to the miners "before descending the mines."

It is now nearly 20 years since the above report, and yet very little has been accomplished in the direction suggested by the Commission.

Mr. Rhodes, the able manager of Messrs. John Brown and Co.'s Aldwarke Main Colliery, Sheffield, has been most successful with his apparatus for testing the qualities of different miners' lamps in an atmosphere of fire damp or in a current of fire damp at various velocities. This apparatus is invaluable for ascertaining the efficiency of a newly designed lamp, or for finding the relative resisting power of any of the lamps at present in use.

I do not think the expensive plant at Aldwarke Main was erected for the purpose of daily testing the lamps used at the mines, as the skill, time, and expense required for each experiment must prevent this.

The Miners' Safety Lamp Tester before us has been designed for daily and rapid testing *alone*, and *not* for testing the relative qualities of various lamps. It can be operated by any inexperienced workman.

In order to save labour the table of the machine (Fig. I.) has been fitted with various trimming attachments. The mechanism with the wheel and handle is used for screwing or unscrewing the lamp bottom and glass ring. It also actuates a device for cutting off the rivets, and again for sealing the rivets.

The actual testing part of the machine is very simple in construction, and is entirely confined within the cone in the centre of the stand. A section of the tester is shewn in the diagram (Fig. II.), from which you will be able to trace the following description :—

The tube "A" is at present connected to ordinary gas supply. It may, in like manner, be coupled to compressed coal gas or hydrogen.

The branch "B" supplying the igniting jet is always kept burning when the tester is in operation, and is used for re-lighting the igniter "C," the latter being sometimes blown out by the explosion.

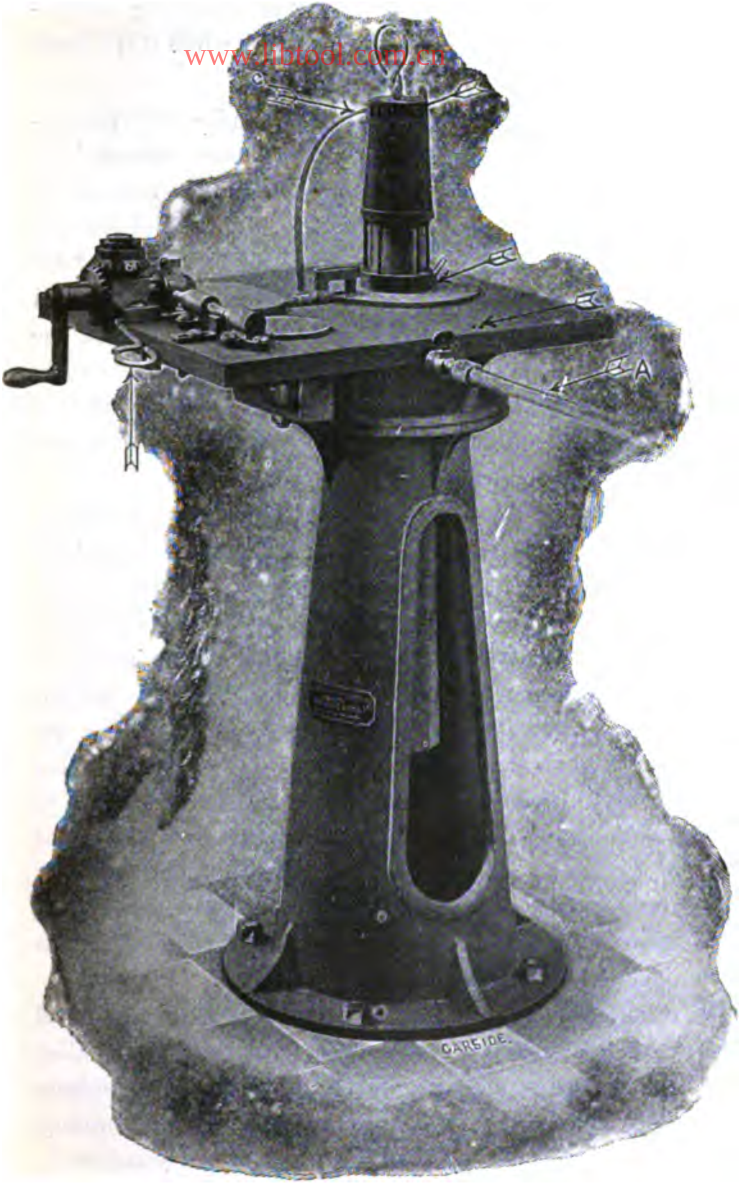


FIG. I.

The gaspipe separates at the tee; "D" running horizontally, supplies the gas to the igniter "C," while "E" leads to the tap "F" at the base of the cone.

The tap "F" being turned on by the handle "G" by connector rod "H," the gas flows into a bunsen burner "I," receiving a mixture of air as it enters. It then returns out of the inner cone (which you will here notice), and receives another admixture of air, and flows to the baffle plate "J," which assists in making a proper explosive mixture, and receives a further supply of air from the vents "K" in the outer cone. The same process is duplicated at baffle plate "L," and again at "M," so that finally we have almost a perfect explosive mixture continually flowing up the cone and escaping at the top.

Returning to the lamp tester, we now have an explosive mixture continually rising in the cone, and escaping through the holes at the top. On placing the lamp over the top of the holes we at once fill the lamp and check the mixture from escaping, except through the meshes of the gauze or joints of the lamp. Now if we apply a light to the outside of the lamp, filled as already stated, it follows that the gas escaping through the meshes of the gauze will ignite and burn slowly, provided there are no spaces in the gauze or joints large enough to allow a flame to pass into the inner part of the lamp; on the other hand, should there be any aperture large enough to allow a flame to pass through, it will immediately light back into the inner chamber of the lamp, causing an explosion.

I think this description has now made clear the novel feature of this system of testing, viz., that the lamp is filled with an explosive mixture, and a light is burning outside the lamp, exactly the reverse of what occurs in the safety lamp when in the mine.

The advantages claimed for this method are that the current of gas, rapidly rising inside the lamp, exposes the lamp to as severe and certain a test as it would experience in a mine if standing in a rapid current of gas. In the system of plunging the lighted lamp into an inverted bell, as mentioned in the report of the Accidents in Mines Commission

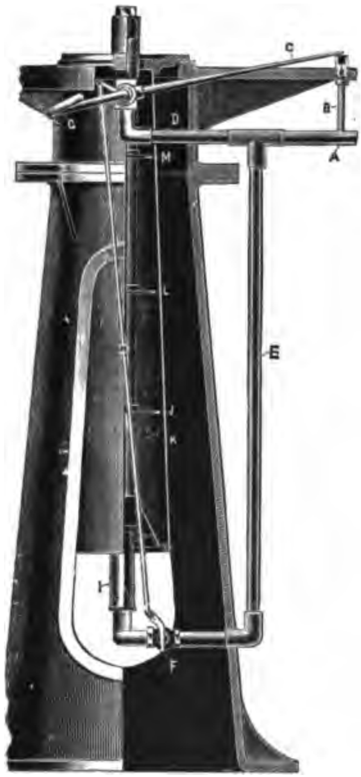


FIG. II.

for 1886, the gas being lighter than the air ascends to the top of the bell, and is too pure to explode, in fact the flame of the lamp is smothered, and no explosion takes place in faulty lamp.

I will now proceed to give practical demonstrations and tests, which will, I think, confirm my foregoing remarks.

For the sake of easy distinction I have arranged that all the lamps in ordinary brass with planished shields shall be perfect lamps, all in aluminium shall be defective; the one with the brass shield has no gauzes. I will now ask Mr. Storey to hand round the lamps which will be used in the first two tests, you will be able then to notice the size of the hole in the faulty gauze.

1st.—I will shew the action of the gas on a perfect gauze without the shield. It will be seen that a blue flame surrounds the entire surface of the gauze, and burns slowly; the explosive mixture inside the gauze being in the meantime maintained, this proves the gauze is proof against flame passing through it.

2nd.—The action of an imperfect gauze without a shield. The gauzes in this test have had a small point pushed through them. The light will be applied at the opposite side of the damaged part of the gauze, yet it will be seen that the gas works round and finds the enlarged place in the mesh, and allows the flame to pass, causing a loud explosion.

3rd.—A complete perfect lamp with shield will now be placed on the machine. To notice the effect it will be necessary to look carefully at the vents on the top of the shield, as only a slight flash will be seen, and then the gas will burn slowly as shewn on test No. 1, which is, of course, obscured from view in this case by the shield.

4th.—The lamp with brass shield is without gauzes. The violent explosion following the test shows what would happen should the lampman omit to put in the gauzes. I think you will agree it is a strong reminder.

5th.—I will now show three perfect lamps and one imperfect lamp, in the order named. Please notice the light flashes in the first three cases, and the loud report in the last one speaks for itself.

6th.—Lamp with faulty glass. The glass in this case being chipped, a violent explosion follows the test.

7th.—I will now ask Mr. Storey to test one perfect lamp, and then one imperfect, and afterwards change the gauzes from one lamp to the other. An explosion occurs with the faulty gauze.

8th.—Is a test which shews the advantage of having two gauzes, providing they are a good fit within themselves. Both the gauzes in this lamp are damaged, but the damaged parts are at opposite sides, which shews, that if the two gauzes are a close fit, they will not allow the flame to pass one defect to the other.

9th.—Two gauzes which are not close fitting, and both damaged, with the damaged parts opposite each other, exactly as in the previous test. This, we find, will allow the flame to pass from one defect to the other, and explode, proving that the principal advantage in having two gauzes is only obtained by having them close fitting.

In conclusion, Mr. President and gentlemen, I may add, it has been objected that the machine you have seen in operation will tend to make the man in the lamp-house careless and rely too much on the machine. Even if he does, I think we have in the lamp tester such a perfect detector, that the lampman will be bound to exercise even more care than he does at present to avoid the loud explosions in the lamp-house.

A lampman at an ordinary colliery, with the aid of an assistant unscrewing for him, is expected to clean 70 lamps per hour. Is it possible for him to detect the following faults which might occur? :—

1st.—He may omit the gauzes altogether.

2nd.—He may pass a gauze with a hole in it, 3rd.—He may damage the gauze or seam in the act of putting it into the lamp.

4th.—He may fail to detect a faulty glass.

5th.—He may tighten the glass askew.

Even though he be able to detect all these faults, there are the following which might be added from a manufacturer's point of view :—

6th.—Meshes of gauzes not being to regulation size.

7th.—May have faulty seams which are very hard to detect.

8th.—Middle plate and glass screw may not be parallel.

9th.—Glass may not be parallel.

How can a lamp-man detect these faults without special appliances? Yet, I very much question if any of our present day lamp manufacturers have such a thing as a tester on their premises with which they can test each lamp before it leaves their factory.

The lamps before you are made with an accuracy never before achieved in lamp work. Any part of any lamp is interchangeable with the corresponding part of any other lamp, and this obviates the necessity of keeping the several fittings of each lamp separate. In fact they are finished with the special care that ought to be devoted to an object on which the lives of many miners may depend, and these may rightly be called safety lamps, as when used with the Patent Miners' Lamp Tester they are worthy of that name.

Before concluding, I beg to acknowledge the great assistance I have derived in this paper from Mr. A. W. Storey, the able manager of Messrs. R. Johnson, Clapham and Morris's works.

A vote of thanks was accorded to Mr. Johnson, on the motion of Mr. Percy Wood, seconded by Mr. Wordsworth.

Mr. Wood suggested that it would be better to test the lamps with the bottoms on rather than the top parts only. He thought also that in actual practice the testing after the manner described by Mr. Johnson would be attended by danger of suffocation for the lampman, by reason of the escape of unburnt gas. To ensure that the lamp-man tested all the lamps, it seemed desirable to have some kind of a register attached to the machine.

Mr. Wordsworth said he was of opinion that a careful lampman would be able to detect the defects in the lamps used in the experiments.

Mr. Gerrard said he was very glad this matter had been brought before this Society, for it is most important to secure the protection of the light in the lamp in fiery mines such as we have in this district. For his own part he regretted that there were so many patterns of lamps in use. It would, he thought, be much better if mine owners would agree on one uniform pattern. The lamp defects he had seen that afternoon were large. What was needed was to have the minute defects revealed.

Mr. Wordsworth: Has Mr. Johnson ever tested a lamp with one wire broken which would be difficult to see?

Mr. Johnson: I don't think we have tried one with one broken wire only.

Mr. Saint asked Mr. Johnson how long it took after an explosion, to reproduce the explosive mixture in the machine, ready for another test?

Mr. Storey: The time occupied at present is about five seconds.

Mr. Johnson, in replying, assured Mr. Wood there was no danger of suffocation from gas, for the simple reason that comparatively little gas was required for the testing process. As to the suggestion of a register, it was quite possible they might be able to add something to record the testing of the lamps, but that must be left to a future time. It appeared to him, and he thought Messrs. Platt—who had the machine in use at their Moston Colliery would confirm him—that there was really no great difficulty in getting a lampman to test the lamps regularly. There was one very curious thing. When his firm brought the machine out they only expected it would detect faults in the gauze and not in the lower part of the lamp; but Messrs. Platt's man has pointed out that he has several times detected a faulty glass through the machine. The fact that on several occasions a defective glass has been discovered shows at once how valuable the machine is. As to one pattern of lamp, he fully endorsed all that Mr. Gerrard had said. If one standard lamp were used it would be produced at less cost than was charged now for varying patterns, and the result would be advantageous in other ways. The testing machine had been made to meet a great need. It was, he submitted, the best one ever put forward. It allowed a lampman to test his lamps as rapidly as he could screw them together. Anyone must admit that a mechanical tester had certain advantages over the unassisted care or eye of any individual.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL AND MINING SOCIETY.

PART XIII. VOL. XXVIII. SESSION 1903-1904.

The ORDINARY MEETING of the Members was held on Tuesday, 12th January, 1904, in the Society's Rooms, 5, John Dalton Street, Manchester.

Mr. JOHN ASHWORTH, Vice-President (in the absence of the President), in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society :—

Mr. HUBERT BRADSHAW, Yew Tree House, Stoneclough, Manchester.

Mr. J. DICKSON, Westhoughton Colliery, Westhoughton, Bolton.

Mr. W. DIXON, Manager, Eccleston Hall Colliery, Prescot, Lancashire.

Mr. PETER HIGSON, 18, Booth Street, Manchester.

Mr. PHILIP CROSBY POPE, Electrical Engineer, 56B, Liverpool Road, Birkdale.

The following Paper on "Coal Cutting by Electricity" was read by Mr. ALFRED J. TONGE :—

COAL-CUTTING BY ELECTRICITY.

BY MR. ALFRED J. TONGE.

I hope you will not be disappointed at the meagreness of the few notes which I have strung together upon coal-cutting, and which I beg leave to read to you. I came very near to "special pleading" before the esteemed Secretary of the Society to liberate me from this task. The victory rested with him, and I can now appreciate the troubles of those who have been through the same conflict. I have been really loth to take this subject for two reasons:—

First, because of the valuable and complete papers that have lately been read before the Society, and—

Second, because of the wide field which it is possible to cover, and my inability to devote the close attention necessary to encompass it. I therefore only claim to supplement the papers on this subject already referred to.

My experience in coal-cutting at the Hulton Collieries dates from June, 1899, when we installed our first cutter in the Half-Yard Mine.

What exactly possessed us at that time I cannot now say. The scarcity of thin seam colliers and the desire to keep abreast of the times were the chief reasons for our looking into the question of coal-cutters. After visiting various collieries and seeing a few kinds of electric cutters at work, we choose a "Jeffrey" disc long-wall cutter as the most suitable of the electric machines for our purpose.

We now have six electric cutters working day after day, and have others ready to be again put to work in other districts.

Types of Cutters.

When I say that we have four types of cutters at our collieries it may be thought that we have carried experimentation too far. I do not find that we have suffered much from this. Each make of cutter we have tried has some special feature which suits the mine. At any rate this was the object in our choice each time. The characteristics of each cutter are known to most.

The "Jeffrey" was our first choice because it seemed best at that time for thin seams—running on one rail, cutting on the floor level, being very compact, light, and low. It was put in the Half-Yard Seam. (The "Diamond" machines at that time were not driven by electricity). This machine we afterwards transferred to the 1 ft. 8 in. seam, and a second one was purchased.

The next type of machine tried was the "Diamond" long-wall cutter. This we got for a thicker seam, a deeper undercut, and to cut above floor level. The "Diamond" was also put in a fourth seam, although by this time we had returned to a shallower cut, and to cutting on the floor level.

The "Morgan-Gardner" chain machine was obtained chiefly for the purpose of dispensing with the use of rails in thin seams and its compactness.

And lastly, a "Hurd" three-phase bar cutter and a "Diamond" three-phase disc cutter have been purchased to work at our New Pits. The choice of three-phase cutters is very limited, so we chose *all* the types.

I am not able to say anything whatever of the three-phase cutters as we have not yet tried them, so that any particulars given later refer only to continuous current machines.

Generating Plant.

There are three generating stations of 150, 60, and 600 k.w. capacity respectively.

The first-named, situated at our Nos. 1 and 2 Chequerbent Pits, was the first one installed, but originally consisted of a 50 k.w. plant. Subsequent extensions have been made. The plant now consists of two 500 volt multipolar generators, each of 75 k.w. capacity, belt driven by two horizontal engines, 18 in. cylinder and 3 ft. stroke, making 120 revolutions per minute, steam pressure 80 lbs.

There are five cutters driven from this plant, but we also feed three electric haulage engines and two pumps, and light up the surface and underground from it.

The second-named plant of 60 k.w. capacity is turbo driven, with a voltage of 500. The turbine revolutions are 3,200 per minute, and a fan is also direct driven from the same turbine. The generator supplies current for one cutter, one pump, and lights for general surface work.

The third-named plant, situated at our New Main Nos. 3 and 4 Pits, consists of two "Parson's" three-phase turbo alternators, which are each of 300 k.w. normal capacity, voltage 465.

Many classes of work are being fed by these, but coal-cutting has not yet been added.

Method of Carrying and Distributing Current.

The main armoured cable is taken from behind the switchboard, down the shaft, and from junction boxes at the pit bottom smaller armoured branch cables are taken into the different districts. The armoured district cables are then taken to points contiguous to the working face, and each district cable is likewise provided with junction box and switch box. At the end of these district cables are fixed drums upon which the trailing cable is coiled and which contain special facilities for connecting the ends of the cable. The trailing cable is paid out along the face prior to commencing each cut.

In all cases inbye, the junction boxes, switches, and cut-outs are enclosed in tight cases, and where the motors are of the enclosed type the covers are kept good.

These junction boxes are of cast-iron with leading in glands. They are provided with covers, held on by screws and wing nuts.

The switch boxes are similar, and contain a knife switch and fuse mounted on slate base. The switch is operated from the outside. Both boxes are mounted on timber, which are fixed on the side of the roadway.

The cables that are laid along the roadway are insulated and armoured with two layers of galvanized iron wire, and are loosely suspended from the roof or sides by spun yarn, so that in the event of a fall they are released and borne to the floor without putting undue tension upon another part.

Arrangements are made by which the current is switched off the cable in the roadways when no work is in progress.

Amount of Coal Cut by Machine.

The total amount of coal cut by our machines in 1902 was 41,850 tons, and as the total amount cut by machinery, as given by Mr. Gerrard in his report for the Manchester district was only 80,036 tons, we thus participated in one half of the output.

At the present time we are cutting at the rate of 100,000 tons for the year, and last year (1903) we cut 70,568 tons.

The amount cut has a direct bearing upon the cost per ton, and it will thus be inferred that our costs per ton are not stationary, but are improving month by month. Were this not so I am afraid our experience in coal-cutting would not present too rosy a picture.

I have taken out the costs for the last three months of both cutter coal and hand got coal, and they are as follows :—

COMPARISON OF COST OVER THREE MONTHS.

Seam	ft. in. 1 8	ft. in. 3 0	ft. in. 3 6	ft. in. 2 0	Average
	s. d.	s. d.	s. d.	s. d.	s. d.
Cutter: Coal Cutting and Cleaning up. .	0 11¼	0 3½	0 3¾	0 6	0 6
Filling out and Drawing	2 7½	1 11	1 9½	1 10	2 0½
Total Underground ..	3 6¾	2 2½	2 1¼	2 4	2 6½
Hand Got Coal: Getting and Filling. .	4 0½	3 0¼	2 10½	2 11¾	3 2¾
Difference: Advantage to Cutter	0 5¾	0 9¾	0 9¼	0 7¾	0 8

This table shows cost only as affected by the underground labour. There still remain to be added the items of wages of attendants, coal consumption, stores, sinking fund or depreciation and interest on capital account.

I have had these worked out also, and it may come as a surprise to know that the advantage on underground work above referred to is about neutralized.

I do not think, however, it would be fair to take the maximum figures. As an illustration, the item of stores and replaces alone amounts to 3¼d. per ton over a fairly long period, but included in this are a few costly items for alteration of cutters, say a smaller cutter wheel, sleds under cutter, &c. These ought not to recur.

Again the depreciation taken at 10 per cent. and interest at 5 per cent. amounts to 2¼d. on the tons cut, but we have almost doubled our output of cutter coal during the past year, and we hope to again double it with the same plant next year. For this reason I do not care to include these figures. The coal consumption is about ¾d. per ton. The coal cutters are on the average 1500 yards from the generators.

The question of the advantage or disadvantage of a coal cutter as against hand labour is largely dependent, in our experience, upon the average tonnage rate previously paid to the collier for hand labour.

In the case of the 1 ft. 8 in. seam I ought to say that we have that cutter working in a district in which a shilling per ton extra was paid to the collier for "hard coal," and I have not included the extra shilling for the hand got coal in the comparison table.

The stores also vary with the hardness of the cutting.

Our experience leads us to say that a machine cutter will not take out holing dirt that is much harder than could be got by hand. An extra degree of hardness adds considerably to the stores and cutting cost.

In a table shown later it will be seen that the amount of coal filled per man after the cutter is about twice the amount filled by hand holing, or 14·8 to 7·2, and the cost per ton for filling, as on the table already given, is 2s. 0½d. as against 3s. 2¾d. In other words, for a 100 per cent. increase in amount of coal filled there has only been 37 per cent. reduction instead of 50 per cent. in price paid. This has gone to increase the wages paid per man, but the "size" and expense of the man employed has risen. Instead of a collier and light drawer we have now a collier and two more highly paid drawers. The crux of the saving really lies in this particular question of filling and drawing, and I have maintained at other times and places the great probability that the collier, as such, must really cease to exist if coal-cutting is to find its true level. The higher wages in coal mining, as in other trades, will eventually be paid to the most intelligent workman, and not simply because a man works on the coal face as distinct from the roadways.

Eefect of Cutters upon Quality of Coal.

The quality of coal obtained is certainly changed by the cutter. On the whole the slack has not improved but has depreciated. The rise in quantity of cutter coal has been coincident with the call of the consumer for more dust to be taken out of the slack, which in itself is suggestive.

In one seam, the Half-yard, although the percentage of round was improved the whole of the slack was rendered useless because of a band of dirt on the floor which the cutter persisted in holing in. In hand labour we can keep on the top of this dirt and have good slack. But just as the slack is often of less value the round coal is more often improved. In three out of the four mines under consideration the quantity of round coal has certainly been improved. I cannot say exactly what the increase is, but may safely put it at 10 per cent. The size and quality of the round coal are improved at the same time. In the Three Feet Mine the coal sticks very tenaciously to the roof and much chipping is necessary.

COAL CUT FOR QUARTER ENDING 1ST DECEMBER.

Seam.	Machine.	Yards of Face.	Yards Cut 4 ft. to 4 ft. 6in. deep.	Tons.	Per cent. of Coal to Total Raised.
ft. in.					
1 8	Two Jeffreys	350	6004	4018	28
3 0	Two Diamonds	340	9794	11716	36
3 5	One Diamond	70	1950	2884	46
2 0	One Morgan-Gardner..	150	2945	2439	15
	Total	919	20693	21057	30

COMPARISON OF OUTPUT AND AREA.

Seam.	Tons per yard of face per week.		Tons per man per week.	
	Cutter.	Hand.	Cutter.	Hand.
ft. in.				
1 8	0·9	1·1	12·0	6·0
3 0	2·5	1·9	18·0	8·4
3 5	2·5	2·0	16·2	8·1
2 0	1·6	1·7	13·0	7·5
Average	1·9	1·7	14·7	7·2

The area of the ground exposed will of course be in proportion to the number of tons filled per yard of face. The slight difference in the amount filled per yard of face by cutter from that by hand is owing to our cutting being done during one shift, and not throughout the 24 hours.

Improvements Added to Suit Conditions and General Method Adopted.

I have already suggested that we have made alterations and these have been improvements, although I do not say that this would always apply to other mines.

We found the deep cut of 5 ft. 6 in. too great in our seams. The coal did not fall in spite of the extra depth, and the cut being too narrow the coal did not break off sufficiently well. It took much longer also to fill out, and as only the same number of fillers could work at the coal as for a shallower cut, the machine was delayed in returning. It was also difficult to clean from under the coal sufficiently well. In one mine the deeper cut gave us trouble with the roof, in this way: that before the coal could be filled out the roof had broken off behind the coal and came down upon it.

We have found a 4 ft. 6 in. cut the most suitable. This is about the minimum cut which will allow of timbers being set under the new roof, still leaving room for the cutter to pass between them and the coal. We prefer also to cut at floor level, finding that the wheel keeps its position better between the partings, and the floor does not need to be afterwards levelled.

After working the "Morgan-Gardner" machine, we tried the experiment of putting both the "Diamond" and the "Jeffrey" machines on sleds or slides, in lieu of wheels and rails. This was a success from the beginning. The machines now slide along the floor, and the time occupied at, and the really laborious work of, laying rails in a thin seam is eliminated, and two men do the work of three in every case. The collier sets the props in line after filling out the coal. Again, the machine works much more steadily. The blow struck by the picks is more solid and thus more effective. The repairs to armatures are not now so heavy, due to less vibration.

Since this introduction both the Diamond Company, and, I believe, the Jeffrey Company, have fixed sleds to other machines.

We have generally adopted the "backwards and forwards along the face" method of cutting as preferable in the shorter lengths of face, which we are only able to work, but the "Jeffrey" cutters in the 1 ft. 8 in. seam are cutting in a uni-direction, and are "flitted" from end to end.

An important desideratum is the shortening to as fine a point as possible of the waggoning of the coal from the face to the haulage rope.

In conclusion we may safely claim that we have attained such definite objects as:—

(1.) More output per man employed.

(2.) Coal economically worked which previously had been unworkable to a profit by hand.

(3.) More systematic working.

(4.) Better round coal in three out of four mines.

(5.) Greater area exposed in same time in two out of four seams.

(6.) Premium per ton for risk of life reduced by one-third.

I am not able to give the comparison—which seems so desirable—between the two types of cutters, electric and compressed air, and I feel that this can only be done with accuracy by one who has both types at command, and who can put them to work either simultaneously or successively under exactly the same conditions.

It is scarcely possible to say how far the effect of coal-cutting reaches. The official has to keep better vigilance than before, not only as regards safety but also to keep the machine "forging ahead," as the next day's output depends largely upon it.

The collier has been disturbed in his "nest" at the face. He now meets the mechanic and the electrician on his own private preserve, and no doubt considers them interlopers, and work of a higher class, such as the mechanical and electrical is displacing, say 33 per cent. of the colliers' work, and that the most laborious.

Therefore, having installed the coal-cutters, the Hulton Colliery Company would certainly consider that a return to the hand labour would be a step back into the older and darker times.

Mr. J. Gerrard: I have great pleasure in proposing a vote of thanks to Mr. Tonge for his paper. I think it has been delightful to note the concise way in which he has brought the information before us, and I am sure he must have taken much care and trouble to collect that information which is, to my mind, of considerable importance to all those engaged in coal mining.

Mr. W. Pickstone: I beg to second the vote of thanks. I have the same view of the manner in which the paper has been brought before us as that which has just been expressed by Mr. Gerrard. Mr. Tonge apologised before reading his paper. I think he has shown that that apology was altogether unnecessary. We have had two papers on this subject—one by Mr. Hughes, which was highly commended, and now one by Mr. Tonge. I think valuable papers like these from mining engineers will have the effect of elevating the Society on to a higher plane.

The resolution was cordially adopted.

Mr. J. Dickinson: I have listened with the greatest pleasure to the paper, and I think we have now got in the "Transactions"—including Mr. Tonge's contribution—a wealth of information on the subject that will be of the highest service to those persons who are proposing to introduce coal-cutters into their collieries. The "Transactions" will be like a book of reference for them to which they can turn for information on any point.

Mr. Henry Hall, I.S.O., said that the "Champion" coal-cutter was being used to do the ripping of the roof, and did it more economically than men could do it, and, of course, without blasting, which was of great benefit. That is quite a new use for coal-cutting machines.

Mr. Bousfield said that certain changes were about to be made in the "Diamond" coal-cutting machine which would render it more serviceable. They had generally found the 5 ft. 6 in. depth of cut the most satisfactory, but the 4 ft. 6 in. cutter had proved of great advantage in the shallow mines. He thought Mr. Tonge was wrong in suggesting that a machine cutter would not take out holing dirt that was harder than could be holed by hand. As to substituting sleds for the machines to run upon instead of wheels, his firm had been making experiments with them, and had obtained good results. He thought there was a great deal to be said in favour of using sleds, and they dispensed with the services of one of the attendants at the machine.

Mr. J. Gerrard asked Mr. Tonge to explain what he meant by saying the use of machinery reduced the risk of accidents by one third. And in reference to doing away with the rails he thought from more than one point of view it would be advantageous if that could be accomplished. Not only would there be less labour but the risk of injury would be lessened. The point as to increased output he regarded as very important. He had heard the point mentioned before, but not so clearly as Mr. Tonge had expressed it. His attention had been frequently drawn to the great advantage of opening out the seam by machinery. He thought Mr. Tonge had given some excellent figures as to the economical side of the question, although Mr. Tonge was very modest on that point. The figures as to the effect of machinery on the percentage of round coal and on the quality of the slack were very significant. In dealing with hard coal he was sure machinery would render the working much simpler and much cheaper. With regard to the safety of the application of electricity improvements had been made which would go to make the use of electricity in the mines safer. We wanted the electricians to recognise that they must concentrate their efforts to make the use of electricity as safe as it was possible to make it.

Mr. WORDSWORTH remarked that if dispensing with the rails meant a crooked face we should lose one of the great advantages of coal-cutting by machines, and if we lose a straight line of cut, we also lose the straight line of break, and then we shall get out of the straight line of timbering, or at any rate make it less effective. One point that struck him in Mr. Tonge's paper was the statement as to getting more coal by hand per yard of face in the thin seams than was got by machinery. His experience had been that nearly double the quantity of coal per yard of face was got with machinery than could be got by hand, where the coal was hard. Mr. Tonge had spoken of paying one shilling a ton extra for working certain coal by hand. Now he had two machines working under similar conditions. The working of an upper mine had left the bottom one so hard that it meant more than a shilling a ton extra to work it. The difficulty was to get men to work it, and yet when the machine was put in it could be worked at the same price paid for working the virgin coal.

Mr. P. C. Pope said he was interested in mining work from the electrical point of view, and would like Mr. Tonge to give the meeting some particulars about his three-phase coal-cutters, especially after hearing Mr. Gerrard's remarks on the question of safety. In the three-phase cutters the danger due to sparking was entirely eliminated. Comparatively few of such cutters were at work in this country as yet, but their use was increasing. He knew of one at work in a Yorkshire mine; it was working quite satisfactorily, but there were no means of comparing it with other machines in the same pit, as it was the only cutter in use at that place, and any figures bearing on these machines would be useful. He would be glad if Mr. Tonge would tell the meeting the periodicity and power factor of the motors used in the Hulton Colliery Company's mines. The trouble with three-phase motors for coal-cutters was to get them small enough in diameter to cut in thin seams. The company he was connected with were experimenting with special motors for this purpose that would develop 30 horse-power continuously, with either 25, 30, 40, or 50 periodicity. They were 19 inches in diameter, and that was the smallest that had been made for that power. Another point he would like to ask was what trouble, if any, Mr. Tonge had experienced with trailing cables. They had usually been a source of trouble. He had had a lot of bother with them on a somewhat similar class of work, and had used all kinds of armouring, and had had more dire results with armour than without it. He had also tried braided leather as a protection to the insulation, but the leather was soon caught on tram nails, &c., and got torn, and it could not be satisfactorily repaired by the men underground. He finally used ¼ in. tar cord wrapped closely over the outer braiding of the cable, and that had served very well. A pitman could always see if anything was wrong with it, and easily repair it when necessary. In conclusion, he expressed the opinion that there was not much to fear from sparking at the machines or switches, as they were easily made flame tight; the only danger from this source lay in the cables themselves.

Mr. Hugh Crankshaw remarked that he had had some experience with electrical coal-cutters, and that the surest way to keep a straight line of face was to have the props set in a straight line parallel with the coal face and to have the machines running on sleds with a back guide rail on the machine, which rubbed against the props and thus kept the machine to its work. Mr. Garforth had proved it possible to make the continuous current motor safe, but the cable, as every one knew, was the chief source of trouble. It was not much use arguing about forms of motors till the difficulty with the cable was overcome.

Mr. Tonge, replying to the questions, said they got the same output in two seams from the same length of face in the same time with the cutter that they did by hand, but, as he had explained, that was because they did not work the cutter more than one shift. If they worked it oftener they would improve their position with the cutter. So far they had worked to feel their way cautiously, and had preferred to work it in one shift at night. As to keeping a straight face with the cutter, they could do that as Mr. Crankshaw had explained. If, however, the coal was hard and you had the cutter on wheels you had a great difficulty in keeping the rails straight, and if there was one part of the face harder than another a hump was formed there and the straight line of face was lost, whereas with the sleds the man set the props beforehand in a line, and, of course, the machine was much more rigid. He quite confirmed what Mr. Bousfield had said about the sleds dispensing with the services of an attendant. In every case that had been their experience. They were managing now with one man less at the cutter, so that in one mine they were working it—owing to the sleds—at 2¼d. per ton as against 3¼d. with the machines on wheels. With respect to Mr. Gerrard's question, as to the proportion per ton for risk of life. His remark in the paper on this point was perhaps not quite clear, but, he explained, that as the men got nearly twice the amount of coal that they did formerly by hand, and as the total number of men in the mine was reduced by about one-third for the same output, assuming the risks were no greater with the cutter than with hand labour, they reduced the premium per ton, but not the premium per man. In reply to Mr. Pope's query as to periodicity, he had to say it was 50. With regard to dragging the cables, they had experienced some difficulty in the matter. They did not find that armoured trailing cable was always best. An unarmoured cable was undoubtedly at the present time in the thin seam better for them than any other they had tried.

OUR UNDERGROUND WATER SUPPLY.

The discussion on Mr. Pickstone's paper upon the water supply of the country was resumed. (*See* Part VI., Vol. XXVIII.)

Mr. Pickstone, in opening the discussion, said he thought the impression was increasing that the Government should take some over-charge of the national water supply. The coal supplies were important. Two commissions had sat; one was sitting still, and one sat some thirty years ago on that subject. Now, the supply of water was much more important than the supply of coal, because we could get our coal from abroad when our own was finished up, many years hence. We should have need only to go abroad for our coal if England continued to be a nation of shopkeepers and manufacturers and engineers as she had been in the past. In the first discussion on this subject Mr. Watts took exception to water which had been treated chemically in order to make it suitable for house consumption, but he thought that water had been successfully treated in that way at Southport for many years, and probably it was treated in a similar way elsewhere. Mr. Watts was in favour of utilising to a greater extent than we at present do the water that came down from the clouds. Mr. Watts remarked that as a rule floods were few in every year. So they were, and it was possible that if water companies and corporations built larger reservoirs the difficulty that arose in some districts through insufficiency would be overcome. That was a question of expenditure. The water came down but was not at present stored as it might be. He submitted that it would be a good thing for the nation if some department of the Government took the control of the supply. As to Mr. Watts's question — what was meant by way-leaves?—he had to say he did not mean the deep underground passages, but those near the surface. You had to obtain leave from landowners (and pay them for it) to bring water-pipes through their property. Take the case of Birmingham. Birmingham was laying water mains to some Welsh hills or rivers 80 or 90 miles away, and she had to get way-leaves for the water to pass from the reservoir to her people, and probably hundreds of persons were interested in preventing the laying of water-pipes except on terms satisfactory to themselves. Well, if the water supply were under Government control that would be provided for—not by annihilating the rights of the individual owner, but by giving him what he ought to receive considering that public convenience was of greater importance than private ownership. Mr. Pickstone dealt with other points raised in the previous discussion, and insisted that nothing had been said to weaken his plea for Government control of the water supply.

Mr. Sydney A. Smith said Mr. Pickstone on a previous occasion had advocated the nationalisation of the British coalfields, when his great argument was that the coal was being rapidly worked and so much of it sent abroad that the coalfields would soon be exhausted. Now Mr. Pickstone wanted the water supply put under Government control. Mention had been made of the Dukinfield Collieries. There was a large supply of water in those mines, which had ceased working, but it was not fit for domestic use, and he did not think any treatment of a practical character would make it fit for drinking purposes. Of course if it was a question of getting an extra supply for watering the streets much of the water now flowing to waste could be utilised, but it would require a separate set of mains, and entail the expenditure of a considerable sum of money. Apart from the question of the water which might be obtained from the collieries, there was a good supply of water to be found in the New Red Sandstone round about Manchester, as had been proved on several occasions. His firm put down a pumping station for a bleach works near Bury, and they had obtained a large supply of excellent water from the Sandstone at a comparatively shallow depth. They did a similar work in Pendleton, and again an abundant supply was obtained. A curious fact was brought to light at the Bury pumping station concerning the rainfall and the time it took to percolate through the earth. At that place the water tunnels were 150 feet below the surface, and after a very dry season there came a heavy fall of rain; this occurred on several occasions, and it was noted that about three months usually passed before the rainfall affected the underground supply of water.

Mr. JAMES TONGE, said he thought the Society was indebted to Mr. Pickstone for bringing these subjects forward. He shared Mr. Pickstone's opinion quite strongly that the State ought to have control of both coal and water—coal because it was being wasted by being in the hands of private owners, and water because it was not preserved and utilised as it might and should be.

Mr. HENRY HALL, I.S.O., said he did not like the idea that we should get our drinking water from disused collieries, nor did he like Mr. Pickstone's idea that Manchester should be the area where the water should be collected from for drinking purposes. He thought, as a rule, the purest water was near the surface. Mr. Pickstone told them there would be no danger of getting foul water underground from an area thickly populated with people and thickly covered with houses. For his own part he imagined that the water on the surface was in connection with the water below.

Mr. PICKSTONE: I think there is no water below except what comes from the surface.

Mr. HALL: Then the one is in connection with the other. Would there not be set up something like what you have in your conservatory? Would not the warmth of the earth affect the deep water, and cause it to gradually rise and come up to the surface? If so, the water below would in time be affected by any foul water above. As to way-leaves, is it not a fact that a water company has the same rights as a railway company, and can compel owners of land to yield the right of way?

Mr. PICKSTONE: Yes. They go to arbitration if they cannot agree.

Mr. HALL: The same as do the railway companies.

Mr. PICKSTONE: I want the State to declare a reasonable price for way-leaves. I want to do away with the necessity to get Acts of Parliament at every turn. I cannot accept the theory that the water from below rose to the surface and shared in the pollution of surface water.

Mr. J. DICKINSON said he thought the information as to the time that the water took to percolate into deep workings is much to the point that has perplexed Mr. Pickstone and Mr. Hall. It took three months for the water near Bury to percolate down to the pumps. That agrees pretty well with the observations made in deep mines such as the metalliferous mines in Cornwall, where the water has taken sometimes six months to get down. But we have now got a subject that has occupied the attention of the lawyers for a long time. The records of the law courts are crowded with cases of water rights. It was a very complicated subject, and he thought that the Legislature would pause very much before they began to alter the law in this respect. It was a very difficult business to alter any one of these water rights. He did not think we need labour the subject too much, for we shall not produce much effect on the Government.

COHESION OF STRATA OVERCOME BY PRESSURE AND OTHER CAUSES.

By Mr. Joseph Dickinson, F.G.S.

In 1893, Vol. XXII. of the "Transactions," I brought before this Society an account of the difficulties experienced in working the Royley Mine at the Nook Pit, Broad Oak Colliery, Ashton-under-Lyne, from outbursts of soft coal and gas, which was discussed by us at a later date; it was also followed some time afterwards by a paper on the same subject by Mr. John Gerrard before the North of England Institute of Mining Engineers; also a paper by Mr. Frederick G. Meachem, communicated by me to this Manchester Society (1896, Trans. Vol. XXV.), on irruptions of coal into the "thick coal" workings at Hamstead Colliery, South Staffordshire; followed by further notes communicated in 1898 by Mr. John Finch; as well as communications elsewhere.

Bearing upon this subject, I see by a quotation in to-day's Manchester *Guardian* (January 11th, 1904), that similar difficulties are being experienced in driving the Simplon Tunnel through the Alps.

SIMPLON TUNNEL DIFFICULTIES.

The Milan correspondent of the *Daily Telegraph* writes that several experts, after visiting the piercing works at the Simplon tunnel, state that serious difficulties have arisen in carrying out the work. Owing to some inexplicable pressure exerted by the rocks, the wooden frames supporting the foremost tunnel are constantly bent and broken. No effort

> to stop the rockslides have been successful. In some places also the ground of the tunnel has sunk, overturning all the proppings and necessitating the excavation of fresh drainage channels. Geologists are unable to give an explanation of these movements. On the Swiss side, moreover, hot springs have burst out, scalding the labourers and compelling the suspension of all work. Water filters into the tunnel in tremendous quantities. About eighteen kilometres of the tunnel have now been pierced, leaving about two kilometres to complete the operation.

It has long been assumed that in certain zones of depth in collieries excessive quantities of firedamp are met with. It may be that such increase is due to cohesion of strata being overcome by pressure. The outbursts from pressure have in occasional instances smothered workmen, and have been dealt with according to circumstances, which have been described. One of the ways of dealing with ordinary excessive pressure is by wide driving, with pack walling at each side, and having the permanent roadway in the middle where it remains almost as secure as the interior of a pipe.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL AND MINING SOCIETY.

PART XIV. VOL. XXVIII. SESSION 1903-1904.

The ORDINARY MEETING of the Members was held on Tuesday, 9th February, 1904, in the Society's Rooms, 5, John Dalton Street, Manchester.

Colonel GEO. H. HOLLINGWORTH, F.G.S., President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society:—

Mr. CHARLES ARTHUR BUCKLEY, The Thorns, Prestwich Park, near Manchester.

Mr. GRIFFITH MORGAN DAVIES, 24, New Road, Ynisbwl, Pontypridd.

Mr. ROBERT B. GLOVER, Manager, The St. Helens Cable Co., Ltd., St. Helens.

Mr. G. P. HATTON, Civil Engineer and Surveyor, Dungannon, Co. Tyrone.

Mr. JAMES NICHOLSON, Jun., Mining Engineer, Bank House, Deansgate, Bolton.

Mr. FRED. ROBINSON, Haydock, St. Helens.

The following paper was read:—"The Palæontology of the Lancashire Coal Measures, with especial reference to the Collections in the Manchester Museum," by Mr. H. BOLTON, F.R.S.E., The Museum, Bristol:—

THE PALÆONTOLOGY OF THE LANCASHIRE COAL MEASURES.

By Mr. H. Bolton, F.R.S.E., The Museum, Bristol.

PART I.

The present paper contains the results of a series of observations carried on over a period of years upon the character, and vertical and geographical range of the fossils of the Lancashire Lower Coal Measures. The opportunity to further prosecute the study has ceased with the writer's removal from Manchester, and it seems desirable that the results so far as they have proceeded should be made available for other workers in the same field. The observations now recorded have been obtained by field work, and a careful examination of all collections to which access could be gained. Mainly, however, they are the result of examination and determination of the large collection of Lower Coal Measure fossils in the Manchester Museum, Owens College, made while the writer was an Assistant Keeper at that institution. So far as possible an attempt has been made to compile a list of all the animal fossils known, their horizon, and the locality where they are known to occur. Such a compilation, if accurate and fairly complete, will be of service as showing the range in time, and the geographical distribution within the known limits of the Lancashire Lower Coal Measures. The difficulties attending the task have increased of late years, owing to the working out of the coal in many places, and the consequent abandoning of the mines, which have speedily become choked up by roof falls and the accumulation of water.

The Lancashire Lower Coal Measures consist of beds of shales with thin ironstones, sandstones, flags, and thin coals, having a total thickness of 1,000 to 1,800 feet

The coal seams in descending order are as follows:—

PASTURE, BASSEY, AND OTHER THIN COALS.

Ft.	in.		
1	0	Upper Mountain Mine.	
0	2	Fireclay Coal.	
0	8	Upper Foot Mine	Mountain 4 ft.
2	6	Lower Mountain Mine	
0	8	Lower Foot Mine.	
2	0	Salts Mine.	
0	10	First Coal.	

It will be noticed that none of the coals are of great thickness, the chief being the Mountain Four Feet, which has been worked under a variety of names in the Burnley and Colne districts.

The Lower Mountain Mine, better known as the Gannister, has been very generally worked, and to a still less degree, the Upper Mountain Mine, and the Salts or Bassey seams.

The remarkable series of names which have been applied to the various seams in different districts, and at various times, has been dealt with in a previous paper by the author, and needs no further reference here.*

With the exception of one horizon, and the occasional occurrence of bands of Carbonicola (Anthracosia) in the shales, the beds are but moderately fossiliferous in point of species, although at times prolific in numbers.

Fossils are most abundant in the black shales which overlie the coal seams, and scanty in the coarse sandstones, flags and grits.

In this paper it may appear that fossils are most often found in the shales which lie in close relation to the coal seams, but this apparent segregation is doubtless due in

* "The Nomenclature of the Seams of the Lancashire Lower Coal Measures."—*Trans. Manch. Geol. Soc., Vol. XXV., Part XVI.*

great measure to the fact that fossils are more readily obtainable from the roadways and roofs of the seams than from surface exposures, where they readily crumble away.

Surface exposures are fairly plentiful in cloughs and stream courses, but unfortunately both shales and fossils readily disintegrate when thus exposed, and little can be made of the latter.

Even if got out whole, the specimens are apt to fall in pieces on drying, unless they have been extracted from ironstone nodules or ironstone bands which occur in the shale.

The presence of iron pyrites is also a fertile cause of destruction.

The roof shales of the Upper Foot or Bullion seam contain great numbers of flattened spheroidal masses of earthy carbonate of lime with an outer crust of iron sulphide or pyrites, usually in a very stable condition. These "bawm-pots," as they were once called by the colliers, are richly fossiliferous, and must not be confounded with the more irregular masses known as "bullion balls," which occur in the coal itself, and consist of carbonised and well preserved plant tissues.

In the accompanying pages all the animal fossils of the Lancashire Lower Coal Measures, other than the gasteropoda and cephalopoda, are fairly completely recorded—so far as they are known up to the present time.

The gasteropod and cephalopod groups have been partially omitted, because the former is in great confusion—few definite species being recognised and several undescribed—the latter (cephalopod) group, including a number of species of *Orthoceras*, to which the same remark will apply.

Any attempt to record species of these groups, except such common forms as *Goniatites Listeri*, would inevitably be rendered nugatory when revision takes place, whilst likely in the meantime to prove misleading.

The lowest group represented by fossils is that of Vermes, the highest that of Amphibia, whilst the most prolific in point of species and numbers are the Mollusca and Pisces.

Vermes.

Worm castings and tracks are occasionally abundant in the coarse grits. They are well seen in a coarse, yellow sandstone, lying about 70 feet above the Upper Mountain Mine at Hoyle Hey Clough, Old Meadows, and Broadclough Heights, near Bacup.

Arenicola carbonaria, Binney.

Upholland Flags everywhere. (Salter, Geol. Surv. Mem., Geology of the Country round Oldham, p. 35.)

Spirorbis carbonarius, Murch.

Pimbo Lane (Over Gannister), Bispham Colliery (above Mount. Mine). (Salter, *op. cit.*, p. 35.)

Spirorbis pusillus.

As Microconchus, recorded by E. W. Binney and Professor Hull, from over the Lower Mountain (Bassey, H.B.) Mine, at Billinge. (Hull, Geol. Surv. Mem., Geology of the Country around Wigan, p. 10).

Brachiopoda.

Discina orbicularis.

Examples of this species have been obtained from the roof of the Four Feet Mine at Colne. *(W466, e. coll. Wild, M.M.)

* This and succeeding similar references indicate the Register numbers and the name of the collection in which the specimens quoted occur in the Manchester Museum, Owens College.

It is interesting to note that the same species occurs in the "marine band" of the Middle Coal Measures, at Ashton Moss Colliery, Audenshaw. The specimen from this locality is—(L2620, e coll. Cairns, M.M.).

Lingula mytiloides, or L. Credneri.

It seems impossible to say which of these two species is the one occurring so abundantly throughout the shales of the Lower Coal Measures.

The species is most common in the shales lying between the Lower Mountain mine or Gannister and the top bed of the Rough Rock. It is most easily found in the black shales, both in the coal measures and in those of the millstone grit series below.

Lingula mytiloides or L. Credneri occurs in the lowest shales of the Lower Coal Measures throughout Rossendale. Examples are in the Dugdale Collection, M.M.

Greens Clough, near Portsmouth, in shales over the Upper Rough Rock. E. coll. Dugdale, M.M.

Carre Heys, Colne, over the Mountain Four Feet (W 505 e. coll. Wild, M.M.).

Kersley Moor, horizon not known. M.M.

Pimbo Lane (over Gannister). (Salter, Geol. Surv. Mem., Geology of the Country around Oldham, p. 35).

Lingula sp. Occurs in association with Posidonia (Posidoniella), over the Gannister coal at Billinge. (Hull Geol. Surv. Mem., Geology of the Country around Wigan, p. 10).

Eagley Shore Bridge, north of Bolton, below the Gannister coal. (Op. cit., p. 34.)

PELECYPODA.

Carbonicola (Anthracosia) robusta.

This species is rare in the Lower Coal Measures. It is recorded by Hull as follows:—Above the Gannister coal at

Bradshaw Brook, half-a-mile below Bradshaw. (Hull, Geol. Surv. Mem., Geology of the County around Bolton-le-Moors, p. 34.) Below the Gannister coal at Eagley Shore Bridge, north of Bolton. (Hull, op. cit., p. 34.)

In black shale, above shale bed coal (Bassey Mine) at Rushton Colliery, near Blackburn. (Dr. Wheelton Hind, Monog. Carbonicola, &c., Pt. II., p. 159.)

Carbonicola (Anthracosia) rugosa.

A specimen of this species has been recorded from Cant Clough, near Burnley, by Dr. Wheelton Hind, in his Monog. on Carbonicola, &c., by whom it is doubtfully referred to the Yoredales. The horizon from which the specimen came is much more likely to be the Lower Coal Measures.

Carbonicola (Anthracosia) acuta.

This species has been recorded from the roof of the Mountain Mine at Bankhouse, Shaw, near Oldham. The valves are curiously elongated, and seem to approach C. aquilina. (W. 539 e. coll. Wild, M.M.)

Shales over Lower Mountain or Gannister seam, at Stacksteads colliery, near Bacup. Found by the late John Lord, and in his collection.

Dr. Hind, in his diagrams of the Wigan and Blackburn district (op. cit., p. 159), indicates that this species occurs, in the one case (Wigan) between the Rough Rock and the Lower Foot Coal, and in the other (Rishton, near Blackburn) immediately over the Shale Bed coal (Bassey or Salts seam) in association with C. aquilina and C. robusta.

The horizon is probably the same in both cases, and identical with that given here for C. aquilina in the Rossendale district.

In the diagram of the coal measures in the Oldham district, Dr. Hind records C. acuta over the First Coal of the Holcombe Brook series (Bolton), from the Gannister or Lower Mountain Mine, in association with A. subconstricta, and from the 40 yards or Upper Mountain Mine at Burrs, half-a-mile north of Bury, in association with C. aquilina, Anthracomya Williamson, and A. Wardi.

Over Gannister coal, Broadfield, east of Rochdale. (Salter, Geol. Surv. Mem., Geology of the Country around Oldham, p. 61.)

Over Gannister, Pimbo Lane, Bispham Colliery. (Salter, Geol. Surv. Mem., Geology of the Country around Oldham, p. 35.)

Carbonicola (*Anthracosia*) *acuta var. rhomboidalis.*

This species is represented by (L. 2066) in the Kay-Shuttleworth collection in the Manchester Museum, Owens College. The specimens are from Burnley, but the horizon is not stated. It may be either Lower or Middle Coal Measures.

Carbonicola (*Anthracosia*) *acuta var ovalis.*

Above the Gannister coal at Bradshaw Brook, half-a-mile below Bradshaw. (Hull, Geol. Survey Mem., Geology of the Country around Bolton-le-Moors, p. 35.)

Above the 40 yards or Upper Mountain Mine at Burrs, half-a-mile north of Bury. (Op. cit., p. 35.)

Over Gannister coal at Bagslate Moor, 1½ miles north of Rochdale. (Salter, Geol. Surv. Mem., Geology of the Country around Oldham, p. 61.)

Carbonicola (*Anthracosia*) *subconstricta.*

"Mussel-band" below the Mountain Four Feet seam, Burnley. Examples are in the Kay-Shuttleworth Collection, M.M.

Over Gannister or Mountain Mine in the Oldham district, associated with C. acuta. (Dr. Hind's Monog., p. 161.)

Carbonicola (Anthracosia) nucularis.

This species is recorded by Dr. Hind in his Monog: on Carbonicola, &c. (p. 63 and p. 159), as occurring in the Lower Mountain Mine, Wigan.

Carbonicola (Anthracosia) aquilina.

This species is essentially the Carbonicola of the Lancashire Lower Coal Measures. It occurs in vast numbers in the shale immediately overlying the Bassey or Salts mine at Greave and Oaken Cloughs, near Bacup. It also occurs at Grime Bridge Clough. Specimens from Oaken Clough are in the Dugdale Collection, M.M.

Also at Helpet Edge, Saddleworth. Specimens are mostly in the form of internal and external casts. The species must have covered large banks of mud judging from its abundance at the localities named, it also ranges upwards to the shales under the Upper Mountain Mine. Carbonicola aquilina is probably the species recorded by C. Dugdale from his No. 6 bed of the Lower Coal Measures. (C. Dugdale, Trans. Man. Geol. Soc., Vol. XIX.)

Associated with C. acuta and C. robusta above Shale Bed coal (Bassey or Salts seam) at Rishton Colliery, near Blackburn.

Above the 40 yards or Upper Mountain Mine associated with C. acuta, Anthracomya Williamsoni, and A. Wardi at Burrs, half-a-mile north of Bury.

Carbonicola (Anthracosia) sp.

Over Mountain Four Feet Seam at Carre Heys, Colne. (W. 658 e coll., Wild, M.M.)

Anthracomya Williamsoni.

This species is recorded by Dr. Wheelton Hind from the Upper Mountain Mine, Burrs, half-a-mile north of Bury.

(Monog. Carbonicola, &c., Pt. II.; Mem. Palaeont. Soc., p. 100 and p. 161.) Specimen in the Jermyn Street Museum.

Anthracomya Wardi.

The same horizon is given by Dr. Wheelton Hind for this species as the last, namely:—Upper Mountain Mine, Burrs, half-a-mile north of Bury. (Op. cit. p. 106.) Specimen in the Jermyn Street Museum.

Anthracomya sp.

Above the Upper Mountain Mine at Burrs, half-a-mile north of Bury. (Hull, Geol. Surv. Mem., Geology of the County around Bolton-le-Moors, p. 35.)

Bispham Colliery, over Gannister coal. (Salter, Geol. Surv. Mem., Geology of the Country around Oldham, p. 35.)

Naiadites (Anthracoptera).

Naiadites modiolaris.

I have not seen a specimen of this species from the Lower Coal Meaures, but it is recorded by Dr. Wheelton Hind, from "30 feet below the Arley Mine, Rochdale." (Op. cit., p. 133.)

Naiadites quadrata.

This species is recorded by Dr. Wheelton Hind, from Bunker's Hill, west of Rochdale, 30 feet below the Arley Mine. (Op. cit., p. 141.)

Naiadites crassa.

This species was first recorded from the Lower Coal Measures by the late C. Dugdale under the name of Myalina crassa var modioliformis. It occurs in 50 feet of black shale under the Woodhead Hill rock and immediately above the ten-inch coal.

At Troughgate, near Bacup, a band of shale, two feet thick and full of this shell, was cut through in the railway cutting. The band was hard enough to take a polish, and was locally known as "*Troughgate Marble*."

Examples are in the Dugdale Collection, M.M., and the museum of the Bacup Natural History Society.

Naiadites sp.

Naiadites, the species of which are not mentioned, are stated by Dr. Hind to occur in the Oldham district, immediately over the First Coal above the Millstone Grit, and also high up in the Gannister Series. (Monog. Carbon., &c., p. 161.)

Above the Upper Mountain Mine at Burrs, half a mile north of Bury. (Hull, Geol. Surv. Mem., Geology of the Country around Bolton-le-Moors, p. 35.)

S. antiquus, Hind.

Roof of Mountain Four Feet, Carre Heys, near Colne. (W 626 and W 627, e coll. Wild, M.M.)

Lower Coal Measures of Burnley. (L 2081, e coll. Kay-Shuttleworth, M.M.)

The specimen (W 627) was figured by Mr. Geo. Wild as "Anthracosia, new angular species." Trans. Manch. Geol. Soc., Vol. XXI., Pl. II., fig. 7. (W 626) is associated with ostracods.

Posidoniella (Posidonomya).

Posidoniella laevis.

This pretty little shell has long been known to Lancashire collectors as Posidonia Gibsoni. It is especially characteristic of the roof shales of the Upper Foot or Bullion Mine and the Mountain Four Feet, where it occurs in great numbers, almost everywhere where these seams are exposed. It also ranges down to the Yoredale shales in the Todmorden Valley, where it was first found.

Recorded specimens are as follows :—

Posidonia Gibsoni, Brown. A specimen so named is in the Manchester Museum. Pimbo Lane (over Gannister coal), Bispham Colliery. (Salter, Geol. Surv. Mem., Geology of the Country around Oldham. p. 35.)

Roof of Mountain Four Feet, Townhouse, Brierfield, near Colne (W 633, e coll. Wild, M.M.).

Roof of Mountain Four Feet Mine, Trawden, near Colne (W 636, e coll. Wild, M.M.).

Roof of Upper Foot or Bullion Coal, Sholver, near Oldham (W 630, e coll. Wild, M.M.). (W 628) from the same locality is associated with Goniatites Gilbertsoni.

Roof of Mountain Four Feet, Burnley. (L 2084, e coll. Kay-Shuttleworth, M.M.)

Found in No. 10 bed of C. Dugdale, at Greens Clough, near Portsmouth. The horizon is low down in the series. Specimens in the Dugdale collection, M.M.

Roof of Mountain Four Feet, and Bullion Seam at Sharneyford, Reaps Clough, and Heighter Hey, near Bacup. Specimens in the Dugdale collection, M.M., and Museum of the Bacup Natural History Society.

Roof of Upper Foot or Bullion Seam at Dearnley, near Rochdale. (W 635, e coll. Wild, M.M.)

Over Gannister coal, Pimbo, near Wigan. (Dr. Hind: Monog. carbonif. Lamellibranchiata, p. 25, Pal. Soc., 1897.)

In shale nine feet above Bullion or Upper Foot Seam in Oakenclough, opposite a house called Pasture Bottom. Collected by the Author. As Monotis laevis recorded from Shore Edge, four miles north of Oldham, above the Gannister coal. (Salter. Geol. Surv. Mem., Geology of the Country around Oldham, p. 62.)

Posidoniella minor.

This species is a smaller form than the last and often confounded with it, and has an equally wide range.

Roof of Mountain Four Feet, at Trawden, near Colne. (W 629, e coll. Wild, M.M.)

In shale above the Upper Rough Rock at Tower Clough, Cliviger. Collected by the Author, and e. coll. Dugdale, M.M.

Roof of Bullion or Upper Foot seam, Heighters Hey, near Sharneyford. (e coll. Dugdale, M.M.)

In shales below the Old Lawrence or Tumbling Cob rock, and above the Gannister or Lower Mountain Mine at Heighters Hey, near Sharneyford. Collected by the Author.

Roof of Bullion or Upper Foot Seam throughout Rossendale. Collected by the Author, and collections in the Museum of the Bacup Natural History Society.

Posidoniella subquadrata.

This species is very rare, and so far is only recorded from two Lancashire localities. As the shales at these localities are very fossiliferous, careful search will almost certainly result in the finding of more.

Roof of Mountain and Four Foot Seam at Colne.

Roof of Bullion or Upper Foot Seam at New Hey, near Rochdale. (P 1779 e coll. Dawkins, M.M.)

Roof of Bullion Seam at Dearnley, near Rochdale. (Dr. Hind, *op. cit.*, p. 101.)

Posidoniella laevigata.

As Posidonia lævigata recorded by Salter from above the Bullion Coal at Sholver, two miles north-east of Oldham. (Salter. Geol. Mem. Surv., Geology of the Country around Oldham, p. 62.)

Posidoniella sp.

As Posidonia from over the Gannister coal at Billinge. (Hull Geol. Surv. Mem., Geology of the Country around Wigan, p. 10.)

Monotis (?) obtusa.

From Count Hill, north-east of Oldham, from above Gannister coal. (Salter. Geol. Surv. Mem., Geology of Country around Oldham, p. 61.)

Aviculopecten papyraceus.

This species occurs in the greatest abundance in the shales over the Bullion or Upper Foot Seam and the Mountain Four Feet. Where found in the "bawm-pots" the shells are usually uncrushed and in splendid preservation. Occasionally in the shales south of Bacup (Sharneyford) a mass of what appears at first sight to be shale, three or four inches in thickness, is found to consist almost wholly of the thin flattened valves of this species. Roof of Mountain Four Feet Seam at Trawden, Colne. (W 639, e coll. Wild, M M.)

From above the Gannister Coal at Roebuck Low, half mile N.E. of Oldham; Ogden Mill, five miles N. of Oldham; Shore Edge, four miles N. of Oldham; Count Hill, N.E. of Oldham; Dog Hill, Oldham.

From above the Bullion Coal at Sholver, two miles N.E. of Oldham.

From above Gannister Coal at Lower Lomax, Bury. (Hull, Geol. Surv. Mem., Geology of the Country around Bolton-le-Moors, p. 35.)

Shaley Brow, over the Bullion Coal. (Salter. Geol. Surv. Mem., Geology of the Country around Oldham, p.35.)

Roof of Bullion or Upper Foot Seam, Dulesgate, near Todmorden. (P 801, e coll. Dawkins, M.M.)

Roof of Bullion or Upper Foot Seam throughout Rossendale. Collected by the Author.

Shales over Bullion or Upper Foot Seam at Heighter Hey, Sharneyford. (e coll. Dugdale, M.M.)

Roof of Mountain Four Feet at Burnley, Lancashire. (L2080 e coll. Kay-Shuttleworth.)

Roof of Bullion or Upper Foot Seam at Sholver, Oldham. (W643 e coll. Wild, M.M.)

And ditto, Moorside, Oldham. (W641 e coll. Wild, M.M.)

Ditto, at New Hey, near Rochdale. (e coll. Dawkins, M.M.)

Ditto, at Hough Hill, Stalybridge, in shales and "bawm-pots." (W642 e coll. Wild, M.M.)

Ditto, at Starring, Dearnley, near Rochdale. (W640 e coll. Wild, M.M.)

Ditto, at Cloughfoot, Rossendale. Coll. J. A. Lee, Museum of the Bacup Natural History Society.

Nucula sp.

Roof of Bullion or Upper Foot Seam at Carre Heys, Colne. (W652 e coll. Wild, M.M.)

"*Crassa minima.*"

Roof of Mountain Four Feet Seam at Carre Heys, Colne. (W648 e coll. Wild, M.M.)

Ditto, Bullion or Upper Foot Seam at Sholver, near Oldham. (W647 e coll. Wild, M.M.)

Ditto, at Hough Hill, Stalybridge. (W1212 e coll. Wild, M.M.)

"*Solenomya primæva.*"

Roof of Bullion or Upper Foot Seam, Carre Heys, Colne. (W650 e coll. Wild, M.M.)

GASTEROPODA.

In the earlier part of this paper mention was made of the present unsatisfactory position of the gasteropods of the coal measures. This is probably due to the fact that the extreme rarity of specimens, and the difficulty of sufficiently clearing them from the matrix to determine their species, have acted as deterrents to investigators.

The few which do occur can be divided into three groups, according to their form. Those of least rarity are usually found flattened in the shales, and are turreted shells of from five to eight whorls, either with smooth surfaces or marked by transverse ridges. They have been classed with Buccinum, Turritella, Loxonema, Macrocheilus, Melania and Rissoa.

It is very probable that most of them will be found to fall ultimately into the families Melaniidae and Rissoidae.

The second group includes two or three forms in which the last or body chamber is much swollen, and the spire relatively inconspicuous. It includes forms apparently belonging to the genera Natica and Naticopsis. To the third group belong shells of a Bellerophon type. Seven species of the latter genus are recorded from the English Lower Coal Measures, and one (B. Urii) from the Middle series.

I have found gasteropod shells of a Melania type on two or three occasions in the shales lying between the Bullion or Upper Foot Seam, and the Upper Mountain Mine in the Rossendale district.

From "Bawm-pots" taken from the roof of the Bullion or Upper Foot seam in the Bacup district, I have obtained several specimens of a small shell—Raphistoma (?) ornata—and in several collections of fossils from the same horizon, but where the Bullion seam is joined to the Gannister to form the Mountain Four Feet, as at Carre Heys, Colne, is to be found a small but very perfect shell—Naticopsis globularis.

Both species were described and figured in the Manchester Memoirs, Vol. XLI. (1897), No. 6, by the writer.

The type specimens are in the Manchester Museum, and are registered as follows:—

Raphistoma (?) ornata, Bacup, Rossendale. (L. 3494, e coll. Bolton.)

Naticopsis globularis, Carre Heys, Colne. (W. 467, e coll. Wild.)

CEPHALOPODA.

Our knowledge of the cephalopoda of the coal measures is at present of the scantiest. They are mainly restricted to the Lower coal measures, if we except a very few, most of which are found in the remarkable "marine band" at Dukinfield. Whilst cephalopods were fairly abundant both in species and numbers during the marine phase of the Carboniferous Limestone, and also of large size, they show a great falling off in the succeeding Yoredale shales and Millstone Grit series.

A comparison of a series of cephalopod forms from the whole of the Carboniferous System shows that there was, with the passage from the purely marine conditions of the Carboniferous Limestone to the later littoral and lagunal conditions of the Millstone Grit and Coal measures, an equally progressive reduction in size, numbers, and species.

The inference seems clear that the altered conditions were unfavourable to cephalopod life, and resulted in starvation.

The occurrence of cephalopods in the Coal measures is restricted to those horizons which from their fossil contents indicate some return to the original marine conditions.

This is notably the case with the shales forming the roof of the Mountain Four Feet and Bullion Seams, where most of the cephalopods of the Coal Measures occur.

The genera are those of the Yoredales and Carboniferous Limestone.

Nautiloid forms are as follows :—

Ephipphioceras costatum.
,, clitellarium.
Coelonautilus subsulcatus.
,, quadratus.
Pleuronautilus falcatus.
Temnocheilus concavus.
,, carbonarius.

These occur rarely in the shales and "bawm-pots" over the Mountain Four Feet and Bullion Seams in the Burnley and Rossendale districts.

Examples of most of these species are, I believe, in the Manchester Museum.

The genus Orthoceras is represented by several species in the Lower Coal measures, all of which stand in great need of illustration and description. The specific names given by the older workers are of little value as guides, and some of the specific terms used by them are not recognised by later workers.

One form recorded from the shales about the Upper Mountain mine at Hoyle Hey Clough, near Bacup, has often to the writer's knowledge been recognised as O. teres, a species placed by Crick and Foord (Cat. Foss. Ceph., Part I., p. 121) in the Carboniferous Limestone of Scotland. A second species has received the name of O. cinctum, which is a synonym for O. discrepans of the Belgian Carboniferous Limestone.

Still another form is the Orthoceras obtusum of Brown, a species moderately common in the "bawm-pots" over the Mountain Four Feet and Bullion seams. This species is not recorded by Messrs. Crick & Foord in their British Museum Catalogue. It is, however, so well defined a form that the specific name will probably stand.

An excellent figure of a specimen of this species from the Mountain Four Feet seam is given in Mr. Geo. Wild's paper "The Lower Coal Measures of Lancashire." (Trans. Manch. Geol. Soc., Vol. XXI.)

When the Orthoceratites of the Coal Measures are revised and described, it is the writer's belief that at least half-a-dozen species will be found to occur in the Lower Coal Measures. An undescribed species is recorded by Salter from Shore Edge, four miles north of Oldham, from the roof of the Gannister Coal. (Salter, Geol. Survey Mem., Geology of the Country around Oldham, p. 62.)

At least three species of Orthoceras occur in the "bawm-pots" already alluded to, and in the shales lying above the Upper Mountain Mine of the Rossendale district.

The Ammonoidea forms of the Cephalopod group, more familiarly known as Goniatites, are amongst the best known of Lower Coal Measure fossils, and where they occur in the "bawm-pots" are in splendid preservation. It is not, therefore, surprising that eight species are known. They can be found in many more localities than are recorded here, the fewness of localities being due to the fact that safe specific determination has only become possible of late years, and the older specimens are usually not localised. All the species may be looked for with a fair degree of certainty in the Burnley coalfield, in Rossendale, and along the band of Lower Coal measures which stretch from Littleborough by Dearnley and Rochdale to New Hey and Oldham.

The species known and their horizons and localities are as follows:—

Glyphioceras (Goniatites) sp. near truncatum.

An undescribed species, supposed to be closely allied to G. truncatus, is recorded by Salter from Roebuck Low, 1½ miles N.E. of Oldham, from over the Gannister Mine. (Salter, Geol. Surv. Mem., Geology of the Country around Oldham, p. 62.)

Glyphioceras (Goniatites) reticulatum.

Recorded by Hull as Goniatites Gibsoni, from above Lower Lomax, Bury, opposite Broad Oak Mill, from above the Gannister coal. (Hull, Geol. Surv. Mem., Geology of the Country around Bolton-le-Moors, p. 35.)

Glyphioceeas (Goniatites) diadema.

This species is recorded by Messrs. Crick and Foord from the Coal Measures of Rochdale. From the description of the specimens (C5908, Brit. Mus.) there is little doubt that the horizon is that of the Bullion or Upper Foot Seam.

Glyphioceras (?) (Goniatites) paucilobum.

This species is only recorded by Messrs. Crick and Foord from the Carboniferous Limestone of Yorkshire.

It is mentioned by Salter as also occurring at Sholver, two miles north-east of Oldham, over the Bullion coal. (Salter. Geol. Surv. Mem., Geology of the Country around Oldham, p. 62.)

Dimorphoceras (Goniatites) Gilbertsoni.

This species is generally known to collectors as "Goniatites atratus," and occasionally is found by hundreds in a single "bawm-pot." It can be found in all sizes from a pin's head up to others having a diameter of 15m.m. Larger specimens are rare. It occurs abundantly in the "bawm-pots" over the Mountain Four Feet seam in the Burnley district, and less frequently over the Bullion coal.

Specimens from Carre Heys and Trawden, near Colne, are in the Wild Collection of the Manchester Museum.

Examples from the Lower Coal Measures of Watersheddings, near Oldham, are in the Geo. Scott collection of the Museum of the Bacup Natural History Society.

It is recorded from Halifax by Messrs. Crick and Foord in association with D. discrepans and D. Looneyi. The latter ought therefore to be looked for over the Mountain Four Feet and Bullion seams in Lancashire localities.

Gastrioceras (Goniatites) carbonarium.

This species has unfortunately been long confused with the more familiar G. listeri, and often recorded as the latter. They are often found in association over the Mountain Four Feet and Bullion Seams, but G. carbonarium is the rarer of the two, and appears to be restricted to the horizon mentioned, whilst G. listeri ranges downwards to the bottom of the Coal Measures.

The distribution is general throughout the Burnley, Rossendale, and Oldham districts. A specimen from Burnley Moor (C68082) is in the British Museum collections, as also a second specimen (C2273) from Lancashire, with no locality.

Gastrioceras (Goniatites) Listeri.

We have already stated that this species occurs as a common fossil over a wide area. Almost all collections of Lancashire Coal Measure fossils contain several specimens of the species, chiefly obtained from the horizon mentioned.

It is recorded by Salter from the roof of the Gannister Coal at—

Shore Edge, four miles N. of Oldham.
Ogden Mill, five miles N. of Oldham.
Roebuck Low, one and a half miles N.E. of Oldham.

From the Bullion Coal of Sholver, four miles North of Oldham.

(Salter, Geol. Mem. Surv., Geology of the Country around Oldham, p. 62.)

Shaley Brow, Pimbo Lane (over the Bullion Coal). (Salter, Geol. Surv. Mem., Geology of the Country around Oldham, p. 25.)

Gastrioceras (Goniatites) coronatum.

This is a beautiful little shell, only recorded as yet from the roof of the Mountain Four Feet and Bullion Seams of Sharneyford, near Bacup, where it was found by the writer.

Specimens from the locality are in the British Museum, (C5938) and the Manchester Museum.

CRUSTACEA.

Crustacea are very feebly represented in the Lower Coal Measures, both in numbers and species. This is equally true of those forms familiarly known as Ostracoda as of higher forms.

The development of the Ostracoda group in the whole series of Lancashire Coal Measures is likely to prove an interesting study owing to the fact that specimens are rare in the Lower series, moderately abundant in the Middle Coal Measures, and practically swarm in the Upper series, the increase of genera and species proceeding with the increase of numbers.

The Ostracoda from the Lower Coal Measures are as follows:—

Estheria striata.

Recorded from bituminous coal of the Lower Coal Measures by Professor Rupert Jones (Pal. Soc. Mem., Fossil Estheriae, p. 24.)

Estheria striata, var. Beinertiana.

Bullion coal. Shaley Brow, near Billinge Hall. (Salter. Geol. Surv. Mem., Geology of the Country around Oldham, p. 35.)

Estheriæ.

Roof of Bassey or Salt's coal; also in shale over 40 yards (Upper Mountain Mine) coal, and in shale lying over the two inch coal. (Prof. Rupert Jones, op. cit., p. 29).

Roof of the Mountain Four Feet Mine at Carre Heys, Colne, associated with an example of Schizodus deltoideus. (W626, e coll. Wild, M.M.)

Beyrichia arcuata.

Below Gannister coal at Eagley Shore Bridge, north of Bolton. (Hull. Geol. Sur. Mem., Geology of the Country around Bolton-le-Moors, p. 34.)

Above Gannister coal at Bradshaw Brook, half-a-mile below Bradshaw. (op. cit., p. 34.)

Beyrichia sp.

In grey shale above the Bullion coal at Broad Oak Mill, Bury. (Salter. Geol. Surv. Mem., Geology of the Country around Oldham, p. 19.)

Below Gannister coal at Eagley Shore, north of Bolton. (Hull. Geol. Surv. Mem., Survey of the Country around Bolton-le-Moors, p. 34.)

Cypris or Cythere.

Over Lower Mountain Mine (Gannister Mine, H.B.), at Billinge. (Hull. Geol. Surv. Mem., Geology of the Country around Wigan, p. 10.)

Cytheropsis sp.

Over Bullion coal. Pimbo Lane, Bispham Colliery. (Salter. Geol. Surv. Mem., Geology of the Country around Oldham, p. 35.)

Pygocephalus Cooperi.

A single example of this rare and aberrant species was described by Huxley. It was found by Mr. George Wild above the Mountain Four Feet coal at Carre Heys, Colne, in a bed of shale with nodules called the "Soapstone Bed." (W508, e coll. Wild, M.M.)

Only one other specimen is known, from the Middle Coal Measures of Medlock Park Bridge, Ashton-under-Lyne. This is also in the Manchester Museum.

Anthrapalaemon Etheridgii.

A specimen of the cephalothorax of this species was found in the Lower Coal Measures of Cant Clough, near Burnley, in 1884. It came into the writer's possession, by whom it was verified at the British Museum. The specimen was afterwards lost.

Cyclus Scotti.

The type specimen of this species was found by Mr. George Scott in shale over the Gannister coal at the Old Meadows Colliery, Bacup. It is now in the Manchester Museum. (L926, M.M.)

Prestwichia rotundata.

A specimen of this species is in the Kay-Shuttleworth collection (L2161) at the Manchester Museum. It was obtained from Padiham, near Burnley, and whilst its horizon is unknown the writer regards it as almost certainly in the Lower Coal Measures, and from the horizon of the next species, viz., the Mountain and Four Feet Mine.

Architarbus subovalis.

The type and only specimen of this species was described by Dr. Henry Woodward in 1872, where it is stated that it occurred in a clay-ironstone nodule from about four feet above the "four-feet mine," or "bone-coal" of Padiham.

This description seems to indicate the horizon as above the Mountain Four Feet, a supposition which is strengthened by the fact that the horizon of the species is placed by Mr. R. Etheridge in the Lower Coal Measures. (Etheridge. Fossils of the British Islands, Pl. I., p. 243.)

PISCES.

The fishes of the Lower Coal Measures are mainly represented by detached scales and teeth, whole fishes being extremely rare. A few have been found in the nodules overlying the Mountain Four Feet seam, and fragmentary remains in the ironstone nodules lying over the Bullion seam.

It is a curious fact that fish teeth, scales, &c., always occur in greatest profusion in the shales lying immediately upon the coal seams, and most of all in their lower layers, and even upon the upper surface of the coal itself.

Possibly this can be accounted for by the conditions being unfavourable to life in those waters which lay over the peaty mass representing the present coal seams after their subsidence.

Hybodopsis Wardi.

This rare species is represented by a mass of teeth and six bone fragments from over the Mountain Four-Feet of Colne. The specimen is in the Wild Collection (W978) of the Manchester Museum.

Only one other example is known. It is in the collection of Mr. John Ward, of Longton, Staffordshire.

Sphenacanthus hybodoides.

A tooth from the Lower Coal Measures (Mountain Four-Feet) of Colne is in the Wild Collection of the Manchester Museum (W452).

Acanthodes Wardi.

This species has been found in the shales over the Mountain Four Feet seam at Colne. (W1145 e coll. Wild, M.M.)

Lepracanthus colei.

An interesting example of this fish spine from over the Lower Mountain Mine (Gannister, H.B.) of Burnley is in the Wild collection at the Manchester Museum. The specimen possesses two rows of denticles on the hind border, with the denticles of opposite sides alternating. (W958 e coll. Wild, M.M.)

Gyracanthus formosus.

From the roof of the Upper Mountain Mine at Hapton, near Burnley. (L2170 e coll. Kay-Shuttleworth, M.M.)

Listracanthus spinatus.

This species is founded upon a spine enclosed in a "bawm-pot" from the roof of the Mountain Four Feet or Bullion seam, which was found by the writer in the collections of the Salford Royal Museum, at Peel Park. The locality is unknown, but undoubtedly Lancashire.

A second specimen was found by the writer in the roof of the Bullion mine, at Bacup.

With the exception of an unknown species of Listracanthus from the "marine band" of the Middle Coal Measures of Dukinfield, these are the only recorded occurrences of the genus in the English Coal Measures.

Strepsodus sauroides.

This species has been recorded from over the Lower and Upper Mountain Mines of the Hapton valley, near Burnley.

Also from the roof of the Bullion seam, Oldham. This latter specimen is in the Dawkins collection of the Manchester Museum.

Rhizodopsis sauroides.

As "Rhizodus granulatus" this species is recorded by Salter as follows:—

From Little Mine next below the Gannister (Lower Foot H.B.) at Helpet Edge, Ogden Mill, four miles north of Oldham.

From the same horizon at Crompton Moor, four miles north of Oldham. (Salter. Geol. Surv. Mem., Geology of the Country around Oldham, p. 62.)

From over the Gannister coal at Kenyon Fold, two miles north of Rochdale.

As "Rhizodus granulatus" by Hull, from over the 40 yards or Upper Mountain Mine at Burrs, half-a-mile north of Bury. (Hull. Geol. Surv. Mem., Geology of the Country around Bolton-le-Moors, p. 35.)

Scales and teeth have been found by the writer in ironstone nodules over the Mountain Four Feet and Bullion seams at Sharneyford and Hoyle Hey Clough, near Bacup.

As "Rhizodus granulatus" from Gannister beds above the Lower Yard coal (Gannister H.B.) at Rosegrove, Broadbottom, south of Mottram. (Salter. Geol. Surv. Mem., Geology of the Country around Oldham, p. 62.)

Megalichthys Hibberti.

From above the Upper Mountain Mine in Rossendale. (e coll. Dugdale, M.M.)

At Reaps Clough, near Bacup, from above the Upper Mountain Mine. (e coll. Dugdale, M.M.)

From Lower Coal measures at Hollingworth, near Rochdale, horizon not stated. (e coll. J. A. Lee, Museum of Bacup Natural History Society.)

Recorded by Salter from the following horizons and localities in Geol. Survey Mem., Geology of the Country around Oldham, pp. 35 and 62.

From Lower Foot Mine, at Count Hill, north-east of Oldham.

Over Gannister coal at Bagslate Moor, one and a half miles north of Rochdale.

From Gannister beds above the Lower Yard seam (Gannister, H.B.) at Rose Grove, Broadbottom, south of Mottram.

From roof of Gannister coal at Halliwell, one and a half miles north-west of Bolton.

Recorded by Hull (Geol. Surv. Mem., Geology of the Country around Bolton-le-Moors, p. 35), from roof of Gannister coal at Halliwell, one and a half miles north-west of Bolton.

Megalichthys pygæmus?

A beautiful specimen, showing the greater part of a cranial shield, is in the Wild Collection of the Manchester Museum (W852), and is doubtfully referred by me to this species. It is from the Lower Coal Measures of Hapton, near Burnley.

Cœlacanthus elegans.

From roof of Bullion or Upper Foot seam at Pasture Bottom, Oakenclough, near Bacup. Found by the writer.

As Cœlacanthus sp. of Salter, from Mountain Mine of Bispham Colliery. (Salter. Geol. Survey Mem., Geology of Country around Wigan, p. 35.)

Ditto, above Gannister coal, at Bradshaw Brook, half a mile below Bradshaw. (Salter. Geol. Survey Mem., Geology of the Country around Bolton-le-Moors, p. 35.)

Over Gannister coal at Kenyon Fold, two miles north of Rochdale. (Salter. Geol. Surv. Mem., Geology of the Country around Oldham, p. 62.)

Rhadinichthys monensis.

Recorded as "Palaeoniscus monensis," from the Gannister coal at Bagslate Moor, one and a half miles north of Rochdale. (Salter. Geol. Surv. Mem., Geology of the Country around Oldham, p. 62.)

Also from above the Lower Yard seam (Gannister, H.B.) at Rose Grove, Broadbottom, south of Mottram. (Op. cit., p. 62.)

Rhadinichthys Planti.

From Burnley, Lancashire; horizon unknown. (e. coll. Kay-Shuttleworth, M.M.)

Elonichthys semistriatus.

From roof of Bullion or Upper Foot seam at Pasture Bottom, Oakenclough, near Bacup. (Bolton. Trans. Man. Geol. Soc., Vol. XX.)

Elonichthys Aitkeni.

From "Soapstone Bed," four feet over Mountain Four Feet seam, Burnley. (e coll. Kay-Shuttleworth.)

From roof of Lower Foot coal, Bacup.

Elonichthys Egertoni.

As "Palæoniscus Egertoni" recorded by Salter from the Little Mine (Lower Foot, H.B.), next below the Gannister at Helpet Edge, Ogden Mill, four miles north of Oldham. (Salter. Geol. Surv. Mem., Geology of the Country around Oldham, p. 62.)

Also from the Gannister beds about the Lower Yard seam (Gannister, H.B.) at Rose Grove, Broadbottom, south of Mottram. (Op. cit., p. 62.)

Diplodus teeth.

From above the Mountain Mine of Bispham Colliery. (Hull. Geol. Surv. Mem., Geology of the Country around Oldham, p. 22; Salter, op. cit., p. 35.)

Coprolites.

Roof of Bullion coal, Littleborough. (W. 1101, e coll. Wild, M.M.)

Roof of Mountain Four Feet coal at Colne. (W. 428, e coll. Wild.)

Amphibia.

Hylonomus Wildi (A. S. Woodward).

The collections of Mr. George Wild from the "Soapstone Bed" over the Mountain Four Feet of Trawden, near Colne, contain microsaurian remains of considerable interest. These, first recognised as new by Mr. John Ward, of Longton, were afterwards described by Dr. A. Smith Woodward.

They are interesting, in so much that the family to which the species belonged had not hitherto occurred in Europe, although known from the coal measures of Nova Scotia. The specimen is in the Manchester Museum. (W. 1222, e coll. Wild.)

Microsaurian remains.

The Wild collection contains, in addition to the species mentioned, a specimen (W1130) from the "Soapstone Bed" over the Mountain Four Feet of Trawden, near Colne, which shows what is evidently the under portion of a small amphibian skull, as yet undescribed.

Range in Time.

An examination of the range in time of the various groups of fossils presents an interesting study, and yields valuable results. It will be noted by reference to the range table appended to this paper that fossils of any kind are scanty until the shales over the Gannister mine are reached.

The shales below and above the First coal have yielded but four species, three of which are mollusca, and one brachiopod. Of these four, two, Lingula mytiloides and Posidoniella minor, are common also to the millstone grit series below.

The shales over the Bassey or Salts Mine next in order have yielded Spirorbis pusillus, three species of Carbonicola, and an unknown species of Estheria.

So far, there is nothing in the fossils themselves which can be indicative of purely marine conditions.

This is seen to be hardly the case, however, when we consider the forms found in the beds above the Lower Foot Mine. Here the species have increased to eight, three of which are fishes. The occurrence of the latter point clearly to the incoming of a marine phase, which did not advance very far, judging by the fact that two of the forms are recorded from one locality each and the other from two.

The evidence of a marine phase is suddenly emphasised by the shales over the Gannister or Lower Mountain coal, from which no less than 30 species have been obtained.

Five of these are cephalopoda and eight fishes. The cephalopoda appear here for the first time, and are accompanied by twelve species of mollusca as contrasted with but two species in the shales below the Gannister.

The presence of the cephalopoda alone sufficiently stamps this horizon as of marine origin, and as they are accompanied by five species of Carbonicola, as against three over the Bassey mine, and two over the Lower Foot, we can reasonably assume that marine conditions were more favourable for the development of the latter genus than brackish or littoral.

From what has been written elsewhere it will be understood that the horizons above the Bullion and Mountain Four Feet mines are practically one, and it is on this joint horizon that life was most abundant both in species and numbers. Thirty-five species are known to occur, of which twenty-eight belong to the groups Pelecypoda, Cephalopoda, and Pisces.

The horizon above these two seams is one of considerable importance on account of its wide geographical range.

Speaking generally, it can be traced with the greatest ease over the whole of the Lower Coal Measure area in Lancashire and onwards into Yorkshire, where, as the Halifax Hard Bed, it is as readily recognisable as elsewhere.

Wherever it occurs it seems to yield the "bawm-pots" with their loads of animal remains, and the even more celebrated "bullion-balls," always rich in well preserved plant tissues.

In point of time the bullion balls are slightly, but not much, older than the "bawm-pots."

The great wealth of the shales above the Mountain Four Feet and Bullion seams lies in the lowest portion, and ranges as high as the "Soapstone Bed" of Trawden and Colne, which occurs about four to seven feet above the coal.

Higher than this there is a marked falling off in numbers and species.

From above the Fireclay coal no species have been recorded, largely, no doubt, owing to the fact that it is never worked and is difficult to find on exposures.

The shales over the Upper Mountain Mine show that the falling off in species noticed in the upper shales over the Mountain Four Feet and Bullion mines had continued. Thirteen species are known, only two of which are cephalopoda, seven being pelecypoda, and four fishes. The marked falling off of cephalopoda and fishes is evidently an indication of a return to more unfavourable and less marine conditions.

The thin coals and shales above the Upper Mountain Mine are very little known and have never been worked out. But two species of mollusca are known from them.

One feature which will probably strike the student is that animal life was more abundant immediately after the deposition of the thickest coals, and more scanty over the thin seams.

It is by no means improbable that this was due to more staple geographical conditions in the first case.

Geographically, the various life forms seem to have been most numerous in numbers and species along the north-eastern and northern portions of the Lancashire coal field, more especially in the latter. Over the rest of the area life forms are fairly evenly distributed.

In conclusion, the writer's endeavour has been to prove the horizon and geographical occurrence of each species as far as possible by reference to known specimens, and thus afford data for a better knowledge of the palaeontology, and also a starting point for future work.

The writer must also record his gratitude to Prof. W. Boyd Dawkins and Dr. W. E. Hoyle, of the Manchester Museum, for the facilities given to him whilst a member of the staff, and for continued interest and help.

	Vermes.	Brachiopoda.	Pelecypoda.	Gasteropoda.	Cephalopoda.	Crustacea.	Pisces.	Amphibia.
Shales below First Coal.. ..	—	1	2	—	—	—	—	—
,, above ,, ,, ...	—	—	1	—	—	—	—	—
,, ,, Bassey Mine ..	1	—	3	—	—	1	—	—
,, ,, Lower Foot Mine	—	1	2	—	—	2	3	—
,, ,, Gannister ,,	1	1	12	—	5	3	8	—
,, ,, Bullion ,,	—	—	8	1	14	3	4	—
,, ,, Mountain Four-Feet	—	2	7	1	12	4	6	2
,, ,, Fireclay Coal ..	—	—	—	—	—	—	—	—
,, ,, Upper Mountain Mine	—	—	7	—	2	—	4	—
Thin Coals above Upper Mountain Mine	—	—	2	—	—	—	—	—

	Under First Coal.	Above First Coal.	Over Bassey Mine.	Over Lower Foot Mine.	Over Gannister Mine.	Over Bullion Mine.	Over Mountain 4 ft. Mine.	Over Fireclay Coal.	Over Upper Mountain Mine.	Pasture and other thin coals.
Vermes.										
Arenicola carbonaria (*Binney*)	..	..	..	..	..	..	..	..	..	..
Spirorbis carbonarius (*McCoy*)	..	..	..	..	×	..	..	..	..	..
,, pusillus (*Martin*)..	..	..	×	..	..	..	..	..	..	..
Brachiopoda.										
Discina orbicularis (*Bolton*)	..	..	..	..	..	..	×	..	..	..
Lingula mytiloides (*Sow.*), or L. Credneri (*Geinitz*)	×	..	..	..	×	..	×	..	..	..
Lingula sp.	..	..	..	×	..	..	..	..	..	..
Pelecypoda.										
Carbonicola (Anthracosia) robusta (*Sow.*)	..	..	×	×	×	..	..	..	..	..
,, ,, acuta (*Sow.*)	..	×	×	..	×	..	..	..	×	..
,, ,, ,, var ovalis (*Martin*)	..	..	..	..	×	..	..	..	×	..
,, ,, rugosa (*Brown*)	..	..	..	..	..	..	..	..	..	..
,, ,, acuta, var rhomboidalis (*Hind*)	..	..	..	.	..	..	..	..	..	..

Carbonicola (Anthracosia) subconstricta (*Sow.*)	..	..	..	×	×	..	×	..	..	..
,, ,, nucularis (*Hind*)	..	..	..	×	..	..	..	..	..	..
,, ,, aquilina (*Sow.*)	..	..	×	..	..	..	..	..	×	..
,, ,, sp.	..	..	..	..	..	..	×	..	..	..
Anthracomya Williamsoni (*Brown*) ..	..	..	..	..	..	..	..	..	×	..
,, Wardi (*Salter*)	..	..	..	..	..	..	..	..	×	..
,, sp.	..	..	..	..	×	..	..	..	×	..
Naiadites modiolaris (*Sow.*)	..	..	..	..	..	..	..	..	..	×
,, quadrata (*Sow.*)	..	..	..	..	..	..	..	..	..	×
,, crassa (*Fleming*)	×	..	..	..	..	..	..	..	..	..
,, sp.	..	..	..	..	..	..	..	..	×	..
Schizodus deltoidens	..	..	..	..	..	..	×	..	..	..
Posidoniella lævis (*Brown*)	..	..	..	..	×	×	×	..	..	..
,, minor (*Brown*)	×	..	..	..	×	×	..	..	..	..
,, subquadrata (*Hind*) ..	..	..	..	..	..	×	×	..	..	..
,, lævigata	..	..	..	..	×	×	..	..	..	..
,, sp.	..	..	..	..	×	..	..	..	..	..
"Monotis(?)(Gervillia) obtusa" (*Brown*)	..	..	..	..	×	..	..	..	..	..
Aviculopecten papyraceus (*Sow.*) ..	..	..	..	..	×	×	×	..	..	..

	Under First Coal.	Above First Coal.	Over Bassey Mine.	Over Lower Foot Mine.	Over Ganister Mine.	Over Bullion Mine.	Over Mountain 4 ft. Mine.	Over Fireclay Coal.	Over Upper Mountain Mine.	Pasture and other thin coals.
"Nucula sp."	..	..	..	..	..	×	..	..	..	..
"Crassa minima"	..	..	..	..	..	×	×	..	..	..
"Solenomya primeva" (*Phillips*)	..	..	..	..	..	×	..	..	..	..
GASTEROPODA.										
Raphistoma (?) ornata (*Bolton*)	..	..	..	..	..	×	..	..	..	..
Naticopsis globularis (*Bolton*)	..	..	..	.	..	..	×	..	..	..
CEPHALOPODA.										
Ephippoceras costatum (*Foord*)	..	..	..	..	..	×	×	..	..	..
,, clitellarium (*Sow.*)	..	..	..	..	..	×	×	..	..	..
Coelonautilus subsulcatus (*Phillips*) ..	..	..	..	..	..	×	×	..	..	..
,, quadratus (*Fleming*) ..	..	..	..	..	..	×	×	..	..	..
Pleuronautilus falcatus (*Sow.*)	..	..	..	..	..	×	×	..	..	..
Temnocheilus concavus (*Sow.*)	..	..	..	..	..	×	×	..	..	..
,, carbonarius (*Foord*) ..	..	..	..	..	..	×	×	..	..	..

Orthoceras teres (*Sow*)	..	..	..	..	..	..	..	..	×	..
,, cinctum (*de Konenck*) = O. discrepans (*de Konenck*)	..	..	..	..	..	..	..	..	×	..
,, obtusum (*Brown*)	..	..	..	..	..	×	×	..	..	..
,, sp.	..	..	..	..	×	..	..	..	..	..
Glyphioceras (Goniatites) sp. near truncatum	..	..	..	..	×	..	..	..	.	..
Glyphioceras (Goniatites) reticulatum (*Phillips*)	..	..	..	..	×	..	..	..	..	..
,, ,, diadema (*Beyrich*)	..	..	..	..	..	×	..	..	..	..
,, (?) ,, paucilobum (*Phillips*)	..	..	..	..	..	×	..	..	..	..
Dimorphoceras Gilbertsoni (*Phillips*) ..	..	..	..	..	..	×	×	..	..	..
Gastrioceras (Goniatites) carbonarium (*V. Buch*)	..	..	..	..	..	×	×	..	..	..
,, ,, Listeri (*Martin*) ..	..	..	..	..	×	×	×	..	..	..
,, ,, coronatum (*Foord & Crick*)	..	..	..	..	..	×	×	..	..	..
CRUSTACEA.										
Estheria striata (*Münst.*)	..	..	..	..	..	..	..	..	..	..

	Under First Coal.	Above First Coal.	Over Bassey Mine.	Over Lower Foot Mine.	Over Ganister Mine.	Over Bullion Mine.	Over Mountain 4 ft. Mine.	Over Fireclay Coal.	Over Upper Mountain Mine.	Pasture and other thin coals.
Estheria var Beinertiana (*Jones*) ..	..	..	..	..	..	×	..	..	..	..
,, sp.	..	..	×	..	..	..	×	..	..	..
Beyrichia arcuata (*Bean*)	..	..	..	×	×	..	..	..	..	..
,, sp.	..	..	..	×	..	×	..	..	..	..
Cypris or Cythere	..	..	..	..	×	..	..	..	..	..
Cytheropsis	..	..	..	..	..	×	..	..	..	..
Pygocephalus Cooperi, *Huxley*	..	..	..	..	..	..	×	..	..	..
Anthrapalæmon Etheridgei (*Peach*)...	..	..	..	..	..	..	..	..	..	..
Cyclus Scotti (*Woodward*)..	..	..	..	..	×	..	..	..	..	..
Prestwichia rotundata (*Prestwich*)....	..	..	..	..	..	..	×	..	..	..
,, Birtwelli, *Woodward* ..	..	..	..	..	..	..	..	..	..	..
Architarbus subovalis, *Woodward* ..	..	..	..	..	..	..	×	..	..	..
PISCES.										
Hybodopsis Wardi, *Barkas*	..	..	..	..	..	..	×	..	..	..

Sphenacanthus hybodoides (*Egerton*) ..	..	..	..	..	..	..	×	..	..	..
Acanthodes Wardi (*Egerton*)	..	..	..	..	..	..	×	..	..	..
Lepracanthus colei (*Egerton*)	..	..	..	..	×	..	..	..	..	..
Gyracanthus formosus *Agassiz*	..	..	..	..	..	..	..	..	×	..
Listracanthus spinatus (*Bolton*)	..	..	..	..	..	..	×	..	..	..
Strepsodus sauroides (*Binney*) ..	..	..	..	..	×	×	..	..	×	..
Rhizodopsis sauroides (*Williamson*) ..	..	..	..	×	×	×	×	..	×	..
Megalichthys Hibberti, *Agassiz*	..	..	..	×	×	..	..	..	×	..
,, pygmæus (*Traquair*) ..	..	..	..	..	..	..	..	..	..	..
Cœlacanthus elegans, C. lepturus, *Agassiz*	..	..	..	..	×	×	..	..	..	..
Rhadinichthys monensis (*Egerton*) ..	..	..	..	..	×	..	..	..	..	..
,, Planti, *Traquair*	..	..	..	..	..	..	..	..	..	..
Elonichthys semistriatus, *Traquair* ..	..	..	..	..	..	×	..	..	..	..
,, Aitkeni, *Traquair*	..	..	..	..	..	..	×	..	..	..
,, Egertoni (*Agassiz*)	..	..	..	×	×	..	..	..	..	..
Diplodus sp.	..	..	..	..	×	..	..	..	..	..
Coprolites	..	..	..	..	..	×	×	..	..	..
AMPHIBIA.										
Hylonomus Wildi (*A. Smith Woodward*)	..	..	..	..	..	..	×	..	..	..
Microsauria (?)	..	..	..	..	..	..	×	..	..	..

The PRESIDENT said that the paper, besides being a valuable record, was a testimony to very considerable work on Mr. Bolton's part.

Mr. JOSEPH DICKINSON said he had much pleasure in moving a vote of thanks to Mr. Bolton for his paper, which must have cost the writer a considerable amount of trouble and attention to compose. "It is a subject," Mr. Dickinson continued, "that wants very much bringing up to date in our Transactions. I wish it had been put in a more condensed form, so that it would have taken the attention a little better of many members of this meeting. During the whole of the reading of such parts as have been brought before us, I have not heard the slightest allusion to the three valuable papers that appear in the First Volume of our Transactions. I refer to papers by Mr. Edward William Binney. The first of Mr. Binney's papers read before this Society was a "Sketch of the Geology of Manchester and its Vicinity." The next was "Observations on the Lancashire and Cheshire Coal Field, with section." Another was "Remarks on the Marine Shells found in the Lancashire Coal Field." In those papers by Mr. Binney we have the subject put before us in a concise manner, giving the information so far as it was known in those days; but, as usually happens to pioneers over a wide area, he has fallen into a few mistakes. There is also an incompleteness in Mr. Binney's conclusions which have been brought up to date by more modern observers. But Mr. Binney quotes a great number of authorities. He tells us what Professor Phillips had to say about these Lower Coal Measures; also Mr. Francis Looney and the late Mr. John Hall, who took a very active part in exploring this field, and Mr. Elias Hall, who drew one of the first maps of the geology of Lancashire. I should think that if this paper were compared with some of Mr. Binney's writings and an abstract made of the whole, bringing the subject up to date, it would be a most valuable addition to our "Transactions." In its present form I am afraid it is a little too extended. I see that Mr. Bolton speaks of the way in which two kinds of coal unite and form the Mountain Four-Foot, and he mentions Colne as the place where this union occurs. Now, I have seen where the union takes place at Bacup, and in the district between Bacup and Burnley. All through the Oldham district the Upper Foot is quite a distinct mine. The fossils that have been described lie about it in a most marked manner, and the water that comes from it is very ochery. It will stain your clothes and your hands almost the same as if you had dipped them into nitric acid, and it takes time to wear off, as nitric acid stains take time. Passing northward, near Bacup, the two mines are merged into one, and become what is called the Four Foot Mine. The fossils of the Foot coal continue with the Four Foot part after the union. I think the fossils are most useful to the miners; they are such an excellent guide for co-relating the seams when you come upon them unexpectedly. When the late Peter Wright Pickup was opening his pit at Rishton he came across a fault before reaching the seam he intended to work; the workmen said the coal seam he was driving for was below, but Mr. Pickup had noticed the fossils and said 'Drive up,' and to their amazement, in a short time, they were satisfied he was right, and they came upon the coal. He was entirely guided by the fossils. I should like to see the paper condensed and combined with Mr. Binney's papers. It will then form a valuable addition to our Transactions."

Mr. J. Gerrard, who seconded the vote of thanks, said the amount of work represented by the paper must have been something enormous. The days Mr. Bolton had spent in the field and at the various museums only those who had tried to get a little information on a subject of this nature could at all gauge. He had done a little investigating and searching himself in the geological field, and could therefore assure the meeting that the long list of fossils given by Mr. Bolton must represent a very considerable amount of research on his part. He thought the list certainly ought to appear in the Society's Transactions. Knowing that Mr. Bolton would not be at the meeting, he had brought two or three specimens to give members some idea of what Mr. Bolton had described. The first of the specimens showed part of a fish (Elonicthys Aitkeni) taken from a nodule found over the Mountain Mine "Four Foot," where the Upper Foot and the Lower Mountain seams had joined together. This fossil was included in Mr. Bolton's list. If the list were published it would prove of great value, for anyone finding fossils in the neighbourhood of Bacup, Burnley, Rochdale or Todmorden would be able to refer to the list and find therein confirmation. Other specimens which he had brought were what were called goniatites—Gastrioceras (Goniatites) carbonarium, and Dimorphoceras (Goniatites) Gilbertsoni. You might probably split 50 nodules without finding any fossil within, and then you might get two or three with these beautiful things in. The economic value of Mr. Bolton's work has been very graphically illustrated by Mr. Dickinson. It was brought to his mind only the other day at Accrington where, probably, for two or three generations Messrs. George Hargreaves & Co. had been working these same seams—the Lower Mountain mine and the Upper Mountain mine—and they thought they knew all about them. They came to a fault in one of their workings, and they drove forward to seek for the coal. From the appearance of the strata and the condition of the fault they concluded the seam they wanted was in a certain position. They worked on in that direction but did not find it. They were puzzled. They went a little further and came to a shale bed full of these shells, and at once they knew where they were. Had they not seen these fossils, or seeing them had not eyes to perceive their meaning, they would have been spending their money in driving and boring for days, and possibly for weeks. Such things were constantly occurring, so that it was distinctly to the advantage of miners, and especially of the younger members of the Society, to make themselves acquainted with the palæontological features of the coal measures. The younger members had time which the older members had not, and they would find, when they once began the study, it would increase their interest in mining very considerably. As Mr. Dickinson had so well said, the Society now possessed a full stratigraphic view of the Lancashire coal measures. The work which Mr. Dickinson did so well forty years ago had been extended by Mr. Binney, by Mr. George Wild and others in several papers in the Society's "Transactions," and now Mr. Bolton had completely brought the story up to date. There was an immense amount of work still to be done. Nobody need think that though this Society had been established since 1838 there was nothing to do. There was very little known of the palæontology of the Middle Coal Measures. There was an immense work to be done in that matter. At Ashton Moss to-day they were groping about. Over and over again they did not know where they were because of the faults they crossed and the dislocation of the strata met with. If they could only be helped by the horizon of some fixed fossil it would be of the greatest possible service to them.

Mr. James Tonge, in supporting the vote of thanks, said Mr. Gerrard had spoken of the desirability of someone doing for the Middle Coal Measures what Mr. Bolton had done for the Lower ones. On that point he wished to say that Mr. Bolton, some ten or eleven years ago, spent a long time in carefully examining a large number of fossils collected by a number of colliery managers in Lancashire from the Lower Seams of the Middle Coal Measures. He did not know whether Mr. Bolton took any notes to keep by him or not, but if he did he must have a considerable amount of information regarding these seams. Specimens were taken to him from all parts of Lancashire, and from all the seams. It might, therefore, be well to ask Mr. Bolton if he could give any information, or if he kept any notes by him of the fossils he then examined.

The resolution was adopted.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL AND MINING SOCIETY.

PART XV. VOL. XXVIII. SESSION 1903-1904.

SPECIAL MEETING AT OWENS COLLEGE.

By the kind permission of the Principal, a SPECIAL MEETING of the Society was held at the Owens College on Friday evening, February 19th, 1904. Tea was served in the Beyer Building, and after an interval for conversation the members had an opportunity of seeing those recent additions to the Museum which are of special interest to geologists and mining engineers. Professor Boyd-Dawkins and Mr. Hall, Assistant Keeper of the Museum, pointed out the various objects of interest.

Subsequently the members assembled in the Natural History Theatre. The President, Col. GEO. H. HOLLINGWORTH, F.G.S., occupied the chair.

Mr. GEO. H. WINSTANLEY, F.G.S., of the Wigan Mining College, read the following paper on "The Mechanical Equipment of Collieries." The address was illustrated by many specially prepared lantern slides :—

THE MECHANICAL EQUIPMENT OF COLLIERIES.

By George H. Winstanley, F.G.S., of the
Wigan Mining College.

Introduction.

At the commencement of the reign of Victoria the well-beloved, it may safely be said that mechanical equipment was a feature in colliery working conspicuous by its absence.

Few can speak from personal knowledge of the conditions which prevailed in mines and collieries in those days, but the Manchester Geological and Mining Society is proud to claim, in the person of Mr. Dickinson, its oldest member, one who has been intimately associated with the mining industry practically since the commencement of that long and glorious reign.

With infinite pleasure I have read and re-read Mr. Dickinson's Presidential Address in the Jubilee year of the late Queen's reign, in 1887, when he was for the fourth time elected to the Presidential chair of this Society. From that address, a history of the development of mining in Britain, we learn that in the days of Mr. Dickinson's early connection with mining, there was to be found little which could be described as mechanical engineering.

Winding appliances were of the most primitive character. Haulage was in some cases effected by the employment of women and even children. Mechanical ventilation was not; mechanical coal-cutting undreamt of; and even the wildest flights of imagination had not conceived the possibilities of electrical transmission and distribution of energy, or its application to mining.

At the commencement of the reign of King Edward the Seventh, on the other hand, colliery working may be said to consist almost entirely of mechanical engineering, and scarcely a single operation at the colliery to-day is carried on without the aid of mechanical appliances. Winding, hauling, pumping, ventilation, coal-cutting, power transmission, all are operations calling for the skill and ingenuity of the mechanical engineer.

We live in an age of engineering, and the colliery manager of to-day must be a mechanical engineer, or at least must possess such a knowledge of engineering as the colliery manager of half a century ago neither possessed nor was in a position to acquire.

Still, in spite of the progress which has been made in engineering generally, the average British colliery is not the best place in which to look for good examples of modern engineering practice, and it is with the object of bringing forward some important features and principles, often it would appear neglected, that I venture to address you upon this subject this evening.

It will, of course be evident, that in the sixty minutes which I must not exceed, it will not be possible to embrace the whole of so extensive a subject, and indeed those matters upon which I shall speak must of necessity be dealt with very generally.

Power Generation.

The prime source of energy at collieries is of course coal, and the steam boiler will no doubt continue to be an important item in the equipment of the colliery, but not necessarily the sole means of developing and applying the energy stored up in the coal.

The time is not far distant, especially at collieries where the manufacture of coke is carried on, when the gas engine will constitute an important part of the equipment for power generation.

In the manufacture of coke, combustible gases are produced which were formerly (and to a considerable extent are still) wasted. These gases represent energy, and may be and are applied to the working of large gas engines, suitable for driving electrical generators and other regularly running machines.

There are already collieries where no coal is consumed solely for power generation. The power required for the various operations being produced partly by steam engines and partly by gas engines. The heat from the coke ovens is utilised for steam raising, and the balance of the power is provided by gas engines operated by the combustible gases resulting from the coking process.

The Energy Capacity of Coal.

It will perhaps be interesting for a few moments at this point to consider coal as a source of power, to enquire to what extent that power is usefully applied in practice.

A pound of good average British coal, completely burnt, is capable of developing heat equal to about 14,000 British thermal units, or in units of work *considerably more than ten millions of foot pounds*. In other words the energy stored up in a pound of coal is *equal to nearly* 5½ *h.p. for an hour*.

As a matter of fact, however, and as a matter of good steam engine practice also, the consumption of *two* pounds of coal is necessary to give *one* h.p. for an hour.

This means that with good high class engines and boilers the energy developed in the steam cylinders is *only* 9 *per cent. of the energy in the coal, over* 90 *per cent. being absolutely lost.*

Without dwelling upon the matter now, it may be instructive to point out that nearly one fourth of the energy passes up the chimney with the heated gases from the boiler furnace, whilst more than half of the energy is lost in the exhaust from the engine.

But these figures relate to the working of good high class engines and boilers. It is to be feared that in average colliery practice the steam engines and boilers can rarely be described as high class, and not always even good, and the fuel consumption is often nearer twenty pounds of coal per indicated h.p. per hour than two,

These remarks will serve to show the necessity for the most careful attention, on the part of colliery managers and engineers, to the question of power generation, and the selection and working of steam boilers and engines.

Boilers.

As a stationary steam generator, for general purposes, the Lancashire boiler is deservedly popular, and the Lancashire boiler will doubtless continue to figure in the equipment of collieries in spite of the evident advantages of some of the more recent types of water tube boilers.

The simplicity, safety, and reliability of a well designed Lancashire boiler leave very little to be desired. Such a boiler, from 8 ft. to 8 ft. 6 in. diameter, and from 30 to 33 ft. long, working under fair conditions at from 120 to 150 lbs. per square inch, supplying steam to good compound condensing engines, is equal to from 400 to 500 h.p., or with mechanical draught even more.

Particular attention, however, should be given to the flues and seating. The former should not be too small, a common mistake which results in the hot gases passing along the flues at so high a velocity that there is not time for a proper transfer of the heat to the boiler. The side flues should be at least 12 in. wide at the narrowest place, the top. The bottom of the side flues about level with the bottom of the boiler, and the bottom flue not less than 4 ft. 6 in. wide by 2 ft. 6 in. deep for a boiler 8 ft. diameter, and 3 in. larger each way for a boiler 8 ft. 6 in. diameter.

Whilst duly recognising the good points of an old and trusty friend, as the Lancashire boiler undoubtedly is, it will be both interesting and instructive to give some attention at this point to one of the most successful of the more recent water-tube boilers, one which appears to be designed and constructed on correct lines, and which has long passed the experimental stage.

The Stirling Water-tube Boiler.

The Stirling water-tube boiler has already found a place at several well-equipped modern British collieries, and is extensively used in connection with other industries. In all cases it appears to have fully realized the claims put forward by its makers.

The Stirling boiler consists of four steel drums—three at the top of the arrangement, called the steam drums, and one at the bottom, called the mud drum. A group of tubes connects each of the steam drums with the mud drum, there being thus three separate sets or ranks of tubes. The three steam drums are also connected with each other above the water line by means of short tubes, and the front and middle drums are similarly connected below the water level.

Over the fire-grate is sprung an arch of fire-brick, which absorbs the heat and becomes practically incandescent, igniting by radiation the fresh fuel as it is fed upon the fire. It is claimed that this arrangement largely prevents smoke, and what is of even greater importance, it heats the cold air entering when the furnace doors are open, and prevents any portion of the boiler being chilled, whereby local contraction would result, and serious strains would be set up, as actually is the case in some other types of boilers.

The feed-water is delivered into the drum at the back, the coolest part of the boiler, and follows a course contrary in direction to that taken by the heated gases. Passing down the back set of tubes into the mud drum, the water is sufficiently heated to bring about the precipitation of the solids which would otherwise form scale, and the sediment accumulates in the so-called mud drum, from which it can be blown off from time to time. The mud drum is screened from the direct action of the heat, with the result that the sediment does not, as a rule, harden into scale.

From the mud drum the course of the water is up the front rank of tubes, and here over 70 per cent. of the actual steam generation takes place. After entering the front drum the water passes across to the middle drum, and thence down the middle rank of tubes. The front and middle rank of tubes remain clean, largely due to the fact that the solid impurities have already been left behind in the mud drum, and partly due to the excellent circulation which prevails in these two sets of tubes.

The steam is drawn off from the middle drum, where the water is comparatively quiescent, thus obviating "priming."

It will be observed that each tube has a free discharge into its own drum directly, and not into a collecting tube as in some types of water-tube boilers, an arrangement which often gives trouble. The circulation, indeed, seems to be almost perfect.

Under fair average conditions these boilers are capable of evaporating from 10 to 11 lbs. of water per pound of coal, as against from 7 to 8 lbs. in a Lancashire boiler working under similar conditions.

The fuel consumption under ordinary conditions is about 16 lbs. of coal per square foot of grate area per hour.

The Stirling boiler can, to some extent, be modified as regards dimensions to suit varying conditions and requirements. The equivalent of a Lancashire boiler, 8 ft. 6 in. by 30 ft., would be from 8 to 15 ft. across the front, 14 to 17 ft. from front to back, and from 12 to 22 ft. in height.

ECONOMISERS AND MECHANICAL DRAUGHT.

Whatever type of boiler may be adopted, however, an attempt should be made to intercept and utilise some portion of the heat which ordinarily passes away up the chimney. It will readily be understood that the temperature of the hot gases, as they finally leave the boiler flues, must of necessity be higher than the temperature of the boiler itself. In a boiler working at say 150 lbs. per square inch, the temperature of the water and steam will be about 360° F., and the hot gases may enter the chimney with a temperature of from 650° to 700° F.

If an arrangement of pipes in which cold water is circulating be exposed to the action of these hot gases, a considerable proportion of the heat may be utilised in heating the feed water, so that instead of supplying cold water to the boilers they are fed with water already heated almost to boiling point. Such an arrangement, perhaps one of the best, is the well-known Green's Economiser.

But the cooling of the hot gases may be carried to such a point that the temperature is too low to produce an efficient draught to effect the combustion of the fuel in the boiler furnace. Indeed, on the score of economy alone, the ideal arrangement would be a number of economisers with water in successive stages of heating, until practically all the heat developed by the coal had been absorbed, a result which is scarcely possible in practice. It is possible, however, so to lower the temperature of the hot gases from the boiler flues that it becomes necessary to provide some other and more economical means of maintaining a sufficiently vigorous draught, than is afforded by the heated column in the chimney.

Now just as furnace ventilation is far more costly than fan ventilation, so also is chimney draught as compared with mechanical draught. A tall chimney, capable of maintaining a vigorous draught for a large range of boilers, is a costly luxury both as regards initial outlay and fuel consumption.

The complete induced draught arrangement would appear to be one in which the hot flue gases are utilised both for superheating the steam, and for heating the feed water. In superheated steam the temperature is raised to a higher degree than that due to the working pressure of the boiler, and in engines supplied with superheated steam the advantages of working expansively or compounding are more fully realised.

A well designed fan for an induced draught arrangement is a comparatively inexpensive appliance, and the power for driving it amounts to less than 1% of the power developed by the engines supplied by the boilers. It enables almost any kind of fuel to be consumed, it increases the evaporative power of the boiler, which means that two boilers with induced draught may be equal to three boilers of the same size without such assistance.

It enables thick fires to be kept on the grates, which, with a good draught, is a more economical system of firing than the thin open fires necessitated by a poor draught.

With induced draught a costly chimney is unnecessary, all that is required being a chimney for the purpose of carrying the products of combustion to a level where they will not be a source of annoyance, say from 30 to 50 feet high, according to the locality. A smaller number of boilers will develop more power, whilst the cost of the mechanical draught plant is comparatively small. A saving is thus effected both in first cost and in fuel consumption, not to mention other important advantages of which time will not permit full consideration this evening.

Winding Engines and Equipment.

By reason of the important character of the work which they perform, the winding engines naturally occupy a prominent place in the equipment of the colliery. The colliery winding engine has work to do totally unlike that which any other type of steam engine is called upon to perform. Starting from rest, it has to put in motion a mass amounting to probably 100 tons or even more; not merely to put in motion, but to impart to the greater portion of that weight, in a few seconds, a velocity it may be of 60 miles per hour. This high velocity has only to be maintained for a short space of time, however, perhaps half a minute, and before the expiration of a minute from starting the whole mass has to be brought to rest again with the cages adjusted to within a fraction of an inch.

Here is a case where economy, however desirable, must not be permitted to take the place of simplicity. An engine capable of developing, in so short a period of time, probably 2000 h.p., and still be under such perfect control that the cages may be stopped at precisely the same point, time after time all the day over, with scarcely a fraction of an inch of variation, must of necessity be free from complication.

Compound condensing engines are possible for colliery winding, and indeed some excellent examples are to be found at collieries in this country and abroad, both cross compound —with the high pressure engine on the one side and the low pressure on the other—and double tandem compound, in which there is a complete tandem compound engine on either side of the drum.

Interesting as these may be, as examples of high class modern engineering, it is questionable whether the increased economy is really worth the extra complication and additional first cost.

My own humble opinion is, that whilst being well designed and well proportioned, and amply powerful to deal with the desired output, the winding engines should be as simple as possible.

A pair of single cylinder engines with Cornish valves, and an automatic trip expansion valve gear, combine simplicity with a reasonable degree of efficiency, especially if connected with an independent condensing plant.

The cylinders should be so proportioned that either engine alone can raise the maximum load, and if equipped with a steam operated reversing gear, a Burn's foot brake, and an auxiliary steam brake, such a pair of winding engines will give very satisfactory results.

A well designed plain cylindrical built up steel drum, of from 20 to 30 feet diameter, as light as consistent with strength, with a balance rope under the cages, would seem to give quite as much satisfaction as the elaborate, costly and heavy conical spiral drums which are sometimes advocated.

My late chief and colleague, Mr. C. M. Percy, used to say that in his opinion flat winding ropes were only fit for one purpose—to hang the man who invented them. I would suggest, however, that in addition to being admirably suited for this interesting ceremony, they have one other useful application, viz., as balance or tail ropes under the cages. The freedom from any tendency to twist makes them particularly suitable for this purpose.

As a matter of interest I have worked out the approximate dimensions for a pair of winding engines, to be capable of raising at least 1100 tons per day from a depth of 900 yards, with and without a balance rope.

The cages would carry 3 tons 12 cwts. of coal, the weight of the rope would amount to considerably more than 6 tons, and if not counterbalanced the engines would require a pair of cylinders 50 in. in diameter by 8 ft. stroke, for a drum of 23 ft. diameter.

With a balance rope, however, and a drum of the same size, the cylinders would only be 36 in. diameter and 6 ft. stroke.

The load against the engine at the commencement, half-way through, and towards the completion of the wind, in both cases respectively, would be as follows:—

With Balance Rope.	Position of Load.	Without Balance Rope.
8,064 lbs. ..	At commencement ..	22,464 lbs.
8,064 lbs. ..	Half-way (meeting point) ..	8,064 lbs.
8,064 lbs. ..	Towards completion ..	A negative load of 6,336 lbs.

That is, with the unbalanced rope there is *actually a load of nearly 3 tons urging the engines forward at the moment they have to be brought to rest.*

With regard to the equipment of the engine, I should like to see it made compulsory, under the Coal Mines Regulation Act, that every colliery winding engine must be fitted with some contrivance of the nature of the "Visor," to *absolutely prevent* overwinding, racing and running away, and starting in the wrong direction.

Very few winding arrangements at British collieries to-day omit the detaching hook, an appliance which does not, and can not, prevent overwinding, but which only comes into operation when an overwind actually occurs.

Personally, however, unless used in conjunction with a controlling device on the engine, I do not place much confidence in detaching hooks.

A detaching hook is of no use to the descending cage, and of very little service to either cage or to the engine when the latter from any cause is running away. On the other hand, a controlling device renders overwinding at high speed, or indeed at any speed, impossible. A controlling appliance is as necessary to a colliery winding engine as is a safety valve to a steam boiler.

In connection with this subject there are two incidents firmly impressed upon my mind, which I may be excused for introducing here. Some years ago, at a Lancashire colliery, a cage full of men was being drawn to the surface. The cage happened to be raised a little too high; the detaching hook severed connection with the rope; with its human freight the cage was dropped down the shaft; and many children became fatherless, and wives widows.

It is not for me to fix the blame, but I firmly believe those men's lives would not have been lost had that particular detaching hook been absent.

The other case is one to which Mr. Dickinson drew the attention of this Society some little time ago.

At a Tyldesley colliery, the engine-man, whilst raising 24 men to the surface, had a sudden seizure of a fatal character. As the man lost consciousness he contrived to stop the engines, and almost immediately expired. One contemplates with horror what the result might have been. Yet it is an occurrence which might be repeated at any colliery with far more serious consequences.

With some reliable controlling appliance, which shuts off the steam and applies the steam brake when the engineman, from any cause has failed to do so at the right moment, such occurrences would be impossible.

Winding Ropes.

It has been a matter of some considerable surprise to myself that this important matter does not always receive that amount of careful attention which its importance demands. The questions of strength and factor of safety are only too often ignored. I am personally acquainted with colliery managers who had no idea of the breaking strength of the winding ropes they were using, nor the actual strains to which they were subjected in the regular course of working.

The winding rope has to bear so serious a responsibility that we cannot afford to neglect a single precaution to ensure its absolute safety. The vast development of energy, of which the engines are capable, is all applied through the agency of the rope. Day after day it has to raise to the surface, at express speed, hundreds and even thousands of tons of coal. Twice at least, in every working day, the life of every workman in the mine is for a short space of time dependent upon its strength and tenacity, and it is a regrettable fact that there are colliery owners and officials who make a point of purchasing, for this particular purpose, the lowest priced productions of the rope manufacturer. That such ropes are really not cheap is as easily demonstrated as the fact that high class ropes are in the end the most economical.

Some years ago the Inspectors of Mines found it necessary to address a communication to colliery owners and mine managers on this subject. The thought has often suggested itself to me that some regulations ought to be embodied in the Coal Mines Regulation Act bearing upon this matter. There should be a minimum strength and quality for the steel wire of which winding ropes may be manufactured, say 100 tons per square inch of sectional area of the wire, with a further stipulation determining the factor of safety, which should not be less than 10, that is the actual working load should never be permitted to exceed one tenth of the breaking strength of the rope.

This factor of safety, 10, is none too high to provide for the great and sudden variations of strain to which the winding rope in ordinary working is subjected. At starting, and whilst getting up speed, the strain upon the rope often greatly exceeds the actual weight of the suspended load, a fact frequently lost sight of. The increase of load amounts to 70 lbs. per ton for each foot per second in the rate of acceleration. With a loaded cage weighing seven tons and an acceleration of velocity at the rate of 10 feet per second, the actual strain upon the rope would be over nine tons.

This figure is by no means exaggerated, an acceleration of more than 10 feet per second may, and probably does, occur at one moment or another during the starting of the wind, and even if that particular rate of acceleration exists only for a second the strain upon the rope for that short period is greatly in excess of the load.

Limits of Deep Winding.

The best quality of steel winding ropes procurable to-day practically limit the depth of ordinary winding to 1,000 yards. I do not mean to suggest that coal cannot be drawn from greater depths than this, with existing arrangements; as a matter of fact it would be possible to wind from 1,500 yards, but at that great depth the weight of the rope itself would be out of all proportion to the weight of coal which could be raised, for each ton of coal in the cage there would be about seven tons of rope.

Coming back then to the figures first named—1,000 yards—at this depth the weight of the rope would be equal to the suspended load, whilst at 2,000 yards the weight of the rope itself would absorb the whole of the factor of safety of ten, and no suspended load would be possible.

It is, however, not improbable that in the future we may be able to procure a steel wire, at a cost making its use possible for winding ropes, which may possess a greater strength than anything hitherto suitable for the purpose.

Experiments with steel with which nickel has been alloyed seem to suggest that this is possible. Such a steel, drawn into wire, is said to possess increased tenacity without suffering any loss in ductility, whilst at the same time such wire possesses a remarkable property of resisting corrosion.

It remains to be seen to what extent nickel steel will be utilised in the manufacture of colliery winding ropes; it would probably mean a much lighter rope of greater strength.

Mechanical Ventilation.

During the last twenty-five years mechanical ventilation has very largely superseded furnace ventilation. The furnace, with all its attendant dangers and disadvantages, with its low efficiency and limited capability, is still employed to some extent, but not at places claiming to rank as well equipped or modern collieries.

On the ground of economy alone the furnace stands condemned, consuming, as it does, at least ten times as much fuel as a modern fan and engine for the same ventilation.

There are in general use several types of fans giving excellent results, and it would be difficult to single out any one as being entirely superior to all others. Perhaps the most popular at British collieries are the Walker, the Schiele and the Waddle.

The Walker fan, from the excellence of its design and construction mechanically, has justified the name "indestructible" which its makers have adopted, and it deservedly occupies a prominent position amongst mechanical ventilators, and finds a place at many of the best equipped and most modern collieries.

There is, however, in the design of centrifugal fans, a point upon which I hold a view not in accordance with that put forward and acted upon by many makers of centrifugal fans, and recent developments in fan construction have proved my views to be correct.

In all the fans named, and in many others, the blades spring from the centre and take a backward curve to the circumference, the idea being to set the air in motion gradually and provide the easiest path from the centre to the periphery.

In a centrifugal pump, where the fluid to be set in motion is heavy and the inertia considerable, this idea is correct, and the provision of such blades necessary, but in dealing with so light a fluid as air, of which it takes more than thirteen cubic feet to weigh a pound, this coaxing process is entirely unnecessary, and it is a perfectly simple matter to impart to air a high velocity in a very short space of time.

The Sirocco Fan.

The Sirocco fan has not hitherto figured prominently as a colliery ventilator, the simple explanation being, I believe, that its makers were fully occupied in meeting the demands made by the Admiralty and others who had recognised its immense advantages.

The practical uses to which it has already been put, and the severe conditions under which it is working with perfect satisfaction, speak well for its capabilities, and it is not improbable that in the near future it will rank as one of the best mechanical ventilators for collieries.

The most interesting feature about this fan is (if I may use the expression) that it "knocks on the head" many of the generally accepted theories with regard to centrifugal fans. Theories which, I am afraid, numerous fan makers will not abandon without a struggle; the struggle, however, will be hopeless.

For instance, it has been held that the velocity with which the air leaves the tips of the blades is, theoretically, the same as the circumferential velocity of the fan itself, and in actual practice somewhat less.

Actual measurement in the case of the Sirocco fan proves beyond the possibility of doubt that the air leaves the periphery *with a velocity almost twice as great as the velocity of the fan itself.* What does this mean? It means that a small fan of this type will deal with a much greater volume of air than a larger fan of any other make, whilst the useful effect is somewhat higher.

Again, we have been brought to believe that the theoretical water gauge attained by any fan may be calculated, by arriving at the vertical height through which a body would require to fall in order to acquire the same velocity as that of the circumference of the fan. Having calculated this height in feet, we work out the weight of an equal column of air standing upon a base of one square foot, from which in turn we get the water gauge in inches.

In the Sirocco fan, remarkable as it may appear, the actual water gauge is greatly in excess of this so-called theoretical or calculated water gauge, and to produce a given water gauge this fan has a lower circumferential velocity than any other type of fan in existence.

The distinctive features of the Sirocco fan are these:—It has an absolutely clear inlet of practically the same diameter as the fan itself. (All other fans have the inlet much smaller in diameter than that of the revolving portion.) The blades are very short radially, being only about one-sixteenth of the fan diameter. The width of the blades, however, is greater than usual, about three-fifths of the diameter. There are a larger number of blades than are usually found in centrifugal fans, 64 being the number adopted in the Sirocco. The blades take more the form of scoops, with a forward curvature, and in working there is an entire absence of eddy current.

The casing is of the usual form, spiral, with an expanding chimney. Altogether, this fan attains such astonishing results as to merit the most careful attention of all those who are interested in fan construction and mechanical ventilation.

As an example of what the Sirocco fan can do in actual operation, and in comparison with other mechanical ventilators for colliery purposes, a fan of well-known make at a Lancashire colliery is producing 233,000 cubic feet per minute. This fan is 24 feet in diameter, and the circumferential velocity 7,425 feet per minute. A Sirocco fan has recently been installed at a colliery in the North of England, it is 75 inches in diameter, and is producing 226,000 cubic feet per minute, circumferential velocity 5,770 feet per minute.

The significance of this comparison is too obvious to need further comment.

Fan Engines.

The constant running and steady load of the fan, particularly the high speed fan, is specially adapted for electrical driving, indeed no arrangement could be simpler than a fan of the type last described, directly coupled to a suitable electro-motor, and at collieries where electrical power plant is being installed it is not unlikely that provision will in many cases be made for driving the fan electrically.

At the same time, it is probable that the fan engine will continue to occupy an important place in the colliery equipment; and in this particular application of the steam engine we have ample scope for the successful introduction of high class and economical engines.

The conditions which render the adoption of compounding questionable in connection with winding engines are absent in the fan engine. The fan is the one appliance at the colliery which is practically in continuous work year by year from the first day of January to the last day of December, and in this sense it very nearly approaches the conditions under which the highest possible class of steam engine, the marine engine, has to work. The ideal fan engine is the compound condensing engine, the most convenient form of which for this purpose would appear to be the cross compound.

With the larger sizes of high speed fans direct coupled high speed engines may be employed with increased efficiency; but the slow speed engine, driving by means of cotton ropes, is an arrangement with which little fault can be found.

Power Transmission and Distribution.

One of the most important problems in modern colliery engineering is the question of power transmission. In colliery working so many operations have to be carried on at places far removed from the source of power, not only at the bottom of deep shafts, but far away in remote parts of the mine. It is no uncommon occurrence, in modern colliery working, to find that it is necessary to transmit power to places a mile or two away from the boilers, and in the future we may expect to have to deal with still greater distances.

The colliery engineer therefore requires some means of transmitting energy which is at once convenient, economical, efficient, and safe.

For practical purposes we need consider two systems of power transmission only—compressed air and electricity.

The former has been employed, in a more or less satisfactory manner, for many years. Its only advantage is its comparative freedom from danger. It is not exactly a convenient system, and certainly not economical. Low as is the useful effect, however, even with the best possible appliances, it is only too frequently found, in colliery practice, that important points are neglected which tend to still further reduce the already low useful effect.

It has to be recognised, in the operation of compressing air, that a large portion of the energy developed by the steam engine is re-converted into heat in the air. This in itself would not be a serious matter if the air could be used before the heat was dissipated, but as a rule this is not possible.

The generation of heat in air compressing acts unfavourably in two ways. First, the heat represents energy which is lost, and secondly the somewhat high temperature imparted to the compressed air produces what may be described as a false pressure, against which the engine has to operate, although the ultimate effective pressure of the air is lower than the maximum attained in the compressing cylinder.

The loss of energy due to the first cause, the generation of heat, cannot be avoided. The rise of temperature may to some extent be checked by cooling during compression, effected in single stage compressors by surrounding the compressing cylinder with what ought to be, but from my own personal observation rarely is, cold water.

In two stage compressors the air is cooled by means of a sort of surface condenser, with cold water circulating, placed between the first stage cylinder and the second, and through which the air passes on leaving the low pressure cylinder.

I have often been struck with the fact that in nearly all colliery air compressing plants the air taken into the compressor is the warm air of the engine room. One knows the usual high temperature which prevails in an engine room, and starting with warm air at the very commencement of the operation, has an appreciable effect upon the efficiency of the plant. The air taken into the compressor should be as cold as possible, and it ought not to be a difficult matter to arrange for a direct communication with the outer atmosphere.

The high class compressing plant of the present day is the two stage compressor with mechanically operated valves and intermediate cooling. The application of mechanically controlled valves to an air compressor places it, in point of general efficiency, far above the older types with the ordinary valve arrangements in which the opening and closing is effected by the air.

But even with the best possible appliances, with large pipes and well designed motors, the total efficiency of transmission cannot, as a rule, in colliery practice, exceed 30%. Indeed, it is doubtful if 100 I.H.P. in the steam cylinders of the compressor will give 30 H.P. in useful work from the motor. Except in a few instances present colliery practice falls far short of this.

ELECTRICITY.*

For power transmission and distribution, electricity is the ideal form of energy. Electrical transmission possesses advantages which place it far above any other system of power transmission at present possible. It is convenient, it gives a high useful effect, and its application *on proper lines* is attended with no more danger than the application of energy in any other form.

As a rule the plant is not so costly as compressed air plant for the same power. Flexible cables are more manageable and more convenient than rigid pipes, and an electric motor occupies little space as compared with an air motor of the same power.

Generally speaking, the efficiency of transmission, as between the I.H.P. of the engine driving the dynamo, and the output of a motor a mile away, is well over 60 per cent.

* These notes were written and printed before the publication of the Report of the Electricity in Mines Committee. The writer observes with satisfaction that his views are confirmed by this Report.

In connection with the applications of electricity to mining, one expects to be called upon to discuss the question of safety or danger. Personally I am of opinion that the dangers attending the use of electricity in coal mines have been somewhat exaggerated. Of course I am aware that so-called accidents have occurred, and that lives have been lost, but I think that if anyone will carefully investigate those cases, they will be satisfied that not electricity was to blame, but the employment of unsuitable appliances, or the misuse of proper appliances, in some cases the result of woeful and unpardonable ignorance.

It will not be disputed that electricity can work destructively, but what form of energy can not? Electricity can destroy life, cause fires and explosion of gas, but it is not alone in this respect. On the other hand, an element of danger need no longer be a source of disaster when its nature is recognised and understood, so that suitable precautions may be adopted. Once recognised and appreciated, an element of danger is to a great extent disarmed.

Winding operations are not free from danger, but we have learnt what precautions to take, what factors of safety to provide.

At one time in the history of mining inflammable gas was perhaps the most serious element of danger to be dealt with, and was responsible for an immense sacrifice of life. To-day, fire-damp is not less capable of working destruction than it was half a century ago, but we have become familiar with its properties, we know how to render it and other noxious gases harmless, and our systems of ventilation and lighting are such that colliery explosions, at least in this country, have become comparatively rare. Fire-damp has been disarmed, but as we know full well its destructive properties still remain, and any defect in our ventilation, or an imperfect safety lamp, may lead to disasters greater than any which have blackened the records of the past.

We remember the incident in the story of George Stephenson's encounter with the House of Peers, when defending his railway scheme against the stupid prejudice of short-sighted statesmen, he was asked by one noble lord what would happen if a cow got in the way of one of these trains which he proposed to whirl along at the appalling speed of nearly twenty miles an hour. "Would it not," asked the eminent statesman, "prove somewhat awkward." Stephenson's broad Northumbrian reply was that it would, no doubt, be very awkward—for the "coo."

In considering the application of electricity in mines, one is anxious not to play the part of the noble lord, nor yet that of the "coo."

Looking back to the days of Newcomen, when steam engines were atmospheric engines, and were supplied with steam at a pressure only slightly above that of the atmosphere, and the boiler was more like a good-sized kitchen kettle than anything else, I sometimes wonder what would have happened if someone had ventured to suggest steam boilers working at 200 lbs. per square inch. He would certainly have been regarded as mad, and his scheme one fraught with danger. Yet steam boilers to-day do work at 200 lbs., and we do not hear much about their dangers.

A Lancashire boiler, 8 ft. by 30 ft., in working trim, at 150 lbs. per square inch, represents explosive energy, which might be let loose with frightful results, to the extent of 207,000 foot tons, equal, in fact, to the explosion of three-quarters of a ton of gunpowder. Yet in everyday work such boilers are not regarded as constituting a serious element of danger. Under proper control, indeed, they are perfectly safe appliances.

There are colliery managers to-day who do not hesitate to take steam boilers down their pits, but who regard electricity as too dangerous for use in mines.

Let it however be fully realized, once and for all, that whilst electricity can work destructively—certain precautions taken, certain provisions made, it need never lead to disaster, nor at any time jeopardise life or property.

Electricity is what might be described as a high-class form of energy, necessitating the employment of high-class appliances under the supervision of highly-trained men. Electricity and ignorance are incompatible, and the combination is sure to lead to trouble. I would be disposed to make it compulsory for every workman who is employed in connection with electrical appliances to attend a course of instruction in elementary electrical engineering, or to show that he possessed an intelligent knowledge of the important elementary principles.

Wherever switchboards or other electrical fittings have to be in more or less exposed positions, where they are accessible to others than those entrusted with their control, a conspicuously-displayed notice board, with the word "Danger," say, in red letters upon a white ground, should be fixed. Care should be taken, however, that it is kept clean and legible.

Direct and Alternating Current.

Without going too deeply into technical matters, it may be interesting and useful to briefly compare the relative advantages of direct and alternating current for mining purposes.

With regard to alternating current, it would appear that what is known as the three-phase alternating current offers advantages which demand the most careful consideration of colliery engineers.

The alternating current lends itself more readily for long distance transmission from the ease with which it can be transformed from low to high, and high to low voltage. Electrical transmission at a high voltage means a two-fold economy, a greatly reduced loss of energy in transmission, and a considerable saving of copper in the cables. With direct current these advantages are absent.

Quite apart, however, from the possibilities of high tension and long distance transmission, the three phase alternating current offers important advantages as against direct current, which will doubtless in the future lead to its almost universal adoption for colliery purposes, no matter what the distance of transmission may be.

It would be impossible to conceive any contrivance, mechanical or electrical, for performing useful work, in which the element of simplicity is so completely embodied as in the three-phase motor.

It has no brushes, no commutator, no sparking, no complicated windings nor insulation exposed to the liability of breakdown; it consists merely of a drum of simple construction revolving within a cylindrical casing. The drum or rotor is built up of thin rings or discs of steel, longitudinal slots are arranged in its outer surface in which are placed bars of copper. These are connected at their extremities to copper rings, and the whole mounted upon a shaft. The interior of the cylindrical casing, the stator, is similarly provided with discs or rings, slots, and copper wires or strips. The current passes through these fixed stator windings only, and the revolving portion of the machine does not carry any of the current from the mains or leads, with which it has absolutely no connection. In the direct current motor on the other hand, practically all the current flows through the windings of the revolving armature. Brushes and commutators, with their attendant risk of sparking, have to be employed, and difficulty is often experienced with the insulation of the rapidly revolving coils.

The three-phase motor is safe to handle and simple to control. Starting and reversing present no difficulties, and indeed from whatever point of view the three-phase motor is regarded the result is the same—extreme simplicity, efficiency, and reliability are its most prominent features.

A detailed description of an electrical generation and transmission plant would be out of place here; it is sufficient to say, as in every other branch of engineering, that the best appliances must be employed if the best results are desired. Electrical appliances must be perfect, both mechanically and electrically, and must be under the charge and control of competent and skilful attendants.

It is desirable in connection with all electrically operated colliery machinery, hauling gears and pumps for example, but particularly the former, that friction clutches should be provided to permit the motor being thrown out of gear.

In hauling, for example, it is sometimes necessary to stop the rope in the haulage plane almost instantaneously. With a motor running at 500 or 600 revolutions per minute, as part of the haulage gear, and a rope wheel or drum making 10, or even 20 revolutions per minute, forming part of the same gear, it would be possible to stop the latter almost immediately, but not so the motor, which must be allowed some little time to come to rest. With a friction clutch the motor can be thrown out of gear, the brake applied to the rope wheel or drum, and the rope quickly stopped.

All gearing should be machine cut for high speeds, and machine moulded for the heavier and more slowly running wheels. Double helical machine moulded teeth give results which are always satisfactory.

PUMPS AND PUMPING.

There is one application of electricity—for pumping—with regard to which I should like to speak in conclusion. Rotary motion for operating reciprocating pumps, has always presented some difficulty in the fact that in the conversion of rotary to reciprocating motion there is no pause, at the end of each stroke, before the reversal of motion takes place. This operates in two ways—first it necessitates a low speed, and means that comparatively large pumps have to be employed for a small volume of water. Further, with electrical driving it necessitates a considerable amount of gearing to bring down the high speed of the motor to a slow speed suitable for the pump.

The whole trouble, however, rests with the pump valves. The pause at the end of each stroke is necessary to give the valves time to close. The absence of the pause results in a considerable loss of water rushing back through the valves before they have actually closed, and in the pounding of those valves upon their seats in a manner scarcely conducive to long life and smooth working.

The most generally popular type of pump for electrical driving is the three throw arrangement. It does its work well enough up to a certain point, but it is clumsy and heavy, and costly in proportion to the water dealt with.

The ideal arrangement is the Riedler pump, with mechanically operated valves, the immense advantages of which place it in its proper position, at the head of pumping appliances.

The mechanical operation of the valves makes it possible to apply the rotary motion at high speeds, with absolute freedom from shock or slip of water, whilst the high speed possible does away with the necessity for the large amount of heavy gearing usually found in a three-throw electric pump.

The result is that a comparatively small Riedler pump with a spur wheel on the crank shaft, and a pinion on the rotor shaft of the motor, will deal with as much water as a large set of three throw pumps. Only one example need be given. At the Powell Duffryn collieries, a pumping engine of the Riedler type has been installed, under conditions calculated to find out the weak spots if any exist. The engine is a cross compound, with two double-acting Riedler pumps. The rams are $6\frac{7}{8}$ inches diameter, and 4 ft. stroke. The regular speed is 40 revolutions per minute (piston speed 320 feet per minute), at which the delivery of water is 1,000 gallons per minute to a height of 1,600 feet. Either side can be disconnected and run at double speed, 80 revolutions per minute (640 feet per minute) so as to deliver the same quantity of water.

For purposes of comparison it may be remarked that a well-designed duplex pumping engine with 7″ rams, is not capable of more than 300 gallons per minute.

Finally, I would say a word with regard to the centrifugal pump. The simple character of this type of pump, the absence of valves and working parts, has long made it popular for dealing with large volumes of water, but only at low heads. Its high speed and rotary motion make it specially suitable for direct coupling to an electric motor, but hitherto the limited height to which it can deliver water has made it unsuitable for mine pumping.

Recently, however, Messrs. Mather & Platt have introduced what they call a High-lift Centrifugal Pump. This is made in sizes up to 3,000 gallons per minute, and capable of delivering water to a vertical height of 400 feet, with an efficiency, in the larger sizes, of over 75 per cent. A more compact pumping arrangement, for dealing with large volumes of water at moderate heads, could scarcely be conceived. The following are the extreme dimensions of a pump of this type, with its motor, to deliver 1,000 gallons per minute to a vertical height of 400 feet:—13′ 2″ long, 5′ 1″ wide, and 5′ 0″ high. No other pumping arrangement to deal with the same volume of water could be contained within anything like so small a space.

Conclusion.

Although far from having exhausted my subject, I have exhausted my time, and, I fear, your patience. But I cannot conclude without some word of apology—for I feel that when a young man, as myself, ventures to address gentlemen older both in years and experience upon matters such as I have brought before you this evening—some apology is needed. My excuse must be that for twelve years past I have been engaged in a humble endeavour, at the Wigan Mining School, to impart to a small section of the rising generation of colliery managers and mining engineers that information which it is essential they should possess, to enable them in the future to successfully carry forward, to elevate and advance the progress of this, the greatest of all our industries. Throughout that time I have striven to impress upon the minds of the hundreds of students who have passed through my hands, the vital importance in colliery working and management of Economy, Efficiency, and Safety; three great principles, the greatest of which is, and must ever be, Safety.

A great engineering firm in this country has adopted, as a kind of motto, these words, which might well be adopted by the colliery manager and engineer: "Whoever is satisfied with what he does, has reached his culminating point; he will progress no more. Man's destiny is not to be dissatisfied, but forever un-satisfied."

The PRESIDENT said they had had the greatest possible pleasure in listening to Mr. Winstanley's elaborate paper.

Mr. JOHN GERRARD, in moving a vote of thanks to Mr. Winstanley, said he would like to convey to him how much they had appreciated his admirable paper. There was much in it that they could take away and ponder in their minds. He was also pleased that the Society had had another opportunity of visiting Owens College. Professor Boyd-Dawkins was always very good in entertaining them and giving them the *entrée* to the College, and so enabling them to have a most enjoyable evening.

Mr. W. H. JOHNSON, B.Sc., in seconding the motion said he had been very much struck with the able summary to which they had just listened. Mr. Winstanley very properly remarked that in the use of steam they lost a great deal of their power. At collieries one very often naturally thought that as coal was cheap there was no necessity to be careful in the use of it; but, as Mr. Winstanley had pointed out, in the near future very little coal would be used at the collieries. The economy effected by the use of coke was very great, and he inclined to the opinion that people would one day make coke for the sake of the gas and the residual products.

As a dweller in Manchester, Mr. Johnson added, he looked forward to the bright time when they would do away with the clouds of smoke that now polluted the atmosphere, and they would perhaps reach that desirable state of things by generating their power at the collieries, where they would at the same time make large quantities of coke. He hoped coke would be supplied to their domestic fire grates and that coal would no longer be allowed in them. He further hoped that manufacturers would be forced to use either electricity or gas for the purpose of generating motive power. He might perhaps be considered to be looking too far into the future, but he had an idea that young men like Mr. Winstanley might live to see his hopes realised. He believed that the day of the steam engine in its present form was nearly over. The economy of the gas engine was so much greater than that of the steam engine that he could not see how the latter could hold its own on land, although it might do so on the sea. The gas engine could be manufactured up to a very large power, and the economic use of gas had been marvellously perfected. Mr. Johnson joined in expressing the obligations of the Society to the Authorities of the College for allowing them to meet in that room. The motion was adopted with much heartiness.

Mr. STANLEY ATHERTON said that during a recent visit to America he had noticed that in that country there was a tendency to adopt very high air compression.

On the motion of Mr. PERCY LEE WOOD, a vote of thanks having been passed to the College authorities and to Professor Boyd Dawkins,

Professor BOYD DAWKINS said he could not see why the Society should pass a vote of thanks to him. He was a member of the Society, and was very grateful for what the Society had done. It was largely due to the Society that they had a geological collection at Owens College. He assured the gathering it was always a great pleasure to him to see the members of the Geological and Mining Society at the College or in its Museum from time to time.

This concluded the business of the meeting.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL AND MINING SOCIETY.

PART XVI. VOL. XXVIII. SESSION 1903-1904.

The ORDINARY MEETING of the Members was held on Tuesday, 8th March, 1904, in the Society's Rooms, 5, John Dalton Street, Manchester.

Colonel GEO. H. HOLLINGWORTH, F.G.S., President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society:—

Mr. HENRY HOLLINGWORTH, Manager, Ellerbeck Collieries, near Chorley.

Mr. GEORGE L. MACALPINE, B.Sc., Altham and Great Harwood Collieries, Accrington.

Mr. MARTIN MUNROE, Mining Student, Shakerley Collieries, Tyldesley.

Mr. PERCY ORMAND, Earlestown, Lancashire.

Mr. CHARLES TURNER, Mining Student, Irlam, near Manchester.

Mr. MAURICE GEORGI, M.Inst.M.E., Assoc.M.Inst.E.E., read the following paper on "The Application of Electricity for Winding and other Colliery Purposes":—

Mr. M. Pickstone in introducing Mr. Georgi said: I may say, first of all, that Mr. Georgi has only been in this country three months yet he speaks English as fluently as I do, and speaks probably most of the other European languages equally well. I travel on the Continent every year in connection with my business as an electrical engineer, and in the course of my visit last year to Silesia I heard some wonderful stories of electrical work at the coal mines, so I at once went on from Buda Pesth to a place called Zabrze. It occupied about 24 hours to get there, but when I arrived I saw something that opened my eyes in connection with the use of electricity for coal winding. I am quite certain there is nothing of the kind in this country. In fact, I was so much struck with it that I at once arranged with the pioneer firm to take over their work in this country. I saw them winding coal with electric motors and doing other kinds of work in a fashion greatly in advance of anything I had seen before. The success of this work is due to the fact that the big firms of Germany and Austria have worked the problem out, not on a rule of thumb basis, but on an absolutely scientific basis. The German staff in a large works is not a rule of thumb staff. They gather round them their experts and they work out their problems in a truly scientific way, leaving nothing to chance. The consequence is we may rely on their guarantees. I advertised in America and Germany for a suitable man and was fortunate enough to come across Mr. Georgi, who occupied a position on the technical staff, in connection with electrical winding machinery, of Messrs. Siemens and Halske, who were the pioneers of this form of electrical work throughout the world. It is difficult for Mr. Georgi to illustrate his lecture sufficiently but, I feel sure, he will do the best he can to explain these difficult matters to us.

THE APPLICATION OF ELECTRICITY FOR WINDING AND OTHER COLLIERY PURPOSES.

By Mr. Maurice Georgi, M.Inst.M.E., Assoc.M.I.E.E.

During latter years special attention has been given by mine owners in this country, and perhaps more especially on the Continent, to the possibility and advantages of using electrical energy for driving their machinery instead of steam or compressed air, which until recently has been exclusively used for that purpose.

Owing, however, to the great importance of the task, and to the vital interests involved, the first steps in that direction were weighty and cautious; but as the results obtained more than fulfilled all expectations, the electrical engineers, fully realising the importance this question had for them, faced the problem resolutely and have had the satisfaction of seeing their efforts completely crowned with success; consequently it has now become recognised that the most rational and economical working of a mine is only obtainable by the adoption of electricity as a source of energy, as the latter alone offers the mine owner and engineer all desirable guarantees as far as convenience, economy, and security are concerned. The best proof of this lies in the fact that nearly all the principal mines in Germany, Belgium, France, &c., are being equipped electrically throughout, as far as their means possibly allow it. For the newer mines anything beside electricity as a motive power is hardly considered.

The machinery of a mine can be roughly divided into four classes :—

(1.) The Pumping Machinery.
(2.) The Ventilating Machinery.
(3.) The Winding and Hauling Machinery.
(4.) Coal-cutting Machinery, Drills, Lighting, &c.

We will examine the various methods that have been employed to adapt electricity as the motive power for each of these classes of machinery, dwelling more especially on those that have given or are likely to give the best results.

Pumping.

We will first turn our attention to the pumping plant of a mine. The electrical equipment of the pumps was one of the first tasks set themselves by electricians some years ago.

The conditions under which they began their work were anything but favourable. Till then the form of energy used for this purpose was exclusively steam or compressed air. The plunger rods of the pumps were then driven directly by those of the steam cylinders, so that a slow speed was found more advantageous than anything else, as with the valves, &c., then in use the speed had of course to be very limited. As a slow running motor is costly and difficult to build, and has a low efficiency and power factor, it was from the first evident that it would be irrational to bring down the speed of the motor to that of the pumps then in use, or to use a gear for high outputs; so that the only way out of the difficulty lay in modifying completely the design of the pumps then in use.

This step has led to the construction of high speed or express pumps, as they are generally called. Although these pumps are practically unknown here, they are in great favour on the Continent. Let us note in passing that identically the same causes have led to the design of high speed engines so much in favour in this country, although, perhaps by way of compensation, these are hardly met with on the Continent.

These pumps can be made to run as high as 250 revolutions per minute, but pumps at even these apparently excessive speeds work perfectly; the driving motor being in all cases coupled directly to the crank shaft. The output of these motors being sometimes exceptionally great—500 to 800 horse power.

Before going into any further details we will examine the causes that necessarily limit the speed of a pump, and what devices are used to counteract the effects.

Let us consider a pump having a single double-acting plunger. As we all know, the output of such a pump is not constant, but varies from 0 to 0 passing through a maximum equal to 1·57 of the average output during half a revolution of the shaft. *(See Fig. I.)*

The flow of water in the rising main is therefore never constant, but is subject to pulsations. To regularise the flow it is usual to place an air chamber above the head valve, the

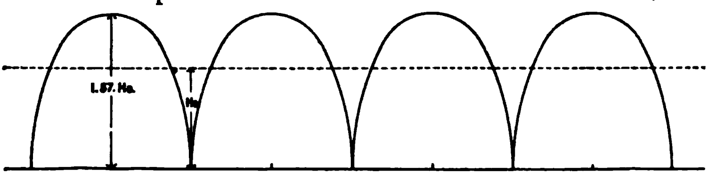


Fig. I.

air imprisoned in the former by its periodical expansion and compression having the desired effect.

The greater the size of the air chamber the more regular is the flow. It has been calculated that to obtain a fairly regular flow the quantity of water that must go in and out of the air chamber at each stroke is equal to 0·2 S R (S = section of the plunger, R = stroke). This mass of water is animated with an alternating motion which communicates itself to the whole of the water inside the reservoir.

As the shocks due to the periodical loss and gain of the kinetic energy contained in this mass increase with the square of the speed, it can easily be imagined that the same must be kept very low in order to avoid the pump and foundations being shaken to pieces.

With a double plunger pump the flow is more regular, as the effort is taken up by two cranks having an angle of 90°

between them, so that when one plunger is animated with its maximum speed the speed of the other is equal to 0. (*See Fig. II.*)

Should the number of plungers be still greater, the regularisation increases proportionately, the volume of the air chamber can be considerably reduced and the speed of the pumps increased. As a rule, not more than three plungers are used, the angle between their cranks being equal to 120°.

The vital part of a high speed pump is without doubt its valves. These have to be of a special construction and design to be able to work properly at high speeds, and to resist the corrosive action of the mine water.

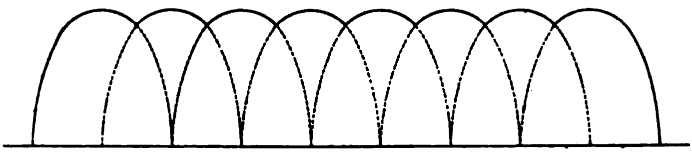


Fig. II.

The pioneers in the line of express pumps are perhaps Professors Riedler and Stumpf. In the Stumpf-Riedler pump the valves are not free, but are governed by means of the shaft in a similar manner to those of a steam engine of the Corliss type. The working of this pump is silent, and as a rule to be depended upon, but the governing of the valves has not given the expected results, so that other designers have completely discarded this method and left the valves to work freely in the ordinary manner.

The best known express pumps of this type are the Ehrhardt and Sehmer, Bergmanns, and Jandin pumps.

The first two named are somewhat similar in design. They are of the ordinary plunger type, with one suction and one pressure valve for each plunger. The plungers are made of hollow cast-iron, and can therefore be easily replaced at a low cost.

Ehrhardt disposes the suction and pressure valves opposite one another, the space between being the run of the plunger. The water thus travels the shortest possible way. The

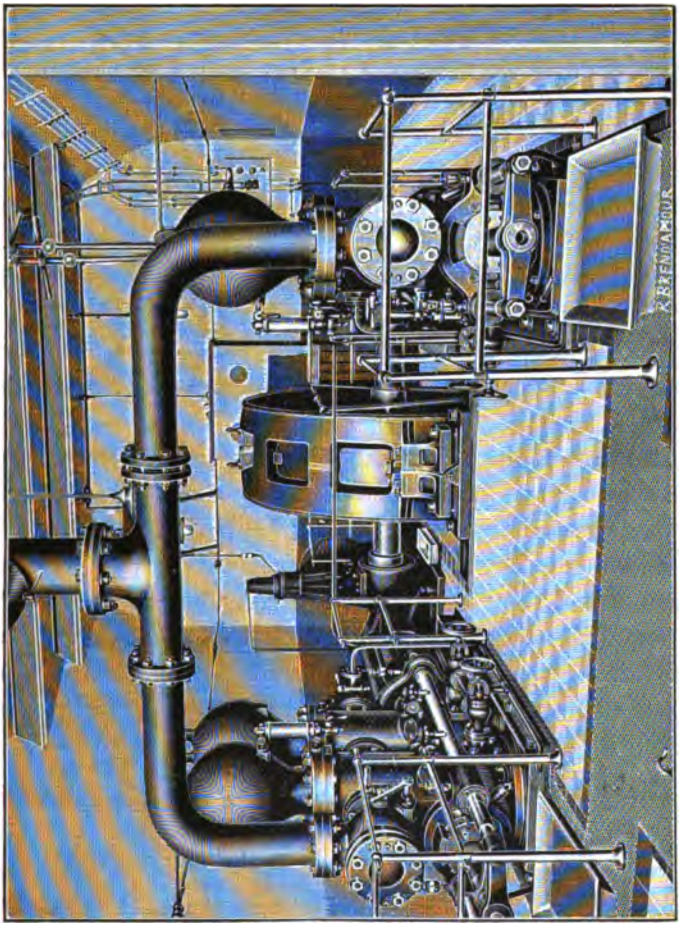


FIG. III.—PUMPS SULZBACH.

valves themselves are of the annular or ring type and displace themselves in a vertical direction. They are made of bronze, the rings belonging to these valves being in bronze with leather packing. (*See Figs. III., IV., V. and VI.*)

The suction air chamber is placed under the water cylinders, differing in this respect from the Riedler pump, where the vacuum air chamber is placed above these, the result being a slightly better value for the height of suction obtainable.

The high pressure air chamber is placed above the body of the water cylinder.

Bergmanns arranges a second head valve over the one situated in the cylinder, the space between the two having a regularising effect on the work of the pump, as it only allows the valve to open gradually, and not suddenly. This latter works as silently as a steam engine at a speed of 125 to 150 revolutions a minute.

The high pressure air chambers, the plungers, &c., are made of wrought-iron for low lifts, and of cast-steel for high ones.

The Jandin pump differs in its principle completely from the above system, and offers really very remarkable features in many respects.

The pump consists of two double-acting plungers of equal size, driven by two cranks having an angle of 120° between them. The pump has six valves. Owing to this arrangement we see that the output during each one-twelfth turn is constant; in an ordinary pump the output is only constant every half turn.

The efficiency of regularisation is equal to $\frac{\cos 30°}{\cos 0} = 0·866$; for a one cylinder pump it is $\frac{\cos 90°}{\cos 0} = 0$.

If c is the output for one-twelfth of a revolution of the shaft, the total output per revolution $= Q = 12$ c. If S be the section of one plunger, and its stroke $= R$, the output for one revolution $= Q = 3$ R S. Now in an ordinary pump the output is but $Q = 2$ R S, so that for an equal volume of the cylinders and speed the

Jandin pump has an output 50 per cent. greater than an ordinary pump.

Calculations shew that for the same degree of regularity the volume of the air chambers of a Jandin pump may be only

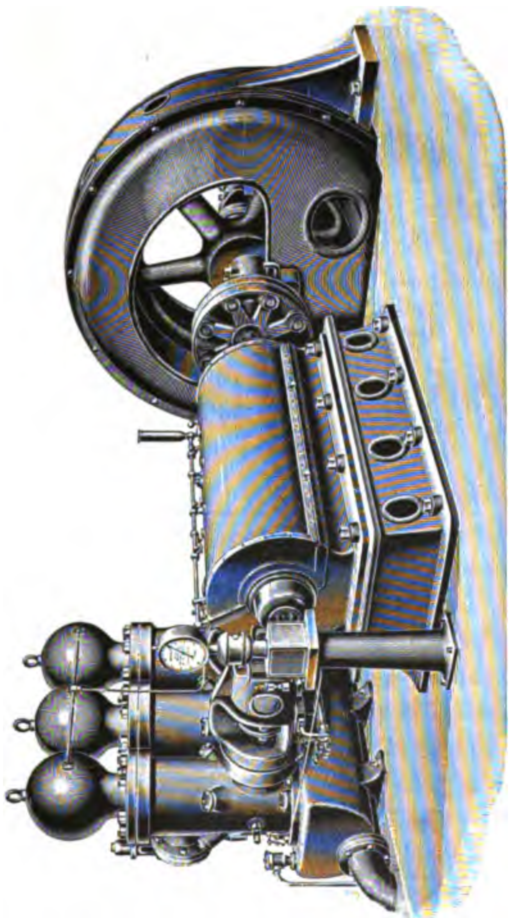


FIG. IV.—PUMPE EMS.

one twenty-third of that of an ordinary pump. This is due to the fact that the flow is practically regulated when it enters the air chambers after passing through *both* cylinders.

Such a pump can easily be made to run very quickly, no shocks, &c., having to be feared.

The valves in this pump are open during four-sixths of a turn of the shaft instead of three-sixths = one-half as with an ordinary arrangement.

There seems to be some misunderstanding as regards the height to which a pump can suck water.

The total suction height for a pump is equal to the atmospherical pressure less the pressure necessary to accelerate the water in the suction pipe and valves, together with other minor effects, such as lifting the valves, &c. Now if we call v the speed of the water inside the suction pipe and u that passing through the valves, the loss in the suction pipe will be equal to $\frac{v^2}{2g}$ and through the suction valve $\frac{u^2 - v^2}{2g}$, as v is *small* its square can be neglected so that the loss $= \frac{u^2}{2g}$. The loss of suction height therefore diminishes rapidly as the speed increases.

With the Jandin pump, owing to the fact that the maximum speed of the water through the valves is but two-thirds of that in an ordinary pump, the loss is but four-ninths or less than one-half of that obtained normally.

For my part I greatly object to make any pump suck at all, and should always prefer placing the pump below or on the same plane as the water in the tank, the working will be much more regular and the suction valves will last much longer.

The pump could best be placed in a water tight room of small dimensions, so that the galleries leading to it might be flooded without the water finding its way into the pump room.

When deciding about the system of pump to be adopted, special attention should be given to the number of valves possessed by the different pumps, and also as to their accessibility, cost, &c. Thus: A two-throw double acting Ehrhardt pump has eight valves; a Bergmanns ten; a Jandin six.

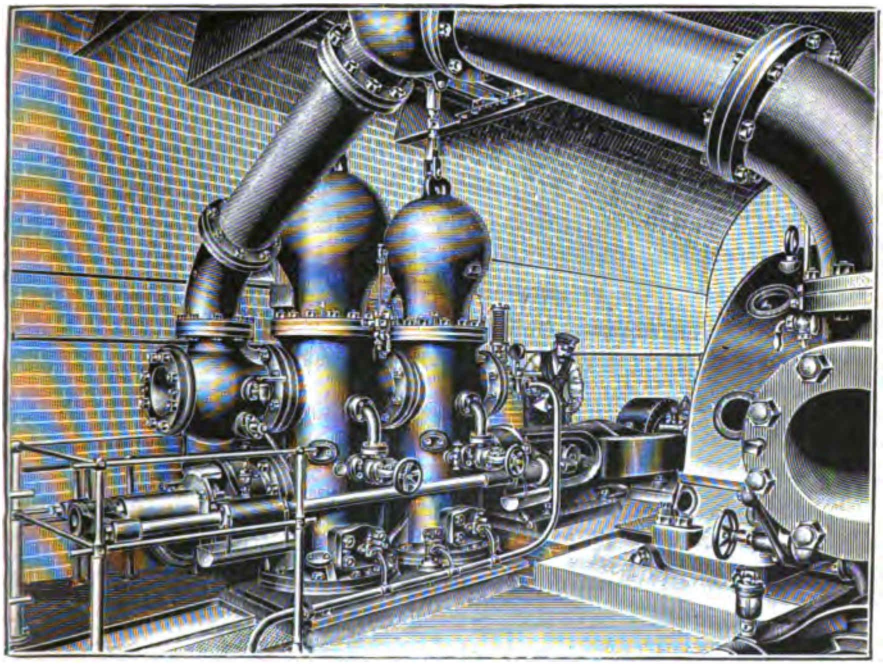


FIG. V.—PUMPE KONIGSHUTTE.

As regards the general efficiency and economy realised, at first sight the use of a steam pump would seem to be more economical as the pump plungers can be driven directly by the pistons of the steam engine. The general efficiency of a plant working under these conditions is exceptionally high, being about 75 per cent. (ratio between the H.P. in water lifted and the H.P. indicated on the steam cylinder); but the disadvantages of using steam in the mine are very great, it being necessary to lead the piping down to the pump from the boilers on the surface; this piping is most costly to fix and keep in order, and it has to be specially protected to prevent condensation; besides the temperature existing in a mine where such a pump is at work is almost intolerable, and necessitates special ventilation, while the space occupied is very considerable; and, therefore, in many cases it has been found more advantageous to use compressed air instead of steam, regardless of the cost.

Should such a pump be driven electrically, however, we shall find, to begin with, that we can use an engine at the power station that will consume much less steam than the engine driving the pump in the mine, so that, even taking into account the transformation of mechanical into electrical energy, the consumption of coal per H.P. on the quantity of water raised is very often in favour of the electrical plant.

Thus at the Mansfield Mine in Saxony, tests gave 22 lbs. of steam per H.P. in water lifted by the steam pump. To obtain the same result with an electrical pump, the engines in the power house would have to consume about 14 lbs. of steam per B.H.P. Nothing prevents us using units with even a lower steam consumption, so that an electrical pump would certainly have the advantage.

We must not lose sight of the fact that by driving our pumping machinery electrically we can centralise all our power generating plant and effect in this way a great saving in labour, and add very considerably to the safety and efficiency of the whole installation, as there would be a considerable reserve to fall back upon, which we have not got in the case of a steam pump. Again, should a pump work only part of the day, no losses occur by keeping the cables under pressure as is the case if we use a steam pump. With an electrical pump we can start at any moment, which as a rule is not possible if we use other sources of motive power.

The motors used for driving these pumps are as a rule asynchronous polyphase ones. These have been found to offer, especially in mining work, great advantages, as they

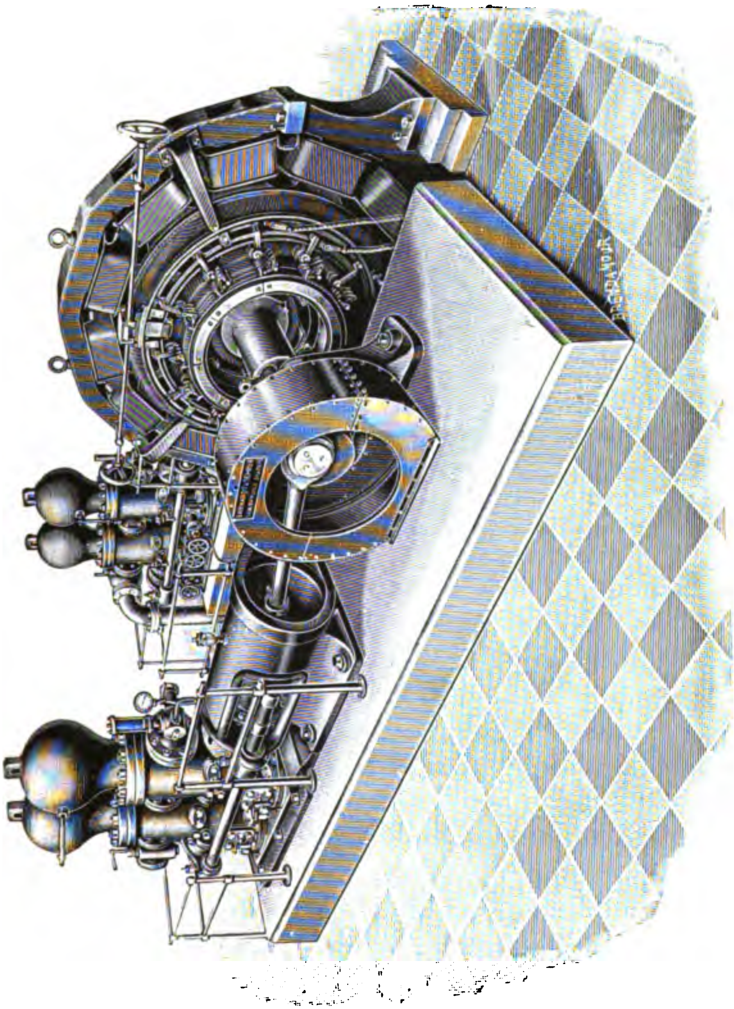


Fig. VI.—Pumpe Recklinghausen.

are stoutly built, possess no commutator, and high pressure can be applied to their winding without the slightest inconvenience. They are practically damp-proof, and for rough work greatly superior to direct current motors.

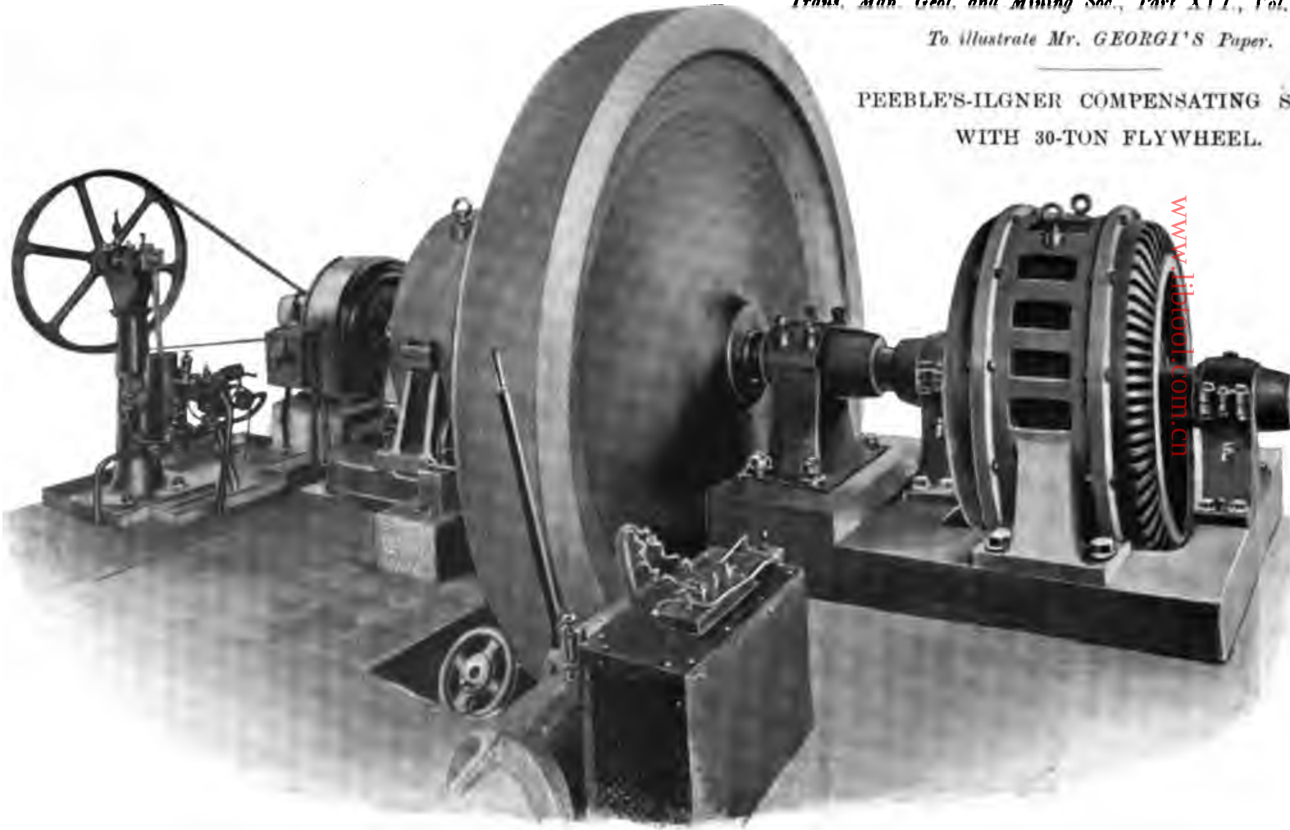
The speed of Express Pumps varies as a rule according to the size, from 100 to 250 revolutions a minute. For large pumps, speeds between 125 and 150 revolutions a minute are most usually met with.

One of the first of these pumps set up is to be seen at the Arnimsche Steinkohlenwerke at Planitz. It is a two plunger Bergmanns pump driven by a Siemens motor at 145 revolutions a minute, and of about 100 H.P. output. The above plant has been running since 1898 without the slightest mishap. A little later a still larger pump of the same kind was erected in the Ferdinandgrube in Silesia. The output of the motor is 450 H.P., the speed of the pump being 144 revolutions per minute. This pump has been running 23 hours a day for the last four years. There is absolutely no reserve to take its place should it fail, thus showing the complete confidence that has been placed upon its reliability.

Since the year 1900 the demand for these pumps has been constantly increasing. In Germany alone there exist over 150 similar pumps, of which Messrs. Ehrhardt and Sehmer have set up over 70. To give an idea of the magnitude of some of these installations I may state that four Express Pumps are running at the Saar & Mosel Bergw. A.G. since 1900. Each of these pumps has a lift of 600 yards, and the motors driving them run at 146 revolutions a minute, their output being 450 H.P., the aggregate output being 1800 H.P. At the Greisenau Pit of the Harpener Collieries, a pump was erected as far back as 1900, having 520 yards head, and a motor of 800 H.P. to drive it.

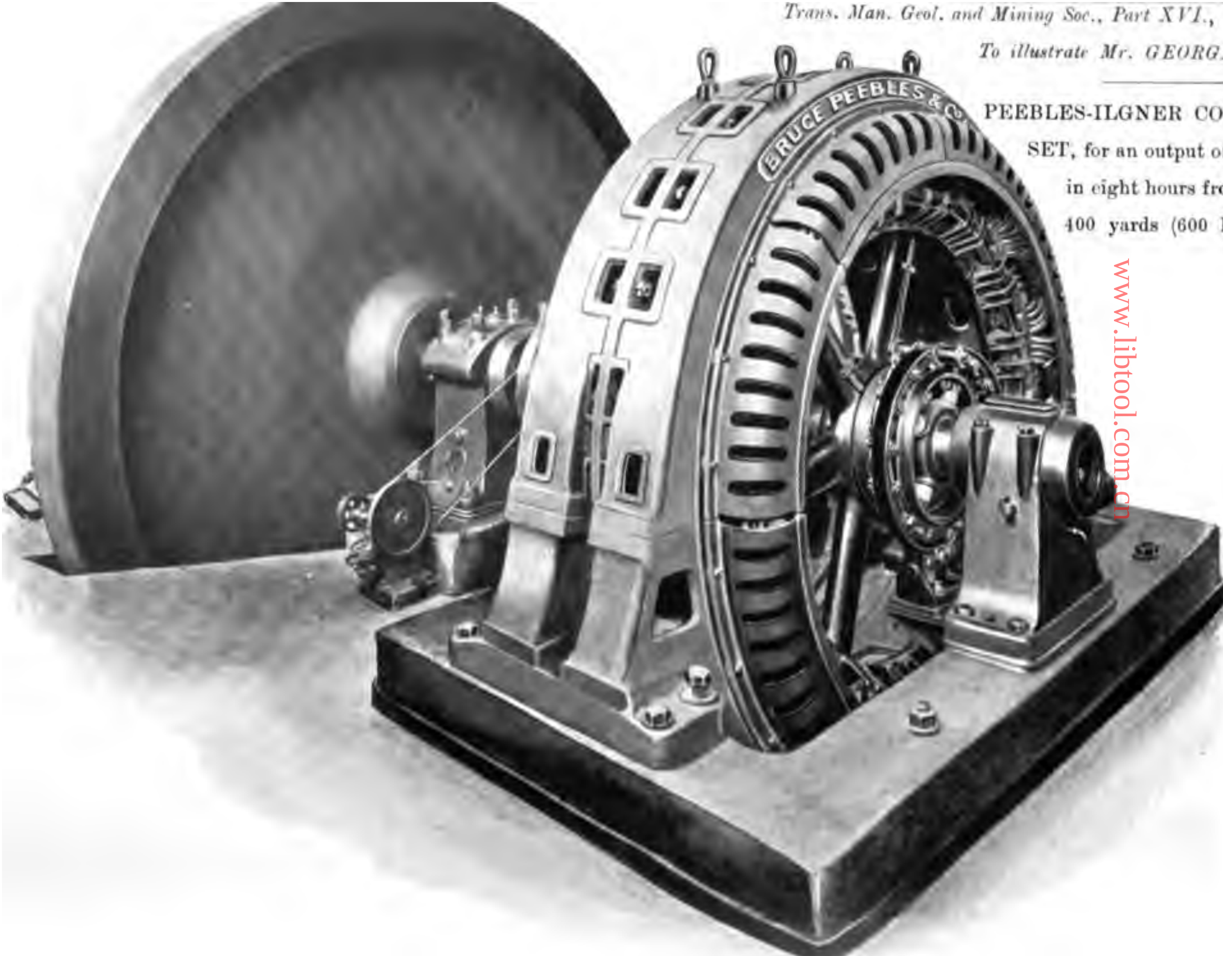
Then again, at the Grillo Pit at Gelsenkirchen, there is a pump running at 100 revolutions a minute, with 700 yards head, and a 780 H.P. motor to drive it.

To illustrate Mr. GEORGI'S Paper.



PEEBLE'S-ILGNER COMPENSATING SET,
WITH 30-TON FLYWHEEL.

To illustrate Mr. GEORGI'S Paper.



PEEBLES-ILGNER COMPENSATING SET, for an output of 2,000 Tons in eight hours from a depth of 400 yards (600 H.P. Motor).

At Mengede there also exists a pump running since 1901, the speed being 122 revolutions a minute, and the output of the motor 730 H.P. Several other installations where pumps of an output corresponding to anything between 500 and 600 H.P. are in use might be mentioned.

Apart from pumps of the plunger type, another system has lately grown very much in favour. I allude to the high lift centrifugal pump, the first of which I believe was designed and built by Messrs. Sulzer, of Winterthur. These are of course admirably adapted for being driven electrically, as their speed is high, their weight is comparatively light, and they occupy an exceedingly small space.

A single pump can work under a lift of 250 yards. It is possible to place two or three in series, and the total lift may then be from 500 to 750 yards. For such high lifts, however, as a rule, an arrangement of this kind is not recommended, as the risks of breakdown are only too obvious. Their efficiency is somewhat inferior to that of an Express Pump, but in many cases this factor has a minor influence, others such as space, first cost, &c., being preponderant: nevertheless, they compare very favourably with the geared two or three-throw pumps generally in use in this country, while in other respects they are undoubtedly superior, especially if the water is sandy or contains solid matter of any kind.

These properties render centrifugal pumps very valuable in certain cases. Thus we might almost exclusively use this kind of pump for sinking a new shaft. In this case, we cannot as a rule employ a plunger pump, as the latter takes up too much space, and it would most likely not work in a satisfactory manner on account of the dirty and sandy water that is met with in the great majority of such cases.

As for steam driven pumps, be they pulsometers or plunger pumps, their disadvantages are only too obvious, it being evident that, as we possess only moderate means of ventilating the new shaft, the heat soon becomes so intense that it must necessarily interfere with the work. These pumps, besides, work very uneconomically.

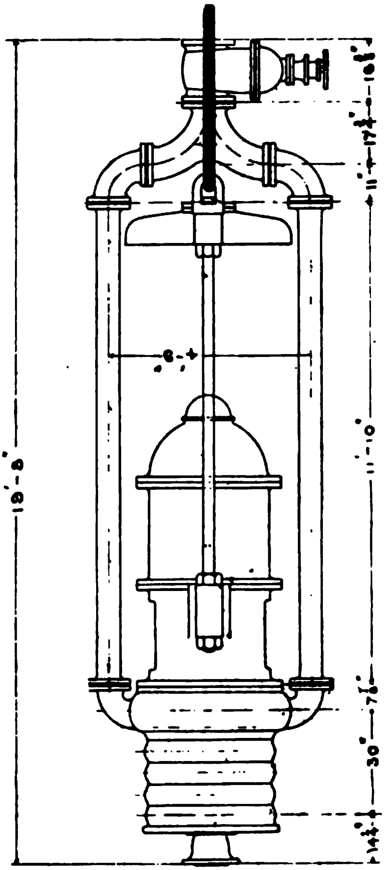


FIG. VII.

The design (*see Fig. VII.*) represents a vertical motor, whose shaft is coupled to that of a high lift centrifugal pump. The motor can be of the enclosed type, or, better still, an ordinary open type motor can be used, the latter being protected against water, shocks, falling stones, &c., by an iron cover.

The starting resistance, switches and fuses, can be placed either above ground or, better still, in an enclosed and protected space, above the motor.

Pumps of this type can be easily fitted with motors, their cost is therefore low and they occupy very little space, the maximum diameter of a pump for a 350 feet lift and an output of 500 gallons a minute being only 4 ft. 6 in.

The flow cannot be regulated by reducing the speed of the driving motor as the head given by the pump would drop proportionately to the square of the speed, so that we arrange a stop valve on the pipe by which the flow can be regulated.

This pump can be lowered and raised by means of an ordinary gear, the ropes need only be small as its weight is not great. Such an arrangement will render great services in a case like the above, being an improvement over the solutions met with until now.

VENTILATORS.

As a rule ventilators used in connection with mines are of two kinds, viz., small fans used for ventilating certain parts of a mine and large fans that have the main task to do.

The first are used in places where the main draught has little or no access or to clear the atmosphere after an explosion, &c. It is obvious that for this type of fan very substantial advantages can be reaped by using electricity as motive power; the space occupied is small and the efficiency very high, especially as very often is the case, motor and fan can have a common shaft, and, further, the whole arrangement can be very easily removed.

Electricity besides being the only economical form of energy for driving small fans offers great advantages for the main ventilators used for ventilating a pit from the surface. As a rule in large mines one shaft is used exclusively for this purpose, in the immediate vicinity of which is placed the ventilator driven by a special steam engine having sometimes its special boilers. Now this arrangement needs at least two men to fire the boilers and to attend to the steam engine as the ventilator is at work day and night. Should we drive the latter electrically no attendance whatever is needed, the ventilator need only be visited once or twice a day. The cost of the plant is greatly reduced as the motor can be run at a high speed, say from 400 to 500 revolutions per minute, and the boilers, &c., are not required.

It should be possible to regulate the output of a ventilator in a simple and economical manner; as the workings become extended, a greater quantity of air is necessary, and it should always be possible at a given moment to rapidly clear the mine of all noxious gases that may suddenly appear.

Let us note that the pressure produced by a ventilator is proportionate to the square of its speed, its output is, therefore, proportionate to the third power of the velocity: so that it is but necessary to vary slightly the speed to obtain marked effects. Thus, should we reduce the speed 20 per cent. the pressure is but 64 per cent. of the normal, and the output 50 per cent. If we increase the speed by the same quantity the pressure is 44 per cent. greater and the output 72 per cent.

A very simple device consists in driving the ventilator by means of a belt; if we slightly raise the ratio of the diameters of the pulleys, which is very easily done, we obtain the desired effect.

If we use continuous current the speed can be regulated by means of the shunt resistance. But more often we have to do with a three-phase plant, and in this case the task becomes more complicated. Of course it is always possible to insert a resistance in the rotor circuit of the motor driving the ventilator, but this method is not economical, so that other devices have been adopted, such as connecting the ventilator to a special generator in the power station and varying the speed of the same; this influences the frequency, and, therefore, the speed of the motor.

The following method is sometimes adopted: the ventilator is designed for giving the maximum output that at any time will be needed, a valve is arranged on the exterior piping, the output is regulated by means of this valve in a fairly economical manner as the output of the motor diminishes proportionately or nearly so.

Electrical Hauling and Winding.

As a rule we find mines generally so arranged that a limited number of main roads of large dimensions start from the shaft. From these smaller roads branch off to the working places where the mineral is being got, either by hand or coal-cutting machinery as the case may be.

The mineral has therefore practically three ways to go before reaching the surface. First, along the secondary roads to the nearest main road, and thence to the pit, where it is wound to the surface.

The hauling machinery is therefore of three kinds:

For hauling the mineral from the dip workings up to the main roads, small gears of from 5 to 20 H.P. are generally used, the rope speed being limited to a maximum of about 6 ft. per second.

The gear is driven by a motor fed by the main directly, or indirectly should the voltage be too high for the size of the motor and controlling apparatus. These gears are very easy to handle, produce no heat, and are exceedingly efficient.

In mines where firedamp is present, with polyphase plant, nothing is to be feared; there being no commutator on induction motors, sparks cannot be forthcoming. The motor can for greater security have its slip rings hermetically enclosed, the starting resistance, switches, fuses, &c., can be made air-tight, or better still, have their live parts in an oil bath.

The arrangements used for hauling the tubs or hutches along the main galleries may be either the main, main and tail or endless rope systems, or locomotives.

It is difficult to say which arrangement is the most advantageous, as a great deal depends on the conditions existing in a given case.

A mine road is usually the worst of roads for running an electric locomotive upon, as it is difficult to properly insulate the trolley wires on account of the humidity, conductive coal dust, &c., present. The ground is continually moving, and the height of the road does not often allow the wires to be out of reach. In some cases, however, locomotives can be used with advantage, as for instance, in high roads with only a single track of great length with sharp curves, and where the output of mineral is not very considerable; a state of things commonly found in metalliferous mines.

As a rule preference should be given to an endless rope haulage, as the output of the motor driving the same, and therefore the load on the power station is constant, or nearly so, and thus a better efficiency can be obtained.

If the inclination of the track is great, it is often better to use a main rope hauling gear, which is often equipped with a motor of great power.

As a rule, all such gears have considerable loads to haul, and the rope speed being slight, large drums turning at but a few revolutions a minute are therefore used. As a means of speed reduction, gearing is generally used; and when the teeth are properly cut and the ratio between the wheel diameters is not too high, the efficiency of a reduction gear is good (about 94 per cent.) *(See Figs. VIII. and IX.)*

In some cases for smaller machines a worm gear is of advantage; with a speed reduction of one-fifteenth the efficiency of this gear may reach 92 per cent., the worm and

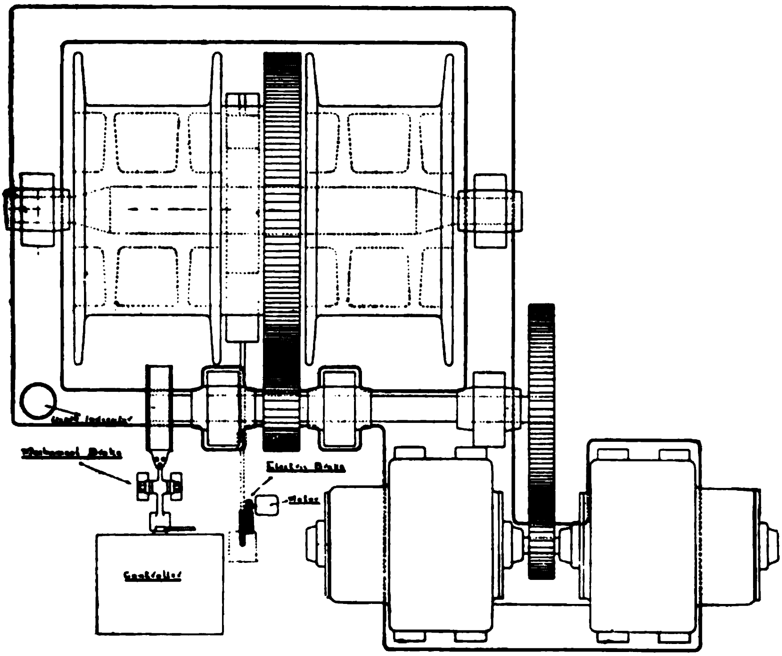


FIG. VIII.

helicoidal wheel are then completely enclosed in an oil bath, the running is perfectly noiseless and the space occupied very small. Worm gearing has the great advantage of having an automatic stop action,—that is to say, the load cannot drive the gear should the current in the motor fail or the brakes not act. Such an arrangement offers therefore great security in this respect.

Another feature of importance with electrically driven haulage gears is the possibility of using a magnetic brake. The brake is lifted by means of a magnet or small motor, so that the driver has only to use his controller or starting resistance and should a fuse be blown while the gear is operating, the brake of course falls instantly and holds up the machine.

With direct current it is indifferent whether a magnet or a small series wound motor operates this brake. With alternating current, however, a squirrel cage motor will be

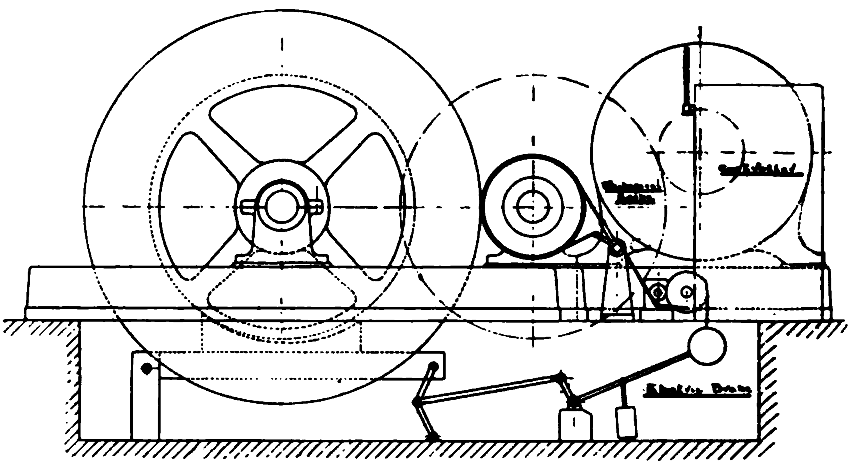


FIG. IX.

found best, as an ordinary magnet having such a high co-efficient of self-induction takes in starting 50 to 60 times the normal current, and is apt to induce dangerous high tension currents when the machine is stopped. This effect can, however, be considerably reduced by placing the magnet parallel to the armature of the motor.

As the power of the motors driving these gears is as a rule small, and speed reduction is only rarely if ever asked for, no special devices or arrangements need be adopted, as the latter would only considerably increase the purchase cost without reducing the working cost in the same proportion.

A starting resistance or controller is therefore amply sufficient. But as the power of the motor increases, should the gear be started frequently and the speed have to be regulated, the question then has quite a different aspect, as the losses that would then occur are of a magnitude that claim consideration. Before describing the methods used to obtain an economical running of the plant operating in these circumstances, we will first examine the working conditions of a machine having to overcome a constant torque, and having work of an intermittent character to perform.

We will call the efficiency of such a machine the ratio that exists between the energy absorbed by the motor terminals and the work done by raising the load. If G is the weight and R the height, the work done is equal to G R kilogram-metres. To do this work P kilowatts are absorbed by the driving motor. The efficiency is equal to:

$$\frac{G\ R}{P 75 \cdot 0736}$$

The losses that occur are of two kinds, those inherent to the machines themselves such as friction, electric losses, &c., and those due to the fact that the load has each time to be accelerated, for which we need a supplementary torque which produces no supplementary work, and the rheostatic losses.

Let us suppose that we are working on an ideal diagram corresponding to efficiency = 1 in which the supplementary energy taken up at the start drives the machine at the end. The output of the driving motor increases with the speed from 0 to a maximum, drops down to that necessary to overcome the torque on the drums once full speed has been reached, and at the end of the wind the kinetic energy of the system is used to drive the machine. (*See Fig. X.*)

We have therefore a sort of cycle, all the energy finding its equivalent in effective work done by lifting the load.

But things do not actually occur in this manner, and we will take for example the case of a winding gear driven by a single motor.

In starting energy must be absorbed by the rheostat, as the motor absorbs a quantity of energy proportionate to the *torque* and not to the work done. Thus during the acceleration period the output of the motor is equal to $\frac{1}{2}$ P × t.

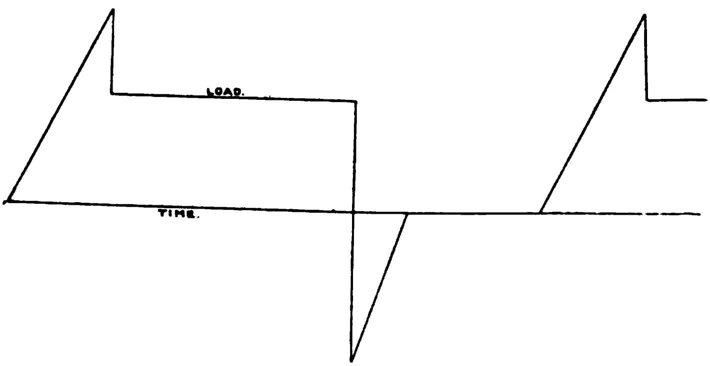


FIG. X.

The energy absorbed is however P t. Therefore in starting we lose each time $\frac{1}{2}$ P t. H.P., &c., which is transformed into heat.

Besides this the energy that is needed each time to produce the necessary acceleration, and which therefore does not do any actual work, is equal to $\frac{1}{2}$ M v^2. M = total masses in motion. v = maximum velocity = 8 metres per second.

Let us, however, suppose that 80 per cent. of this energy is used at the end to drive the engine, 20 per cent. being absorbed in the brakes. The loss due to acceleration would be therefore equal to :

$$\tfrac{1}{2}\, M\, v^2 \left(\frac{1}{\eta_2} - \eta_3\, \eta_1\right) \text{ if } \frac{1}{\gamma} = \frac{M}{m\, g}.$$

The loss in starting is given by:

$$\tfrac{1}{2}\, M\, v^2 \left(\frac{1}{\eta_1\, \eta_3} + \frac{1}{\eta_2}\right).*$$

γ = acceleration of the winding masses in metres per second, m = mass of useful load (coal), g = acceleration due to gravity = 9·81 m. sec., η_1 = efficiency of mechanical part of winding engine and pit, η_2 = efficiency motor armature, η_3 = efficiency motor.

To give an idea of the magnitude of the losses that occur, we will take as an example a winding engine raising an actual load of 2·6 metric tons at the maximum speed of 8 metres per second from a depth of 350 metres or 380 yards.

The effective work done by a single wind is equal to

$$\frac{2600 \times 350 \times g}{3600} = 2460 \text{ Watt hours.}$$

Let $\eta_1 = 0{\cdot}8 \quad \eta_2 = 0{\cdot}93 \quad \eta_3 = 0{\cdot}90.$

$$\text{Friction loss} = \frac{2{\cdot}46}{0{\cdot}8} - 2{\cdot}46 = 0{\cdot}61 \text{ K.W.H.}$$

$$\text{Loss in motor } \frac{3{\cdot}07}{0{\cdot}9} - 3{\cdot}07 = 0{\cdot}35. \text{ K.W.H.}$$

Loss due to the masses in motion, the total of these being 16·8 times as great as the effective load, the radius of gyration being the same:

$$\frac{M\, v^2}{2} = \frac{16{\cdot}8 \times 2600 \times 8^2 \times g}{2\, g \times 3600 \times 1000} = 0{\cdot}4 \text{ K.W.H.}$$

---

* This formula can be established as follows:—

The power required by the engine in starting is equal to:

$$\tfrac{1}{2}\frac{M\, v^2}{\eta_2} + \left[\tfrac{1}{2}\, \frac{v^2}{\gamma}\, mg\right] \left(\frac{1}{\eta_1\ \eta_3}\right)$$

$$\text{if } \gamma = \frac{m\, g}{M}$$

$$\text{then } \tfrac{1}{2}\, M\, v^2 \left(\frac{1}{\eta_1\ \eta_3} + \frac{1}{\eta_2}\right)$$

The loss is therefore $0{\cdot}4\left(\frac{1}{0{\cdot}93}-0{\cdot}8\times0{\cdot}8\right)=0{\cdot}172$ K.W.H. for the acceleration and

$$0{\cdot}4\left(\frac{1}{0{\cdot}8}\times\frac{1}{0{\cdot}90}+\frac{1}{0{\cdot}93}\right)=0{\cdot}98 \text{ K.W.H. for the rheostat.}$$

The total energy absorbed is therefore:

$$4{\cdot}572 \text{ K.W.H.}$$

The efficiency is:

$$\frac{2{\cdot}46}{4{\cdot}572}=0{\cdot}538$$

Should we now manage to suppress the starting losses the efficiency would then become equal to $\frac{2{\cdot}46}{3{\cdot}66}=0{\cdot}670$.

We thus see the great importance of these rheostatic losses and can easily realise the advantage we would reap if they

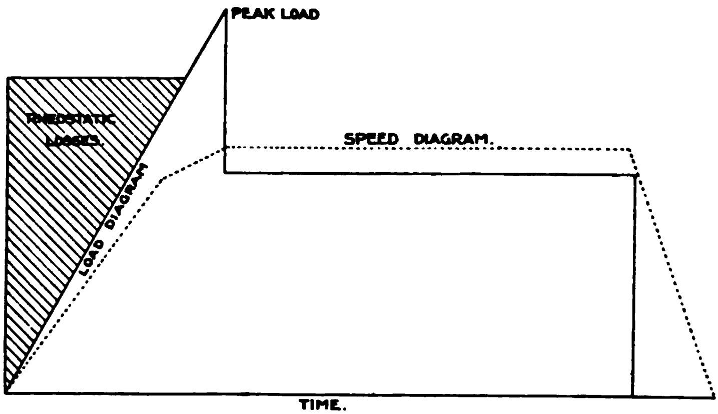


FIG. XI.

could be partially or totally suppressed. With continuous current different methods have been devised to effect this object.

Let us consider the speed diagram of an electrical winding engine. We start with the magnet coils of the motor excited to saturation, the maximum speed of the motor in these conditions is about 80 per cent. of the normal one. Once this speed is attained, we gather up full speed by bringing the field to its normal value. The rheostatic losses are thus only $0{\cdot}8^2=0{\cdot}64$ of those that would occur if the general arrangement be used. (*See Fig. XI.*)

Another method is the following:—We equip the machine with 2p motors of equal size, the total output of which is that demanded by the machine. Each motor is wound for the full voltage, and its shunt coils are permanently connected to the main. The field is thus constant, and the torque therefore dependent on the current in the armature.

If we connect the 2p armature in series the speed of the system is equal to $\frac{N}{2p}$ (N = maximum speed of one motor).

If we group the armatures in two groups of p each we obtain double the above speed, and so on.

Now, let us suppose for instance that we have four motors. To start the machine we connect these all into series, the maximum speed being $\frac{N}{4}$. When this is reached we connect two armatures in series and join these two groups in parallel. The maximum speed is then $\frac{N}{2}$. To finish we connect all the armatures in parallel, the full speed being N.

The loss in the resistance is then given by the following diagram. It is equal to $1 - \frac{1}{2} - \frac{1}{8} = \frac{3}{8}$ of that if but one motor were used. With two motors we can obtain a saving of one-half in this manner. The efficiency of the machine is thus very considerably improved. (*See Fig. XII.*)

On the other hand, should we wish to run at one-half or one-quarter speed, this can be done without loss by simply connecting the motors in one way or the other.

Basing myself on this order of facts, I recently designed, in the name of my firm, Messrs. Bruce, Peebles, & Co., the three following gears for a pit in South Wales. The power needed for the two large gears was equal to 200 H.P. each, and for the smaller one 80 H.P. The driving motors are two in number for each machine. The machines can be run at half-speed with the same efficiency as at full, and they start much more economically than if only one motor was used.

The brakes are two in number, the working brake being driven electrically; the second brake acts on the first reduction gear, and is brought into action by the driver's foot; the current is cut off, and the brake falls should there be overwinding.

But by far the most important problem as regards mining work that has ever been solved is undoubtedly the electrical driving of winding engines.

Tests that have been made on winding engines of all sizes and systems working with modern appliances such as

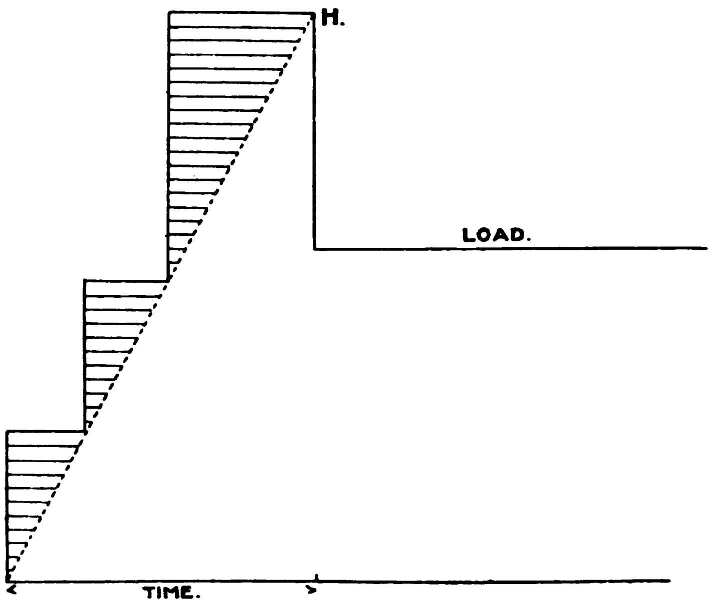


FIG. XII.

super-heated steam, &c., have shewn indiscriminately, and proved that however perfect the engine may be the steam consumption per H.P. on the rope is really enormous.

Thus the very best results obtained with engines working with the super-heated steam, and condensing have been 65 lbs. of steam consumed per H.P. on the rope. But this is exceptional, and I was told only the other day by a competent person that the best result he had ever met with was 75 lbs., and very often 200 lbs. of steam per H.P. on the rope was consumed by engines of an older type working non-condensing.

These results, however unfavourable they may seem, prove only too well that a steam engine to operate under good conditions must work with constant steam admission, which is never the case with a winding engine owing to the intermittent work that has to be performed. Speaking from an economical point of view, not much saving would be realised if we simply connected the motor driving the winding engine to a steam driven dynamo, as all the fluctuations would be transmitted through the dynamos to the steam cylinders, which would shew identically, or nearly so, the same diagrams as those corresponding to a steam winding engine. All we would therefore gain perhaps would be to suppress the boilers near the engine house and other minor advantages; nothing comparable, however, to those offered for instance by an electric pumping set, and as regards actual economy, nothing to speak of would result from this arrangement. This is mentioned because many people are under the impression that the question of driving a winding engine electrically does not differ essentially from driving a haulage gear or some other similar mechanical appliance. This, however, is not the case, the principal thing to be aimed at being to compensate completely the loss due to the intermittent work of the winding engine; or in other words, to find some means of storing energy while the machine is at rest, and to give it up when the same is at work.

Should perfect compensation occur, then we can consider a winding engine as a motor of constant output just like a ventilator or a pump, the load on the engines is absolutely constant, and these working at their most economical grade of expansion have an excellent steam consumption factor. If other items, such as the starting resistance, can be done away with, this will of course favourably influence the general efficiency of the machine; and this being possible, we see that if we use units absorbing 12 lbs. of steam per H.P. hour,—the efficiency between the rope and steam engine being 0·45 (as we will see later on),—the steam consumption per H.P. hour on the rope will then be 27 lbs. or less than half of the quantity consumed by the most perfect winding engine in existence, and about one-third to one-fourth that of the average one.

That is the point we must bear in mind when discussing the economy and advantages of electrical winding, and the one that has always been considered fundamental by us in our experiments. Until it had been solved practically all other efforts were bound to be more or less fruitless.

The credit remains with my former firm, Messrs. Siemens and Halske, to have been the first who some years back looked seriously into the question. An electrical winding engine of about 200 H.P. used for men and minerals had to be erected underground in a salt mine near Brunswick. The work was undertaken by Siemens and Halske, who compensated the fluctuations due to the load by means of a storage battery of suitable dimensions.

The steam engine and dynamo were calculated for the average output, and although the maximum effort was equal to 200 H.P. in starting, the steam engine had an output of 80 H.P.; the battery was fed while the winding machine was at rest, and upheld the dynamo when the former was at work. Diagrams taken on the steam engine showed that the steam admission was practically constant, and the coal consumption remarkably small.

The success of this arrangement was so striking (the output obtainable with the machine being 2½ times as great as that actually asked for and guaranteed) that Siemens and Halske did not hesitate to design and erect a winding machine of 1200 H.P. normal and 2000 maximum output for the Zollern II. Pit on somewhat similar lines; this engine was exhibited at Dusseldorf in 1902.

The load on the dynamos was kept constant by means of a buffer battery, and to start the machine economically the battery was divided into six sections. The machine was equipped with two motors. By branching these on each battery subdivision in turn we gradually reached full speed, the losses in the starting resistance being reduced in a similar way as if we had used a group of motors and connected them in series parallel, as already explained.

The saving in coal was remarkable, and the safety offered very considerable, but the purchase cost of such a plant was high, and its keeping in working order on account of the battery rather expensive; besides, conservative mine owners eyed these efforts with some distrust, and although admitting the many good points of the machine, did not think that the system would meet with much success.

It was of course evident that to enter into competition with the steam winding engine, which had reigned without a rival for the last century, so to say, and with which everybody was well acquainted, the electrical winding engine, besides shewing an important economy in coal used, had also to prove that it was more easily handled and that it offered a greater working safety than a steam winding gear.

These advantages seem, for the present at least, to be found only in the system of compensation and regulation, discovered by Mr. Ilgner, of the Donnersmarkhutte, and applied by us for driving winding engines, rolling mills, &c.

Principle of the System.

This system is based on the simple fact that a continuous current motor, with a full and constant excitation—that is to say, running in a constant magnetic field,—will run at a speed varying directly in porportion to the electro-motive force of supply. Thus it is obvious that if a motor is wound to run at 250 revolutions, when supplied with 250 volts, it will run at 500 revolutions when supplied with 500 volts; therefore, if we arrange that this motor is fed by a continuous current dynamo with independent excitation, whose voltage we can regulate from zero to a maximum by means of altering the excitation of this dynamo, then a motor driven from such a dynamo will run at a speed varying from 0 to the maximum, depending on the voltage of the dynamo which drives it. It will thus be seen that when we start the machine we reduce the excitation of the dynamo, so that at starting the voltage is low, consequently the speed of the motor is low, and we gradually increase the speed to a maximum by altering the excitation of the dynamo, so that no serious resistance of any nature is required, and the motor is started in the most economical manner possible.

The torque required at any moment is, of course, proportional to the current. The voltage multiplied by current represents the energy consumed, so that as the voltage is at a minimun at starting, the energy at starting is also the minimum.

This method of arranging the speed, as will be seen, is economical as regards starting; but assuming that the generating dynamo were either directly coupled to a prime mover or steam-engine, or that the power were taken from a Supply Company through an ordinary motor generator, it is obvious that there would be considerable fluctuations in the supply, or in the running of the prime mover, due, to the fact that the amount of energy taken at different periods of a complete wind varies considerably.

In order to compensate for these variations of energy in the Peebles-Ilgner process, we adopt the following device (*See Figs. XIII., XIV., XV., and XVI.*).

The current from the supply mains drives a special converter, which consists of a motor (H), a continuous current dynamo (D), and a heavy flywheel (S) fixed between the two. The current from this continuous current dynamo drives the main winding motor (F).

This heavy flywheel is the crux of the whole sytem; it is the easiest method yet known of storing energy, and by the kinetic energy therein stored, we can compenste absolutely for the variations in energy required by the winding gear itself.

A practical proof of the absolute compensation of this heavy flywheel can be seen by watching the measuring instruments on the supply circuit, and on the main winding motor.

The readings of the instruments on the winding motor may vary from 0 to the maximum during a complete wind, whereas the ammeter on the supply circuit remains absolutely steady, the whole variations being taken up by the flywheel of the motor generator.

It is obvious that a flywheel can neither give out nor store energy if it is running at a constant speed, as the kinetic energy of a flywheel is directly proportional to its weight, peripheral speed, and slip. Therefore, in a flywheel of this nature, all these three factors should be as great as possible, compatible with conditions of safety, and in actual practice we work with a flywheel of great mass running at

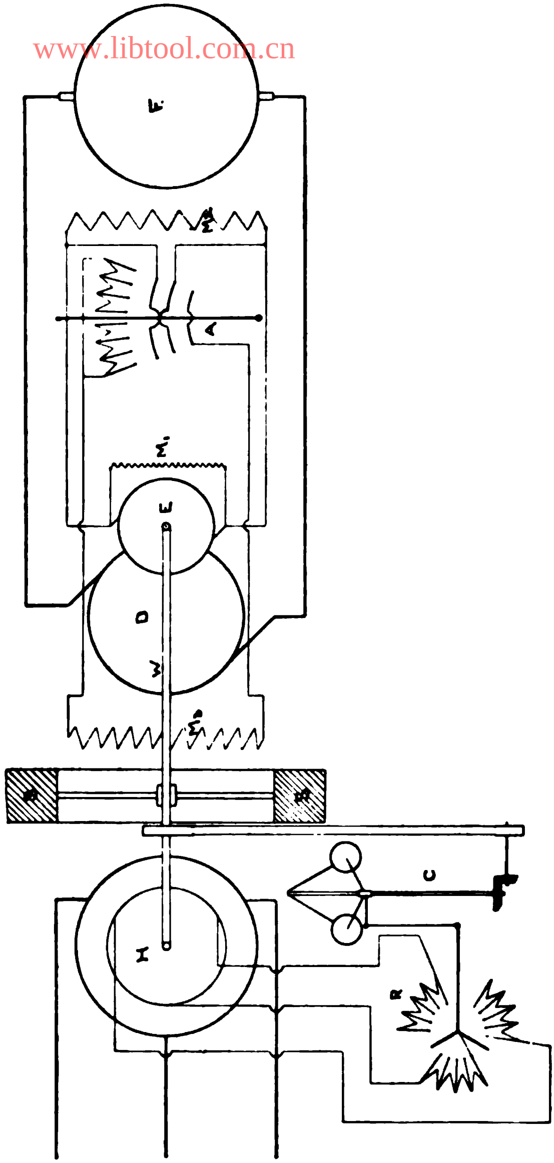


Fig. XIII.

Trans. Man. Geol. and Mining Soc., Part XVI., Vol. XXVIII.

To illustrate Mr. GEORGI'S Paper.

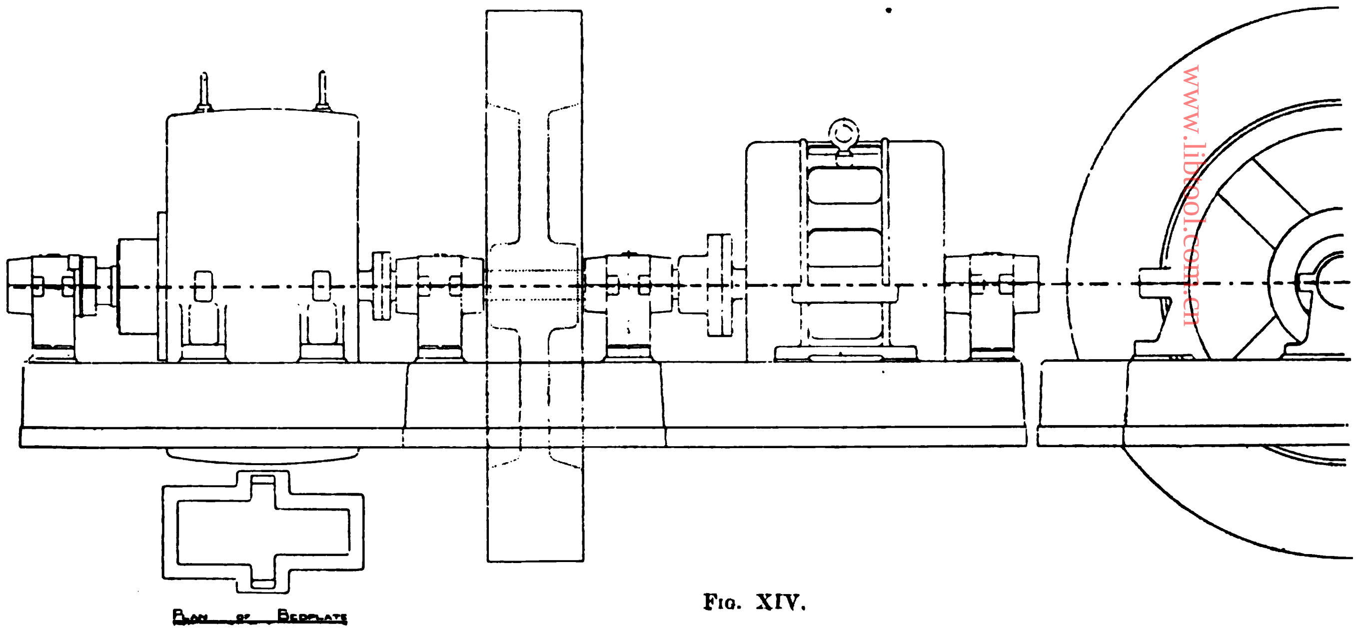


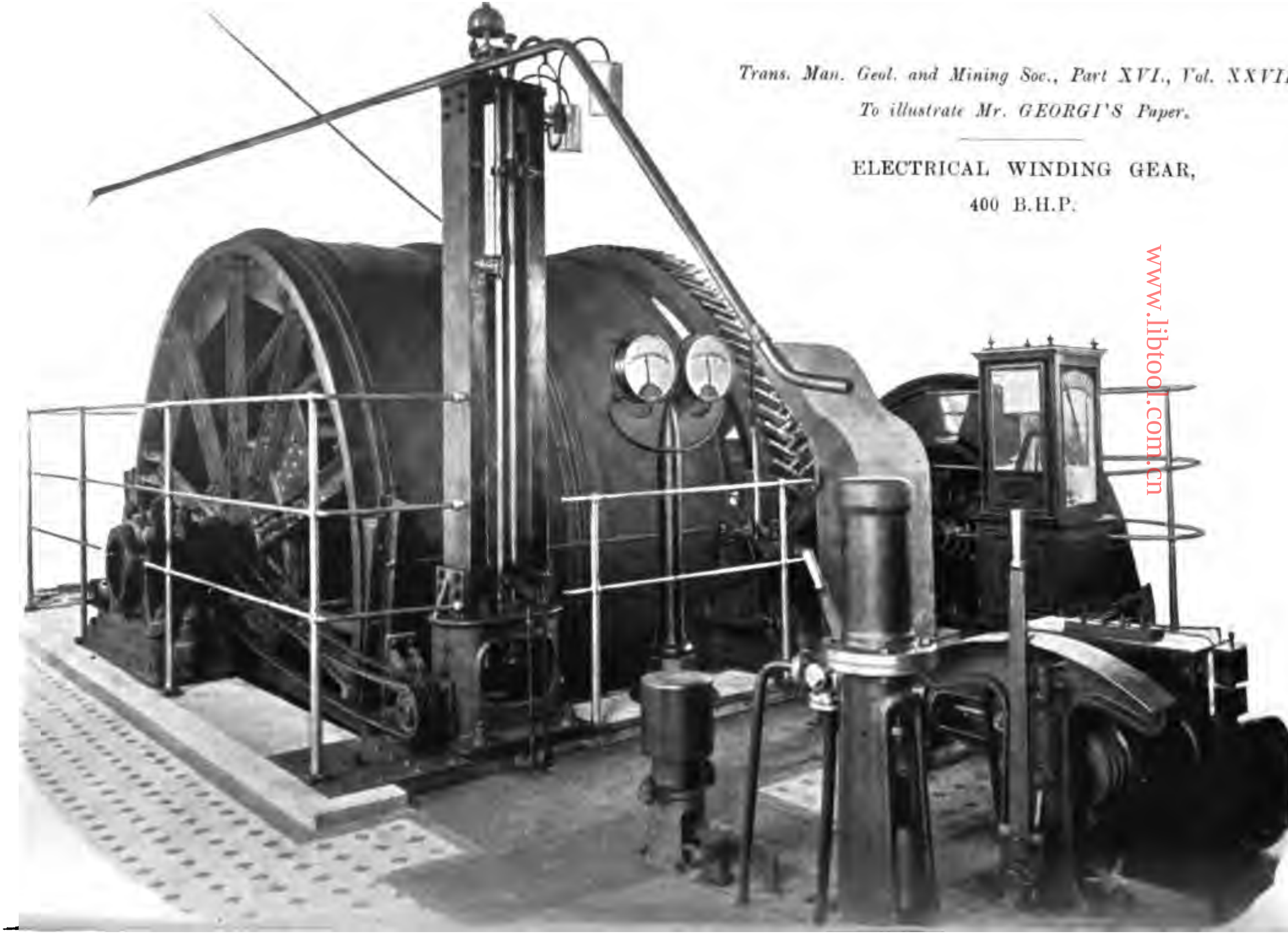
FIG. XIV.

Trans. Man. Geol. and Mining Soc., Part XVI., Vol. XXVIII.

To illustrate Mr. GEORGI'S Paper.

ELECTRICAL WINDING GEAR,

400 B.H.P.



a very high speed, and with an automatic slipping device fitted to the motor of the motor generator, in order to get the variation in speed required. This automatic slipping device acts in such a manner that, if the winding gear requires additional power, the current in the main winding motor increases by means of a magnetic clutch, which inserts resistance into the motor circuit of the motor generator, the speed drops, and the flywheel gives up its kinetic energy to the extent of the drop in the speed $=\frac{1}{2}\kappa\,(\sigma_1{}^2-\sigma_2{}^2)$: κ=constant, $\sigma_1-\sigma_2$=the slip difference. The reverse operation occurs if the winding gear requires no more energy, the current in the motor of the motor generator then only being used to bring the speed of the flywheel from its existing speed up to the maximum.

The weight and speed of the flywheel are so calculated that for a given slip the output of the motor driving the motor generator should remain the same.

Thus the winding motor as far as the supply station is concerned may be considered as an ordinary motor of constant output corresponding to—

$$\frac{\text{Load} \times \text{Depth of shaft.}}{\text{Time of working} \times \text{Efficiency.}}$$

That the speed is practically independent of the load is due to the fact that we use a shunt wound motor. This is a most important advantage possessed by no steam or electrically-driven engine. Any one position of the shunt controller of the motor generator corresponds to one definite speed of the main winding motor.

Brakes are employed, but simply in cases of emergency or for stopping the machine suddenly; they are not used for gradually bringing the machine back to rest, which is done by the retarding apparatus.

Another advantage is that the machine can be always very economically stopped in the following manner:—

Let us suppose that the machine is running at full speed corresponding to the maximum voltage, if we draw the controllers' levers backwards the voltage of the dynamo will drop, but that of the motor remains the same, so that current will go from motor to dynamo. The system is thus

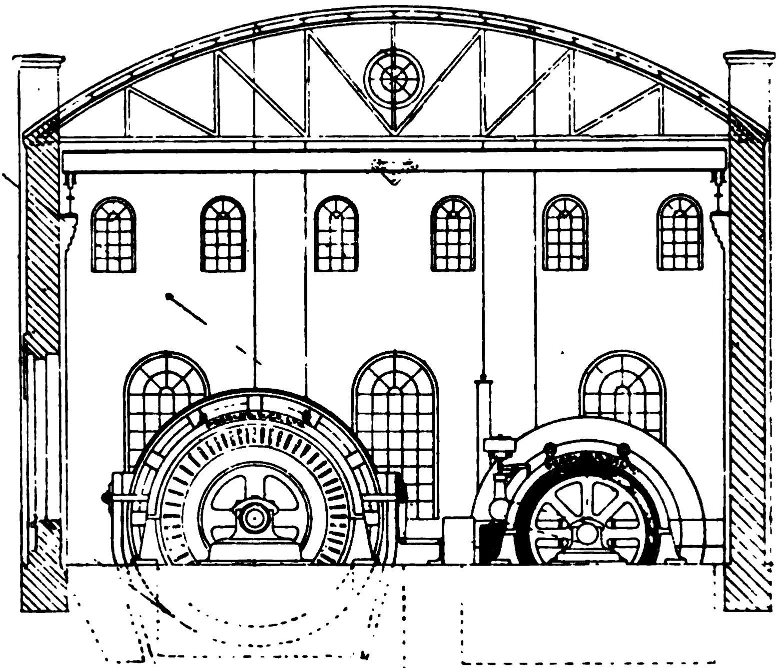


FIG. XV.

economically stopped as the recuperated energy is sent from the dynamo through the fly-wheel and motor back into the supply mains. The brakes are absolutely useless except for holding up the machine.

The machine thus recuperating energy, it is indifferent if the deadweight is badly balanced, for if, at the beginning of the wind, a strong current is necessary to overcome the inertia, the momentum of the drums towards the end will have become negative and will be driving the motor, thus sending energy back into the line. The size of the fly-wheel is independent of a defective cable compensation.

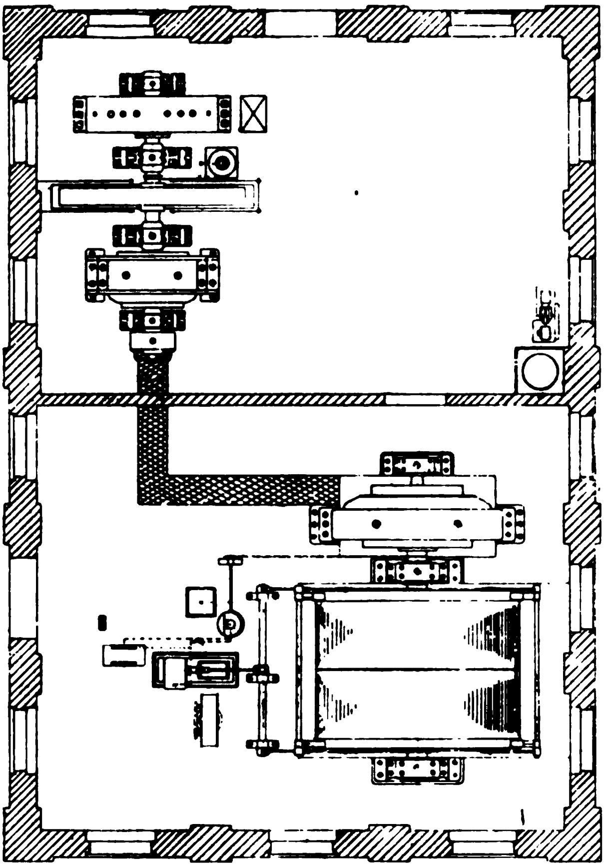


Fig. XVI.

If we examine the actual economy of the system, we find it in no way inferior to that of the very best of other known methods—these being in every other respect far inferior. This is accounted for by the fact that no starting resistances are used, that the energy recuperated at any time is sent back into the line, and that the working factor of the fly-wheel is nearly equal to unity.

The current from the dynamo of the converter is carried without the interposition of any switch or fuse to the winding motor. In this manner no sudden stoppage of the electric supply to the winding motor is likely to occur; the safety appliances are practically useless, as the machine cannot be overloaded, and a short circuit due to defective cables is always noticeable immediately. The field magnet current is produced by a small dynamo on the shaft of the converter.

It is absolutely necessary that the voltage at the terminals of this motor should remain the same whatever its speed may be. To produce this effect we place a very small dynamo, series wound, next to the exciting dynamo. The current of this auxiliary dynamo passes through windings on the poles of the dynamo, having a demagnetising effect, so that the fall in the speed of the converter will have no effect on the voltage, as the loss in turns will be equalised by a stronger field, the current in the auxiliary compensated dynamo diminishing.

General Arrangements.

The disposition of the governing and safety apparatuses as employed is briefly as follows:—

The retarding apparatus, (*See Fig. XVII.*), is composed essentially of the following:—A horizontal shaft is driven directly by means of bevel gearing from the main shaft of the winding engine. The motion of this shaft is transmitted to two parallel ones placed directly under the bed-plate of the machine; these are cut as endless screws, with the filleting in opposite directions, and each is fitted with a courser.

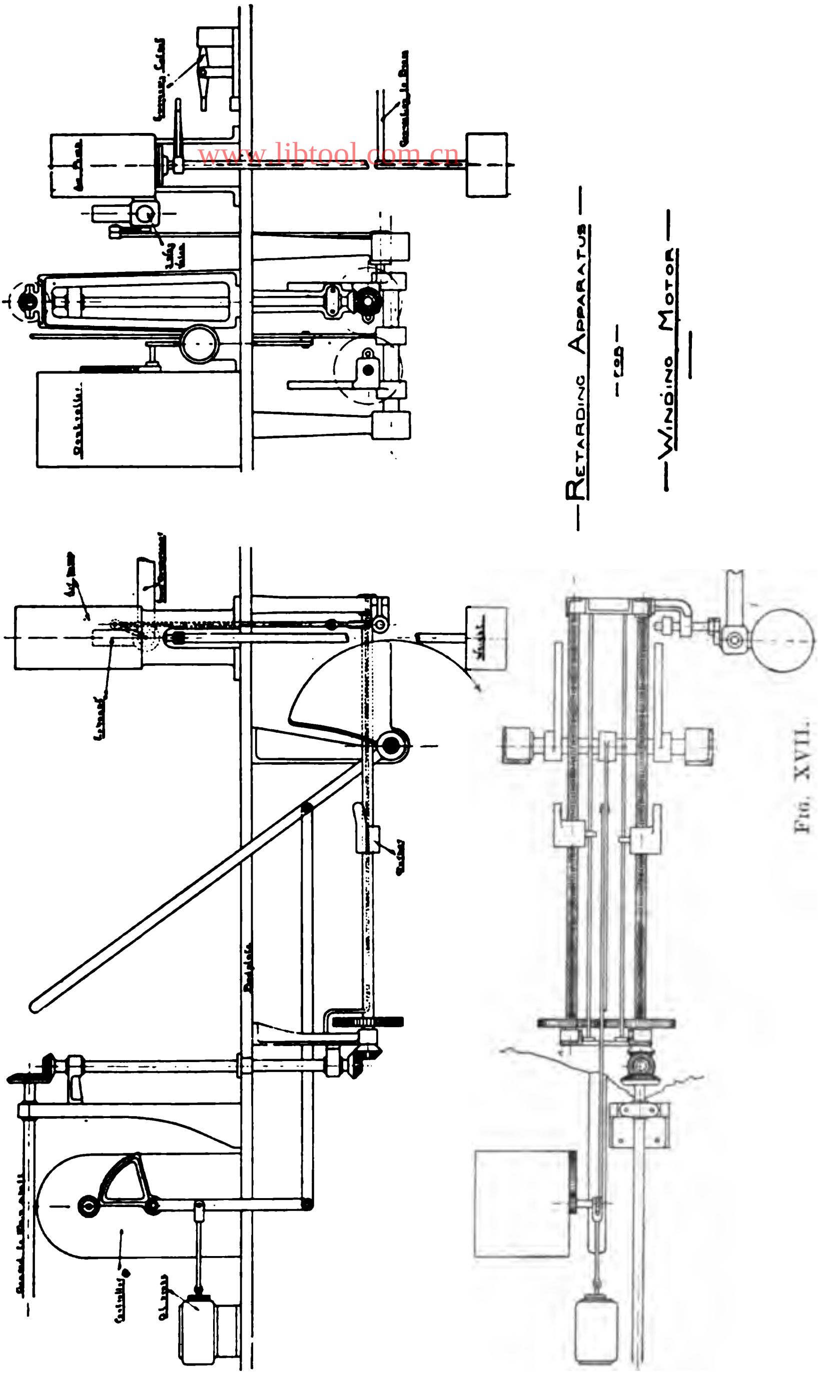


Fig. XVII.

On the pivot of the controllers' lever are fixed two sectors, as shown in the figure.

The working is as follows:—

When a wind is approaching its end and the machine has to be slowed down, courser No. 1 has just come into contact with the disc No. 1 of the lever's pivot.

By its pressure on the same it causes the lever to come gradually back to the position corresponding to the minimum speed attainable; as explained, this operation brings about a most vigorous and economical brakage, energy being thrown back into the line.

Once the lever is on the last notch, the apparatus ceases its action, and by this time the cage has come to the surface. With the remaining voltage available the attendant can perform the last operations, and, when these are finished, push back his lever to zero, thus commutating the current in the field magnets of the dynamo. If, however, through neglect, he should allow the cage to get up into the pit headgear, the courser then strikes on another button, opening at the same time the escape valve of the compressed air piston holding up the emergency brake; this falls down, and, in doing so, cuts off the current, thus stopping the machine.

The brakes, as designed, are two in number. The ordinary working brake will be identically the same as that used with ordinary steam winding engines, the only difference being that compressed air produced by an electrical compressor is used instead of steam.

The emergency brake, which will also be a stop brake, is operated in the following manner:—An air cylinder with a piston holds up the weight, which, on being released, brings the brake into action; the section of the cylinder is calculated so that the weight is only completely lifted when the pressure of the air is sufficient to ensure the proper acting of the working brake. The cylinder is provided with a three-way cock which allows it to be placed in communication with the atmosphere, or the reservoir containing the compressed air. This cock can neither be opened by hand nor by the retarding apparatus, as already described; in any case, the falling of the emergency brake causes the current to be immediately cut off.

We come, therefore, to the conclusion that it is absolutely unnecessary for the attendant to pay any attention to slowing down his machine ; the apparatus does that for him, and also stops it should he be unable to do so. This is a most remarkable performance, which alone ought to render the use of electrical winding engines almost a necessity.

Moreover, the attendant cannot start too suddenly, as the courser takes a certain time to get back outside the radius of action of the levers, and full speed cannot be obtained before this is done.

The maximum speed can never be exceeded; a special speed controller is therefore utterly useless.

The sudden stoppage of electrical energy from the main does not jeopardise in any way the good working of the engine, as the kinetic energy contained in the flywheel is more than sufficient to complete several windings.

Any winding engine can be employed with this system, each having in a given case certain advantages that would justify its being preferred to another. But in any case it should always be advisable to choose such an arrangement that can render possible the use of high-speed motors for a given rope speed, and that at the same time would reduce to a minimum the moment of inertia of the system.

Thus, in Germany, friction discs are much in favour. These possess a small moment of inertia, and can be of a reduced diameter, this factor being only limited by the thickness of the rope, the adherence being a function of the angle embraced and not of the length of arc. Thus, for a flat cable and a strain equal to 10 tons on the rope, and a factor of safety of 10, we can choose a disc of about 10 feet in diameter which, for a maximum speed of 40 feet per second, would require a motor making 75 revolutions per minute.

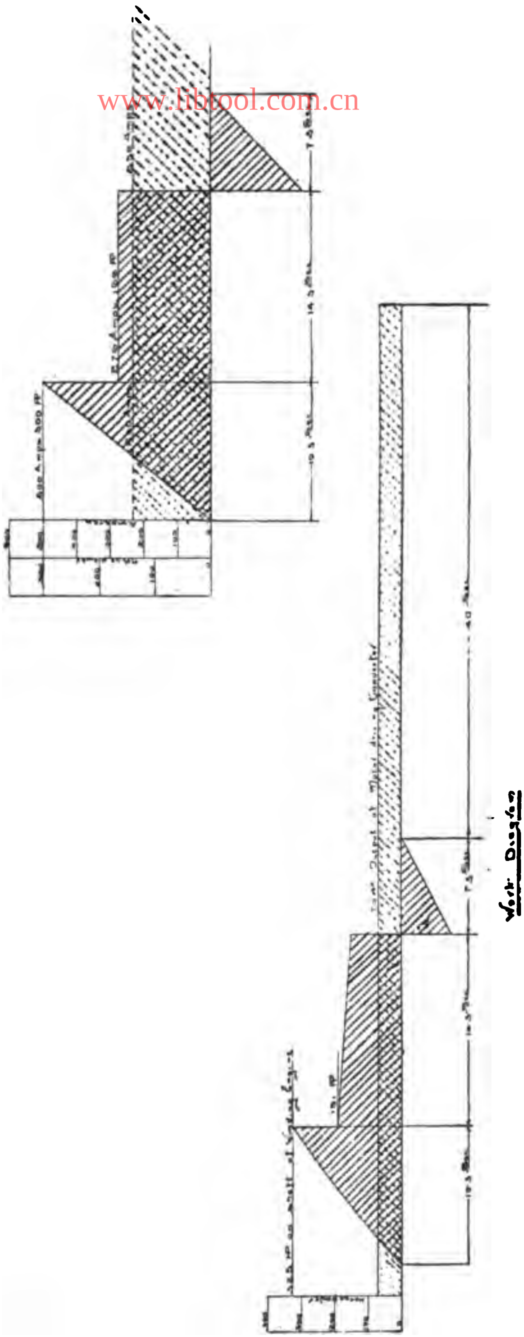
These discs have the disadvantage of only allowing of winding from one particular level, as the distance between the cages is always the same; and then, on the other hand, should the rope break, both cages fall to the bottom.

With them, however, the placing of the cages on the keps is made easier, as only one need be placed, the other falling of itself into position; one manœuvre is thus spared, and then the strain on the rope can never be very great as should the cage at any time meet with an unlooked-for resistance, the cable will have a tendency to slip on the disc, thus saving it from too great a strain.

Diagrams for electrical winding gears for an output of 250 tons in eight hours from a depth of 400 yards are shown in *Figs. XVIII., XIX., XX.*, and *XXI.*, and diagrams for an output of 1,800 tons in ten hours from a depth of 600 yards are shown in *Figs. XXII.* and *XXIII.*

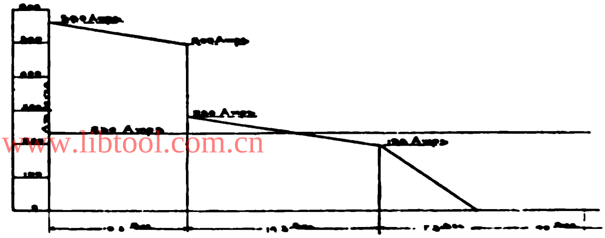
As regards the economy realised by this system, we are prepared any day to guarantee under penalty that the energy consumption per H.P. hour on the rope will not be more than 1·8 kilowatts, taken from the bus bars of the power station. If we set up the steam plant as well, we can then put in units absorbing 18 lbs. of steam per kilowatt on the bus bars. The steam consumption we would then guarantee would not exceed 32 or 33 lbs. per H.P. on the rope.

Another advantage obtained by using the above system is that the steam consumption per H.P. does not vary with the size of the winding-gear. It is as good with 300 as with 1500 H.P. sets.



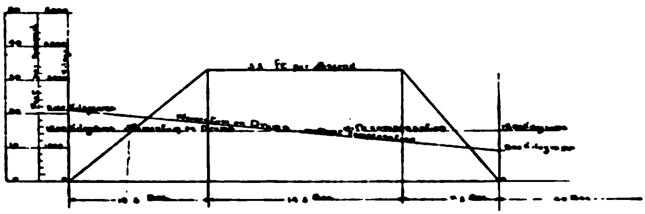
Figs. XVIII. and XIX.

Diagrams for an Electrical Winding Gear for an output of 250 tons in eight hours from a depth of 400 yards.



Load Diagram

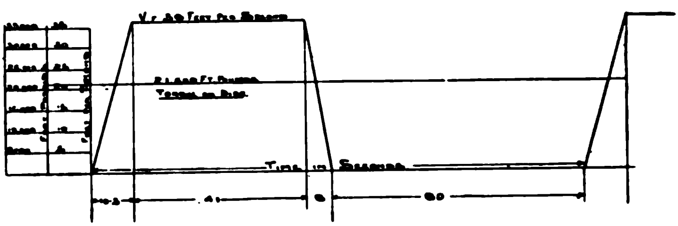
FIG XX.



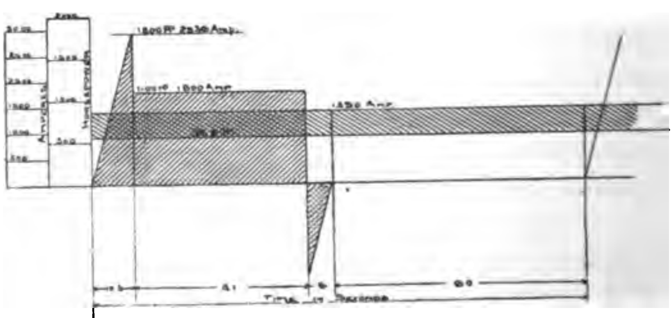
Velocity Diagram

FIG. XXI.

Diagrams for an Electrical Winding Gear for an output of 250 tons in eight hours from a depth of 400 yards.



— VELOCITY DIAGRAM —



— WORK DIAGRAM —

FIGS. XXII. AND XXIII.

Diagrams for an Electrical Winding Gear for an output of 1,800 tons in 10 hours from a depth of 600 yards.

Nowadays electricity can be transmitted very economically with the utmost ease over practically any distance, so that the mine owners of a district would reap considerable advantages by uniting to erect a power station of large dimensions sufficient for all their wants. Energy could be generated at an exceptionally low cost; all boilers, piping, chimneys, steam engines, &c., now met with so freely in all corners about a mine would disappear, all the power needed being provided for by very efficient electric motors occupying much less space, and wanting comparatively little supervision. Energy would be at hand up to any limit, day and night, and an extension of the power plant of the mine could be easily and quickly effected.

Apart from these advantages, which can only be properly appreciated by those in possession of an electrical plant, the economy in fuel would be 50 per cent. at least; repairs, &c., would sink down to a trifle, and three-quarters of the hands now used for actually running the mine plant could be done away with; so that we can safely say that half the machinery-running expenses of a mine could in this manner be saved.

In the power station coal-lifting machinery, automatic stokers, &c., could be used, which would bring down the attendance necessary there to but a few men.

Coal-cutting.

The application of electrical power to coal-cutting machinery is rapidly extending owing to the facility with which the plant can be installed, its economy in capital outlay and its proved efficiency as compared with compressed air. This question is of great importance to those engaged in the mining industry, but seeing that it has been recently discussed before this Society, it seems to be unnecessary to enter further into that branch of the subject at present.

Mr. JOHN GERRARD, H.M.I.M., in moving a vote of thanks to Mr. Georgi, said that it had not been his lot to hear a more brilliant paper for a long time. Mr. Georgi had given them something to think about and the prospect he had held out of doing away with chimneys and smoke was most attractive. With regard to the application of electricity for colliery purposes, it was a little odd that at this time there should be a large meeting, in another place, to consider the application of electricity to mining work, and a code of rules—of over one hundred—would, he supposed, be carefully considered at that meeting. So that we were moving in this country, even if we are slower than they are in Germany. He (Mr. Gerrard) went to the Dusseldorf Exhibition, and spent about three days there. His regret was that he could not spend three more days there. He remembered seeing one electrical winding plant. We are, perhaps, a little slow, but it is to be hoped that we shall be surer for being so. There is much to be said, unquestionably very much to be said, in favour of the application of electricity. It is very convenient, and, apparently, is so very economical; but we have got to be assured, before we use electricity, that it is quite safe. Safety is the first consideration with those who are charged with the inspection of mines, and when that is secured there can be little doubt that electricity will be largely used.

Mr. J. ROBINSON, who seconded the motion, said he had listened with pleasure to the paper, and could verify from practical experience some of the points that had been advanced. He had been rather a close observer of this electrical question in connection with mining for some time. With regard to electrical winding there would, no doubt, be a great deal to be said for it when the electrical people had made a thoroughly safe winding gear that one could depend upon. He had the pleasure of seeing one at work in Germany of 600 horse-power. The work was being done as safely and as comfortably as it could have been done by any steam engine in Lancashire; but still, when he went into the cellar, and saw what happened during the reversing of the engine, when the cage arrived at the surface, he was very much struck with the amount of energy that seemed to be absorbed and lost for all practical purposes. It was certainly a very great pleasure to him to learn that a great deal of the energy and power which was wasted in bringing to rest the winding engine could be saved. It was the knowledge that so much could be saved by means of Mr. Ilgner's compensating arrangement by means of a fly-wheel, &c., that led him to the conclusion that electrical winding would be the cheapest. Then it was pointed out that an electrical winding engine would be an advantage in the event of any stoppage of the generator, for then the men could be brought out of the pit to the extent of two or three windings by reason of the stored-up energy. But the main question upon which he desired information was not as to the efficiency of electricity for winding, but as to its general efficiency and practicability when questions of capital expenditure and matters of that kind were taken into account. Some mining engineers were of the opinion that when the cost of electrical equipment was fully considered there was not much advantage to be gained, from the monetary point of view, from electricity. Nevertheless, it was interesting to hear of what was being done in the way of pumping in Germany, and in that respect he thought that Germany was ahead of England.

The resolution was passed with acclamation.

Mr. Georgi, after acknowledging the vote of thanks, in reply to the questions raised by the mover and seconder of the resolution, said that as regards cost on a fair comparison the advantage was distinctly on the side of electricity.

The initial cost of an electrical winding plant might be 20 to 25 per cent. more than that of a steam winding plant, but there would be a large reduction in the operating expenses.

Mr. Robinson inquired whether it was to be understood that the whole cost of an electrical installation and equipment of the winding drum would not be more than 25 per cent. in excess of the cost of laying down boilers and engines of the ordinary type? It would be interesting to know whether anything was likely to happen if the winding was stopped for five minutes.

Mr. Burrows (who now occupied the Chair) asked for some information as to the probable cost of an electrical winding installation as compared with steam engines for a new colliery.

Mr. Georgi: If you were starting with a new colliery, with no old boilers, no old machinery—starting on the green turf—we would undertake to provide an electrical winding equipment for 25 per cent. above the cost of a steam equipment, and to guarantee the running cost for one year will be 50 per cent. less than it costs with a steam winding plant. I can take you to collieries where this reduction of working expenses has actually been realised.

Mr. Robinson: If you can do that there is a great future for the system. I think you will not be able to execute the orders you will get. A saving of 50 per cent. in working expenses would be a great boon.

Mr. M. Pickstone: The debate might be adjourned until another meeting, and, in the meantime, Mr. Georgi, I am sure, will be glad to meet any member and discuss with him in the fullest detail questions of cost.

Mr. Robinson: It is a very important matter, and I shall be glad if the discussion is adjourned.

The discussion was accordingly adjourned.

TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

PART XVII. VOL. XXVIII. SESSION 1903-1904.

The ORDINARY MEETING of the Members was held on Tuesday, 12th April, 1904, in the Society's Rooms, 5, John Dalton Street, Manchester.

Colonel GEO. H. HOLLINGWORTH, F.G.S., President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and unanimously elected Ordinary Members of the Society :—

Rev. E. C. COLLIER, M.A., the Vicarage, Dinting, Glossop.

Mr. WILLIAM BAKER DIXON, Manager, Birkacre Colliery, near Chorley.

SHELLS EXHIBITED.

Mr. GERRARD exhibited the following shells, which he had obtained from the Coal Measures:—

1. *Anthracomya Phillipsi,* from Dover, at a depth of 1188 feet from the surface, and about 18 feet from the top of the Coal Measures.

2. *Carbonicola aquilina,* from Dover, from the same stratum as Anthracomya Phillipsi.

3. *Anthracomya Phillipsi,* from Bradford Colliery, above the Bradford Four Feet Coal, and a few yards below a stratum of limestone containing Spirorbis.

4. Shells from above the Worsley Four Feet Coal, not yet identified.

A vote of thanks was accorded to Mr. Gerrard for his communication.

Mr. JAMES TONGE, Junr., F.G.S., read the following Paper on "Education in Coal Mining":—

EDUCATION IN COAL MINING.

By Mr. James Tonge, Jr., F.G.S.

Introduction.

In reading this paper on Education in Coal Mining before a Society which has done so much to increase our knowledge of geology and mining for a period of over 60 years, it is desirable to lay emphasis on one point.

Societies like this are sometimes addressed as though they were often careless in their duties and slow to take advantage of improved appliances or to adopt new and better methods, but there is no body of men more conscientious in their duties, quicker to take advantage of any improved appliances tending to the increased safety of the men and workings, or more ready to adopt new and better methods of getting the coal, than colliery managers and colliery proprietors. The writer, therefore, ventures with humility, but without the least fear, to point out a few of the ways in which colliery owners and managers can help to improve the education of the workmen in mining practice, and in this way make the miners' calling at once safer and more scientific.

In the following observations it is not intended to refer to industrial education generally, nor to the special training of mining engineers—Mr. Hall and Mr. Hollingworth have already dealt very ably and thoroughly with these—but simply to refer to the training of miners, under-officials, and managers.

Need for Mining Education.

At the present time there is an outcry for better education in every direction. It must be plain to everyone that those countries providing the best education for their rising generations are producing the best work and proving to be our greatest rivals.

There is undoubtedly great scope for improved education in mining. Mathematics, mechanics, steam, electricity, hydraulics, chemistry, geology, and surveying—all these sciences are absolutely necessary to the mining student or engineer, and he cannot afford to neglect any of them.

But a good mining education is required for another reason. The work of all those engaged underground is difficult and dangerous. It is necessary that all the workers should know not only how to do their work in the most economical and skilful manner, but also in such a way that they may not prove a source of danger to themselves, or their fellow-workmen, or to their master's property.

Education of Boys and Working Miners.

At the present time it may be said that there is no qualification except that of age for boys working underground in this country. It is not necessary for a boy to pass any examination, written or oral, before being allowed to enter a mine. Now it cannot be denied that it would be a great encouragement to an employer in taking on a youth to work below-ground to feel that he was acquainted theoretically with certain appliances and arrangements. Before a boy enters a mine for the first time he should know something of the principle and construction of a safety lamp, and under what circumstances it becomes dangerous; he should know what air-doors and brattice cloths are for, and the significance of a fence. In no other calling—except, perhaps, the seaman's—can it be said that the lives of all the workers are at the mercy of the most ignorant boy. But it certainly is so in this case. It is evident, therefore, that any system of examination for boys desirous of entering a mine must prove beneficial.

The same remarks will, of course, apply to a certain extent to miners generally. It is true that the working of a collier at the coal face is regulated by General Rule 39, which requires that he shall have had two years' previous experience under the supervision of skilled workmen, before being allowed to work alone at the face. But this is not enough. In this respect we are behind some other countries. In British Columbia, for instance, certificates of competency are granted to coal miners after passing an examination in the principles of their calling. These examinations are held every month, and are conducted by a duly-appointed Board of Examiners, under the Coal Mines Amendment Act of 1901.

"*STATEMENT OF CERTIFICATE.*

Form A. *No. B. 137.*

British Columbia.

Certificate of Competency.

Coal Mines Regulation Act.

This Certificate of Competency, granted under the provisions of the Coal Mines Regulation Amendment Act, 1901, entitles the holder thereof . . . ., of Michel, B.C., to follow the occupation of a coal miner in any coal mine in the Province of British Columbia. Granted, after examination, by the Board of Examiners of the Michel Mines. This, by authority of the Board.

EVAN EVANS, Secretary."

But though the advisability of holding examinations for boys and working miners might be questioned, at any rate we must all be agreed that both boys and miners should take advantage of whatever mining instruction they are able to obtain. Some managers are now beginning to insist on their youths attending the local mining classes held under the County, Borough, and District Councils. This is a very important step, and encourages us to press it a little further.

Is it too much to ask that managers generally should require certificates of regular attendance at mining classes from the youths working underground, or, at any rate, satisfactory proof that they are studying the elements of mining? It may be said that practical experience is all that is necessary to enable a workman to become proficient. Well, this can hardly be true of any industry, least of all of coal mining. The principles of mining are best grasped in the schoolroom—their application and practice are only possible in the mine.

But if managers are not prepared to insist on attendance at classes, there are still other ways in which they can improve the standard of mining education.

Mining teachers are continually being asked by students, "What good is a certificate of attendance at mining classes to me? Will my employer take any notice of it?" It is here that the employer can give great encouragement to the study of mining. It is only necessary that he should show to applicants for positions of trust in the mine that he views with approval their efforts to make themselves better acquainted with the theory of the subject. If he begins to make a practice of simply asking each applicant if he attends classes or studies at home, this alone will induce the best of the miners and officials to immediately turn their attention to study.

Many colliery proprietors are already, in their private capacity, encouraging mining study by offering prizes at the various technical schools. This is a good thing, but it would be far more useful if prizes and small scholarships were given by colliery firms, or even by the managers. It is now merely kindness on the part of the donor; let it become a matter of business and the result will be quickly seen in a considerable increase in the number of mining students.

The Colliery Fireman or Deputy.

Let us notice for a moment the importance of the position held by a fireman or deputy.

His responsibilities are great; it is impossible to overrate them. He is the person appointed in accordance with the Coal Mines Regulation Act to decide whether the air in the mine is or is not adequate, and that the mine is in a fit state for the men to enter. It is his duty to see that this condition is maintained during the whole of the time that men are at work. He is responsible for the sufficient supply and efficient setting of all necessary timber. He is expected to see to the observance, by men slow to make themselves acquainted with their own obligations, of the 23 special rules for colliers. And finally he is frequently the authorised shot-lighter. When it is remembered that at least 70 per cent. of the accidents are attributed to the failure to carry out these five main duties thoroughly, the importance of his position may be appreciated.

It seems unnecessary to refer to his other duties in regard to lamps, fences, reports, etc. Enough has been said to show that he must be a very intelligent and conscientious man who fills the position of fireman or deputy satisfactorily.

He should be a good practical man, qualified by experience as a coal getter, timber man, haulage hand and shot firer. But he must also learn the principles of timbering roads and faces, the mechanics of haulage, the chemistry of explosives and gases. And if he is to have his due influence and proper control over the men in his district he must show that he has a clear understanding of the rules he is called upon to carry out himself, or to see carried out by others.

There have been many controversies recently in regard to accidents from falls of ground; many recommendations have been made and new rules have been introduced. Instead of a reduction the latest returns show a great increase in the number of accidents from this cause.

	Underground Fatalities.	Fatalities from Falls of Ground.	Percentage.
In 1901	950	482	50·7
In 1902	907	452	49·8
In 1903	912	566	62·0

It has never before reached 500.

A great deal of this bad record is probably owing to the fact that the fireman has too often been overlooked. But it is pleasing to see that some of H.M. Inspectors of Mines, who probably look upon the fireman as a sort of minor Government official, have not always overlooked him.

In his Report for 1900, Mr. Gerrard says:—

"In connection with systematic timbering, it should be recognised that it is not sufficient the giving of a direction that timbers shall be placed at maximum distances, it is absolutely necessary that such direction shall be enforced. Firemen ought to report to the manager every case of non-compliance with the direction, and the 29th special rule states that the fireman shall stop the miner from working, and see that he commences to put up the required support. Any failure on the part of a fireman to so enforce the direction of the manager should be dealt with in a disciplinary manner."

And again in 1902, Mr. Gerrard says :—

"As regards the falls of roof, although there is a reduction compared with the previous year, I must confess to being disappointed. With very few exceptions the managers have fixed upon reasonable distances as maximum distances, so that there shall be less dependence upon judgment. But I am again compelled to express the opinion that all this is useless unless the requirements are enforced. Firemen ought to report to the manager every case of non-compliance with the direction given, they should have no discretionary power to deal with these themselves. They are required by the rules to see that the worker ceases to get coal or what other work he be engaged upon, and commence to put up the required support. By so doing, not only is the commencement of that which is required made sure, but the opportunity is also given to the fireman to see that it is done in the right way, at the right place."

There is no doubt that in most mines there is a good supply of timber provided by the management. The method of timbering, decided after serious consideration, is the best that could be adopted—but the manager cannot make a careless collier into a careful one by a notice. But he can provide a more efficient fireman, and this would have, we believe, a striking effect. When the fireman is made sufficiently aware of the importance of his duties in this respect, and is absolutely determined to carry them out, there will be a diminution in the number of accidents.

It is often very difficult for the fireman to get the collier to carry out his wishes—you may judge the fitness or unfitness of this official by the ease or otherwise with which he gets the men to carry out his wishes.

Sometimes a collier is actually a better man than the fireman. In this case he will probably use his own judgment, and, if his opinion is contrary to the fireman's, there may be trouble continually between the two parties.

To make the fireman more efficient he should be certificated. A fireman who has succeeded in qualifying himself both by experience and examination for his position will have a moral influence with the men which he cannot obtain in any other way. It is very likely that until this is done the collier will fail to pay him that respect which is due to his important position and which is necessary for the safe working of the mine.

To have a certificated fireman is no new idea. Already in most of the Coal Mining States of America, this official is required to hold a certificate, granted by the Board of Examiners. There is a keener demand in America for better educated mining officials than here. They recognise that mine inspection is of the first importance, but that it can only be efficiently carried out by fully trained men. In Pennsylvania, during the five years prior to the passing of the law of 1880 requiring mine foremen to be certificated, there were 4·9 men killed per 1000 employed below ground. For the five years following, 4·09 per 1000, and from 1885 to 1900, 4·22 per 1000. In other words there were 67 less lives lost in 1901 than in 1885, and this, in spite of increased difficulties and dangers owing to deeper mines, larger volumes of gas, introduction of machinery, and greater amount of shot firing.

Perhaps enough has been said to show that the deputy is in such a position that he can greatly improve the safety of the mine, if he can be made to realise the importance of his position and the necessity of fitting himself thoroughly for it.

MANAGERS AND UNDER-MANAGERS.

Anyone who has thought for a moment upon the manner of training managers and under-managers must have been struck with the lack of a proper system. We are not now referring to the lack of uniformity in the various examining boards, but to the want of organised instruction. Candidates for Certificates are not obliged to show that they have attended certain courses of instruction at a University, Mining College, or Technical School. They avail themselves of any and every source of instruction; classes, lessons by correspondence, the answering of questions in mining journals, private tuition, etc. This may be very good or very bad for the student. At any rate as there is no systematic instruction required by the Board of Examiners as part of the qualification, there is no attempt on the part of the candidate to obtain it. In fact it must at once be confessed that in most mining districts there is no suitable course in mining available.

Co-ordination in mining education is very necessary. At the present time the students in the Technical Schools attend the classes in the Principles of Mining held under the Board of Education—there are a few special classes for intending colliery managers and under-managers. But there is no satisfactory connection between the two. This is in great part due to the fact that the questions set by the Board of Education Examiner are not as a rule practical mining questions—they are questions dealing with scientific principles almost entirely—whereas the questions set by the examiners of the Examination Board are chiefly practical questions. And if the teacher aims at enabling his students to pass the examinations, his method of teaching will be in accordance with the character of the questions. So it comes about that the candidate for a manager's or under-manager's certificate feels that he will derive no benefit from attendance at the Board of Education classes. This is to be regretted, as by far the largest number of mining students attend these latter classes. There are probably 3,000 or 4,000 students attending these classes in England and Wales. The syllabus of subjects under this Authority is certainly an admirable one. It covers very completely the whole of the principles—both of coal and metal mining—and at the examination a paper is set in each Branch and candidates are allowed to choose either paper. The only fault to be found is that too many of the questions are purely scientific, and consequently are not the same help to a prospective candidate for a colliery manager's certificate as they might be.

At the same time we have no hesitation in saying that the standard of the latter certificate would be greatly raised if candidates were required to produce certificates of having passed the Board of Education examination before being allowed to sit for First, or Second Class Certificates of competency. A student has plenty of time to take these classes in the five years' work required by the Coal Mines Act, and a student who has passed the Advanced Stage under the Board of Education will have made the best use of his five years in the mine and will come before the examiners on the whole, better prepared than those who have neglected their opportunities for study.

Experience teaches us that the best mining students are those who have started in the Elementary Class immediately after leaving school, have gone on to the Advanced and Honours Stages, then have joined the Under Managers' Class, sat at the examination after reaching 23 years of age, and have finally presented themselves before the Examining Board for First-Class Certificates, and in most cases they have been successful.

The New Certificates Bill.—But now we must refer to a very important alteration in the qualification for these certificates.

Last year a new Act (Act 3, Edw. VII., Ch. 7,) was passed, and is now in force, which provides that no person shall be entitled to a certificate of competency as a manager or under-manager of a mine :—

> "Unless he shall have had practical experience in a mine for at least 5 years" or "unless he has received a diploma in scientific and mining training after a course of study for at least two years at any University, University College, Mining School, or other educational institution to be approved by the Secretary of State, or has taken a degree of any University to be so approved of, which includes scientific and mining subjects, and has also had practical experience in a mine for at least three years."

It will doubtless be remembered that in Mr. Asquith's Coal Mines Bill of 1895 it was proposed to insert the words:—

> "or such experience or other training as the Board to which he applies may consider equivalent to such five years' experience."

This was strongly opposed by colliery managers and others, and was never made law. It was felt that there was a danger of five years' training in a college being substituted for five years' training in a mine. The new Act is a very wise compromise. There is the recognition that the best scientific instruction is necessary. There is no doubt the standard of the manager's education will be very greatly raised as a consequence of this new legislation. It is intended that in addition to the three years' practical experience, some period of each year during the course of study at the college should be spent in the mine. In this way a practical direction will be given to the course of study and make it really effective as a training for one who will afterwards be, if anything, more a practical man than a theorist. In this way should be produced men who will know how to apply their scientific knowledge to the practical needs of industry, and no industry needs such men more than our own.

Instruction at Present Provided.

Board of Education and Classes for Intending Colliery Managers.

Reference has already been made to these classes which are held at local Technical Schools under the County, Borough, and District Councils. In Lancashire classes are held at the following centres :—

Authority.	No. of Students.
Accrington	28
Audenshaw	11
Bacup	18
Bolton	30
Burnley	13
Chadderton	26
Dalton-in-Furness	54
Denton	12
Farnworth	28
Leigh (including students attending classes for intending colliery managers)	81
Westhoughton	31
Wigan (including students attending classes for intending colliery managers)	133
Worsley (including students attending classes for intending colliery managers)	28
Total	493

Also classes at Abram, Ashton-in-Makerfield, Clayton-le-Moors, Hindley, Pemberton, and Tyldesley, but the number of students attending these is uncertain.

If we put the number of students of all ages attending mining classes in Lancashire at 600 we shall probably be outside the exact number. According to H.M. Inspectors' Reports there are 83,670 persons engaged underground in the Lancashire districts. If we say that 40,000 of these might reasonably be considered to be eligible for attendance at classes, we have to admit that only 600 of these, or 1½ per cent., avail themselves of the opportunity.

The cost of this education to the County and local Councils in comparison to the number of students must be very great. The County Council alone make grants amounting to £750 each year, and it would cost no more to teach three times this number of students. It will be good for the miners, good for the employers, and good for the schools when efforts are made, wherever possible, to increase the usefulness of the instruction given at these centres of mining.

Mining Courses at Universities and University Colleges.

Courses in mining are now provided at several Universities, University Colleges, &c. The chief are: The Royal School of Mines, London; the Glasgow University; the Durham University; the Leeds University; the Manchester University; the Birmingham University; University College, Cardiff; University College, Nottingham; the School of Mines, Camborne; the Glasgow and West of Scotland Technical College; and we believe special courses are being arranged at the new Technical and Mining College at Wigan.

These courses are arranged to be of service to those intending to practise as mining engineers, colliery managers,

managers of metalliferous mines, land and mine surveyors, &c., and generally include such subjects as the following :—

Geology.—Applied Geology, Petrology, Palæontology.

Mathematics.

Engineering.—Civil, Mechanical and Electrical, and Surveying.

Physics.

Chemistry.

Metallurgy and Assaying.

Mining, (Coal and Metal.)

Courses such as these would be recognised by the Home Secretary as equivalent to two years in the mine ; provided a certain amount of practical work was obtained during the two years.

Each institution will probably be given a free hand under the new Act, in selecting the subjects of instruction. It is not likely that there will be a particular standard of education for diplomas and degrees, but we may be confident that the University Authorities, recognising as they are now certainly doing, the need for a highly scientific training for mining engineers and managers, will do all they can to provide this instruction and see that their students are thoroughly trained.

In this respect a Society like this can be of great assistance to the University Authorities. A committee of mining men, with the Inspectors of Mines, could from time to time advise as to the degrees and diplomas to be given and the standard to be maintained in this district.

At the University of Manchester a very encouraging start has already been made, due in great part to the exertions of an esteemed member of this Society, Professor W. Boyd Dawkins.

Situated as it is in the centre of one of the most important coalfields in the country it seems strange that the University here has not already made a name for itself as a first-rate mining institution, especially when we remember that its Professors already teach every science included in the general term Science of Mining, and that the names of Professors Boyd Dawkins and Dixon are so closely associated with it, gentlemen who are known as most reliable authorities, the one on Geology in relation to Mining and the other on the Chemistry of Mine Gases and Explosions.

A very complete mining course has now been arranged, including Geology, Physics, Chemistry and Mining, and this will no doubt be extended at an early date. Already the Mining Department has been well equipped with valuable mining machinery and appliances of the most modern type, and it is expected that before very long there will be a thoroughly complete School of Mining, where students intending to become mining engineers or colliery managers may have the advantage of a good University training and at the same time have ample opportunities of gaining practical experience in various mines in the district where the plant and appliances and methods of working are known to be on the most modern lines. The Society can help greatly to improve the usefulness of the Mining Department of the Manchester University. We have already referred to one way in which this can be done, viz., in giving advice as to the degrees and diplomas to be given and the standard to be maintained. We have no doubt the University Council would welcome the formation of an advisory Committee of mining experts for this purpose. Again, the Society might welcome to its meetings as students the youths at present studying mining at the University.

Although we are able to record this great improvement in the provision of higher mining instruction in this country, we are still far behind the United States and Germany. In the United States alone there are 34 institutions which are devoted either entirely or partially to mining education and the instruction provided is for the most part of a more complete character than has been attempted so far in this country. As a consequence the number of students attending each University is very large. Backed by financial assistance from the State, encouraged by the mine owners, appreciated by the students, it is not surprising that these Universities and Mining Colleges should be doing such good work.

In conclusion, we have pleaded for the better education of the miner, the fireman, the under-manager, and the manager, because we believe that the result will be seen in safer mines and more scientific methods of working. It has been suggested that this Society should act on certain lines, believing that this would be a step entirely in harmony with its other work, and particularly now when its title includes "Mining."

There can be no greater satisfaction either for individuals or societies than to know that they have improved the intellectual status of their fellow-workers.

Commissions, Regulation Acts, Inspectors, none of these take away the responsibility from the miner, the official and the manager, and these responsibilities can only be met when these officials are thoroughly educated.

On the motion of Mr. J. Ashworth, seconded by Mr. W. Saint, a vote of thanks was passed to Mr. Tonge for what the President described as his "very interesting and able paper."

Mr. Henry Hall said he hoped they would have an opportunity of discussing this paper again later on. For the present he thought the author had given some very practical suggestions. No doubt many of those who had heard the paper would be disposed to criticise some of those suggestions. It seemed rather a big undertaking to attempt to teach mining to the little boys and the colliers who were going down the pits. He thought he would have contented himself with starting with the officials, and particularly with the firemen. Mr. Tonge would have quite enough to do if he started there. He, Mr. Hall, was not quite certain whether lack of knowledge among miners and officials was due to themselves or to the fact that the kind of education open to them was not satisfactory. He understood that in the districts Mr. Tonge had mentioned, where there were schools already established, the results up to now had been very fair. He did not think that anyone could charge the Lancashire miners generally with being stupid. He did not know any class of men that showed more tact, more shrewdness, more cleverness, on the instant, as it were, on any occasion. He had noticed lots of accidents and other matters caused by carelessness, but he had never come across any accident that was really due to stupidity. Ask questions of a little boy in a pit and you will find he does not need much book learning. He seems to grow up to the work and to learn his duties in a very short length of time.

Mr. Dury Mitton said he had listened to the paper with very great interest. He thought, however, that Mr. Tonge, in common with other writers on mining education, put forward a very high ideal, which was not always attainable in practice. With regard to what was said about boys, he, Mr. Mitton, did not see exactly how we could begin to teach boys before they were thirteen years of age about mining in schools, they have to pass certain standards as it is, and these little boys in the pit are exceedingly intelligent—at least, a great number he had come across. With regard to firemen being certificated, he did not altogether agree with that proposal. There were many firemen who were not able to get certificates, and if we insisted on certificates being compulsory, we might shut the door against many good practical men. He knew excellent firemen who could not get certificates, and yet we could not get better men for the work in a pit. It would be a pity to make it a matter of certificates altogether, as we should lose a number of good practical men. Mr. Tonge also mentioned diplomas. A very large number of candidates for first and second class certificates show diplomas of science and art examinations, so that, although there is no compulsion in the matter, the value of these diplomas is recognised, and he, Mr. Mitton, certainly thought they should receive marks on a scale laid down by the various Boards of Examination granting mining certificates.

Mr. Gerrard said he thought this was a very wide subject, and he was prepared to support Mr. Tonge's views. Mr. Mitton had spoken in favour of the poor unfortunate practical man who never will get a certificate. If there are good practical men with certificates, why should that poor practical man who cannot get a certificate keep a certificated man out of office? If we keep that idea up then we shall continue in the rut we are in, and that is one of the main reasons why men working in our coal mines will not devote their time to improving themselves—because their employers do not sufficiently recognise their efforts.

The President said we had heard some interesting remarks and diversity of opinion. Mr. Tonge had opened up a very wide subject, dealing with the education of the boy before he went down the pit, to that of the colliery manager, and he thought the paper might be usefully discussed at some later time when we had an opportunity of reading it in print, and as there was other business he thought we might defer the discussion.

The discussion was accordingly adjourned.

AN IMPROVED MEANS FOR CONNECTING COLLIERY TUBS.

Mr. W. H. Jones, of Huyton, submitted a model and explained an improved means for connecting colliery tubs so that they could not become detached without manual assistance. He said it consisted of three links and a T hook. The hook was fixed on the tub. The link was hooked on in the flat way and turned about to the long way. It was then impossible for the link to jump off. The link must be turned flat-wise before it could be unlooped. (*See Figs. 1, 2, 3, 4, and 5.*)

FIG. 1

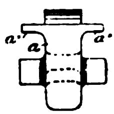


FIG. 2

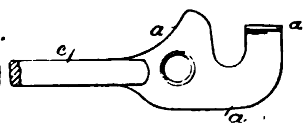


FIG. 3

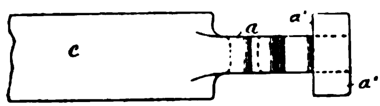


FIG. 4

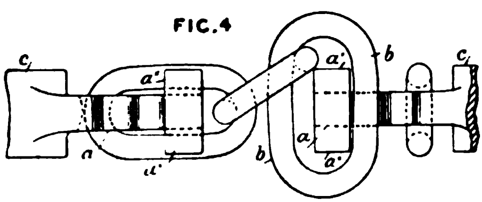
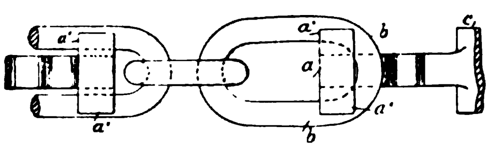


FIG. 5



This idea had not come to him suddenly. Several years' experience down the mine as a mechanic had taught him the causes of the runaways. The waggons got loose and ran away almost every day, in different mines; and he had pondered as to how he could improve the means of connecting the tubs, and after designing five methods for the purpose of overcoming the difficulty he had fixed upon this one as being most safe and simple, and it was adjustable to all the tubs.

Mr. HALL, said: Some time ago we had a lot of pit accidents from tub couplings coming undone, and he made some remarks at an inquest to the effect that he thought colliery managers might introduce something safer. Every day on the railway he saw waggons knocked about and bumped in various ways and the couplings did not seem to come loose so he thought it was within the range of possibility to have an underground coupling that would not be liable to come loose. Since then several plans had been submitted to him, but this one, now shown by Mr. Jones, had attracted his attention most, because it could be manipulated with one hand instead of two. All the others were safe, no doubt, but they required two hands to apply them. This one struck him as being the most practical.

THE PRESIDENT said it was a very simple coupling, and also very effective. Of course, there were various devices for attaining the same object. For instance, there was a coupling with a sort of spike on the inside which prevented the hook getting off when the waggons bumped, but it did not appear to be so safe as this one. He thought this was certainly one of the simplest and best ideas for a safe coupling that he had ever seen.

Mr. PICKSTONE: It can be coupled and uncoupled with one hand?

Mr. JONES: Yes.

THE PRESIDENT: We can all now understand what Mr. Jones's idea is. It is very ingenious, and we are much obliged to him for attending here to show us his model, and we hope he will have some reward for his ingenuity.

A vote of thanks was passed to Mr. Jones for his communication.

Mr. WALTER BALDWIN, F.G.S., read the following paper on "A Carboniferous Air Breather from Sparth Bottoms, Rochdale." illustrated by lantern views:—

A CARBONIFEROUS AIR-BREATHER FROM SPARTH BOTTOMS, ROCHDALE.

By Mr. WALTER BALDWIN, F.G.S.

It is now three years since I first brought before the notice of the members of this Society the well preserved remains of Arthropoda which have been found in the ironstone nodules at Sparth Bottoms, Rochdale*: these gave an insight to Sparth Bottoms as it existed in the Carboniferous Epoch. The strata was laid down in close proximity to an old land surface on the shore of which, between high and low water, the king-crabs were wont to deposit their eggs.

This occasion, however was not the first introduction that this Society has had to Sparth Bottoms and the excellent fossils to be found there, for Mr. S. S. Platt, M.I.C.E., F.G.S, had previously shown the kind of flora which grew and flourished on that ancient land.†

Interesting as these matters may be, our interest is greatly enhanced when we find the remains of any terrestrial air-breathing animal preserved in a fossil state. Indeed, but for our palæozoic coal-strata, we should have little left, except traces of marine life, older than that of the Trias.

Fossil scorpions have been found in rocks of as old a date as the Silurian differing in no important respects from recent ones and almost as highly organised.

The first Palæozoic scorpion which came to light was described by Count Sternberg in 1835 from the coal formation of Bohemia; this specimen was named Cyclopthalmus Senior

* "Prestwichia rotundata." Trans. Manchester Geol. Soc., Part VI., Vol. XXVII., 1901, p. 149.

† "Fossil trees found at Sparth Bottoms, Rochdale, by S. Sidney Platt. Trans. Rochdale Lit. and Sci. Soc., Vol. 3, 1891-1892."

by Corda, from the smaller eyes being arranged in a circlet round the two central larger ones.

In 1839 Corda added a new genus to the pseudo-scorpions under the name of Miciolabis.

In 1868 Messrs. Meek & Worthen described the remains of a fossil scorpion (Eoscorpius Carbonarius) from the Carboniferous Rocks of Illinois, U.S.A., they also described a pseudo-scorpion, Mazonia Woodiana, from Mazon Creek.

In 1873 Dr. Henry Woodward, F.R.S., read a paper before the Geological Society of London, on remains of fossil scorpions from the Coal Measures of England and a doubtful tail segment from the Carboniferous Limestone Series of Carluke, Scotland. These he ranks as Eoscorpius Anglicus.

In 1881 Mr. B. N. Peach, F.R.S., in a paper read before the Royal Society of Edinburgh, reviewed the Genera Eoscorpius and Mazonia of Messrs. Meek & Worthen, and gave a description of Eoscorpius tuberculatus, Eoscorpius glaber, Eoscorpius euglyptus, and Eoscorpius inflatus, from the Carboniferous Rocks of Scotland and the English Borders. Besides these true scorpions certain false scorpions have been discovered, for instance, Eophrynus Prestvicii (H. Woodward), from Coalbrook Dale and Dudley, and Architarbus Subovalis (H. Woodward), from the Coal Measures near Padiham, Lancashire.

I now have the pleasure of drawing attention to the discovery of the remains of a fossil scorpion in the Middle Coal Measures at Rochdale.

In October of last year Mr. Frost, foreman at the Sparth brickworks split open a nodule of clay-ironstone and thus brought to view the dorsal aspect of a well-preserved fossil scorpion. I think that every credit should be given to Mr. Frost for the intelligent interest he has taken in these ironstone nodules. But for his interest and keen sight many

To illustrate Mr. BALDWIN'S Paper.

good fossil specimens would undoubtedly have been lost to science.

It is not intended to give here a complete specific description of this fossil scorpion which has been named by my co-workers (Messrs. W. H. Sutcliffe, F.G.S., W. A. Parker) and myself *Eoscorpius sparthensis* sp. nov.

The total length of the animal is calculated at about 74 millimetres, and in general form somewhat resembles a crayfish.

The head shield or cephalothorox is slightly crushed, so that we do not obtain quite so much information from it as would otherwise have been the case. Fragments of walking limbs are observed and one graceful maxillary palpus is very well preserved.

The body shows seven segments, whilst of the tail or post-abdomen, five out of a total of six are to be seen.

The following dimensions were taken from the specimen:—

Greatest length of cephalothorax	10 m.m.
Greatest breadth of cephalothorax	10 do.
Total length of prae-abdomen..	26 do.
Greatest breadth of prae-abdomen	12 do.
Total length of post-abdomen preserved..	27 do.
Total length of maxillary palpi	36 do.

The skin when viewed under a lens shews small irregular granular markings.

Eoscorpius sparthensis is more graceful than any of the others that have been sufficiently preserved to allow of description.

The geological horizon in which this specimen was found occurs at about forty-seven yards above the Royley Mine, and about eight feet above the bed of nodules which is termed the "Carbonicola acuta" bed in my paper on Bellinurus bellulus*

* "Bellinurus bellulus" Trans., Manchester Geol. and Mining Society, Part VIII., Vol. XXVIII., 1903, p. 198.

I am indebted to Mr. B. N. Peach, F.R.S., of the Geological Survey of Scotland, who examined the fossil and declared it to be a new species.

The Eoscorpius sparthensis has been presented to the Manchester Museum, where it was viewed a short time ago by members of this society, when Professor Boyd-Dawkins kindly pointed out the new exhibits.

Within the last few days I have made three interesting discoveries from the same beds at Sparth Bottoms.

The first of these is the presence of certain small shells contained in the interior portion of some plant remains and are, probably, early forms of land-snails (Spiroglyphus).

The second appears to be the larval stage of a cockroach, and I refer it provisionally to the genus Etoblattina. It is contained in a clay ironstone nodule which is roughly elliptical in shape. The third discovery is a fossil cockroach, or at least some form of Neuropterous insect.

At some future date I hope to give more detailed descriptions of these discoveries.

THE PRESIDENT said: The Society is much indebted to Mr. Baldwin for bringing before us these very interesting discoveries. It has been a considerable trouble to him to bring his slides and to illustrate his address as he has so admirably done. He has certainly made the whole subject very interesting and instructive.

A vote of thanks was accorded to Mr. Baldwin.

Mr. DICKINSON said he would like to ask whether there was anything special about this fossil Mr. Baldwin had called a cockroach to distinguish it from some of the crab or shrimp specimens which we find now in the water? "When we have," Mr. Dickinson proceeded, "nearly every fossil allied with water at one period or another in its life it is well we should keep some leading principle of that kind in view."

Mr. BALDWIN: It is quite different. This is a true air-breather and a true insect, and the shrimps or crabs are not insects at all. They belong to another realm altogether, and, of course, they are water-breathers. The great interest lies in the fact that this cockroach is an air-breather, one of the land forms of life, not at all associated with water. It would have deen drowned had it got into the water.

Mr. DICKINSON: In some of the shell fish is there an intermediate stage between the water and the air-breathers?

Mr. BALDWIN: Oh, yes; that is so in the case of certain of the shell fishes, and also in one of the early scorpions—the one found by Count Sternberg; that was an intermediate form.

The PRESIDENT: Was it amphibious?

Mr. BALDWIN: It was an air-breather at one time of its life, and a water-breather at another. It was, probably, able to exist in both elements; therefore, amphibious. I have not been able to determine it specifically yet as I only found it a few days ago, and about 193 species of the cockroach have been found. There may be more, but there were 193 in 1895. Mr. Scudder gave that number in his last census.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL AND MINING SOCIETY.

PART XVIII. VOL. XXVIII. SESSION 1903-1904.

The ORDINARY MEETING of the Members was held on Tuesday, May 10th, 1904, in the Society's Rooms, 5, John Dalton Street, Manchester.

Colonel G. H. HOLLINGWORTH (President)
in the Chair.

NEW MEMBERS.

The following gentlemen, having been duly nominated, were balloted for and unanimously elected Ordinary Members of the Society:—

Mr. HENRY HUMPHRIS, M.Inst.M.E., Blaenau Festiniog.
Mr. HOWARD J. WALKER, Bank Chambers, Wigan.

The following paper, on "Tapping Fluids under Pressure," was read by Mr. JOSEPH DICKINSON, F.G.S. :—

TAPPING FLUIDS UNDER PRESSURE.

By Mr. Joseph Dickinson, F.G.S.

I. Introduction.
II. In sinking shafts.
III. Old mine workings.
IV. Water mains.
V. Conclusion.

I.—Introduction.

The subject of this paper formed an item in a special report on "The Salt Districts (Landslips)" by the present writer, which was printed in 1873 by order of the House of Commons; and also of a supplementary or second edition, printed in 1882, as part of his official report as Inspector of Mines for the year 1881.

Tapping fluids under pressure requires care. Even tapping a barrel of fresh beer when only a cork has to be driven in sometimes causes an outburst. The process of tapping high pressure fluids in the confined surroundings of sinking shafts and old mine workings is much more critical, especially when precautions against the force have to be taken as the work advances.

If the fluid is only water that may be run to waste and the pressure manageable, the chief requirements are: to bore in advance, keep clear of the outrush, have a course provided for the outflow, and a suitable plug and hammer to stop the bore-hole if needed. But when the fluid is under high pressure and has to be preserved for use other precautions are needed.

Formerly high pressure tapping in mines was done with considerable discomfort and even danger. The transition from the old method to the new in sinking shafts seems to have crept in gradually. But the transition to the new method of tapping old workings is not quite fifty years old and was made at one bound. The extension of the latter new principle to tapping water mains without emptying seems quite recent.

The writer's report was made on the application of a select few interested in the salt districts, yet, as the part of it describing the old and new methods of tapping brine under high pressure relates to tapping mining fluids generally, and as the report has long been out of print, and the new principle only recently extended to another industrial process, a brief allusion to the subject may be appropriate.

II.—Tapping in Sinking Shafts.

Most old sinkers have had experience of influxes of fluid of some kind into sinking pits. Inrushes of brine are quite common in some salt districts. In Great Britain and Ireland not any outcrop of rock salt remains on the surface. If such outcrop ever existed it long ago disappeared, probably by solution. Even now, in some places, water finds entry down to the rock head, where, until saturated, it dissolves the rock salt, forming cavities which at the low elevations become filled with the fluid under pressure.

Formerly, when sinking at such places without a bore-hole in advance, irruptions of rock-head brine were accepted as a matter of course, the sinkers having to escape as best they could from amongst it. Some of the escapes were marvellous. For instance, in a sinking pit at Malkins Bank, a man was buoyed up 90 feet before he could be rescued. As 90 feet head of water presses at 39 lbs. per square inch, and brine being heavier, say, as 12 is to 10, this brine pressure would be about 46 lbs. per square inch.

As the experiences became known, it was observed that before reaching the brine there is usually a bed of hard marlstone called "the flag," and that between the flag and the brine the marl is of a granular structure, called "horse beans" or "shaggy marl." Accordingly, when the flag is reached, and the brine likely to be at high pressure, the shaft is carefully made water-tight with wood casing or iron cylinders down to the flag.

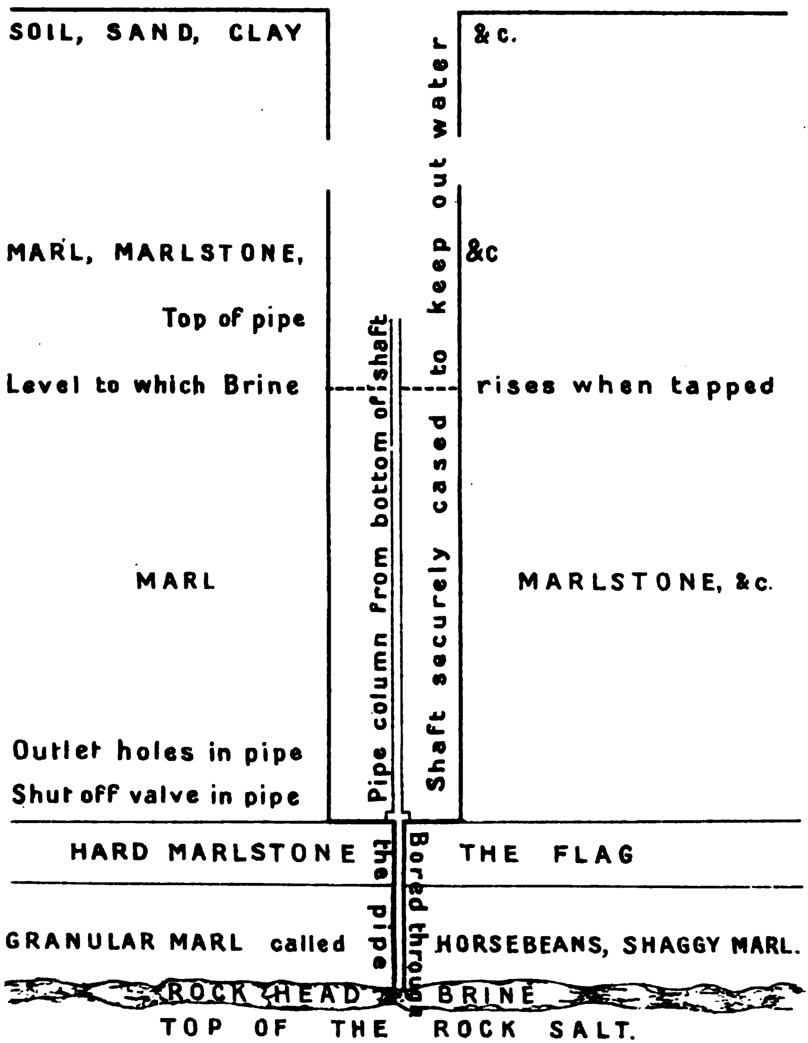
One mode of procedure is then to blast or bore through the flag and shaggy marl, and allow the brine to rise in the shaft; thus winning the brine but leaving the lower part of the shaft inaccessible.

The other, and better mode of procedure, is to make not only the shaft sides watertight, but also the bottom with only a socket hole in it, about four inches in diameter; two such socket holes being left when a duplicate is desired. From the socket a column of pipes is erected to higher up inside the shaft than the expected level of the brine. Near the bottom of the pipe column are holes for the brine, when tapped, to flow through into the shaft; and between the holes and the socket is a stop valve to shut off the supply, so that the shaft may be emptied when needed. Boring rods are then let down inside the pipe column, and the flag and shaggy marl are bored through, allowing the brine, when under pressure, to rise up through the openings to its level in the shaft, ready for pumping. *(See Diagram on opposite page.)*

A plug is sometimes used instead of having the stop valve for shutting off the supply; and when needed for removing obstructions or deepening the bore-hole, the rods may be reinserted down the pipe column.

TAPPING FLUIDS UNDER PRESSURE.

TAPPING HIGH PRESSURE BRINE IN SHAFTS.



III.—Tapping old Mine Workings.

Brine accumulated in old workings is usually tapped near the lowest accessible part, where the brine is generally fully saturated with salt and least liable to admixture with water. The tapping being near the bottom, and the level to which it sometimes rises being as high as the level of the rock-head brine, the pressure is increased according to the depth.

Originally the tapping was done by boring direct into the brine, the men having to rush out amongst the outflow. The first tapping of this kind in Cheshire was at Wincham. A shaft 4½ feet in diameter was sunk in the rock salt; and from the shaft (leaving a few yards below for a sump hole) a drift with a five-eights of an inch bore-hole in advance was driven until the bore-hole proved the brine in the old workings. The bore-hole was then plugged, and a strong wooden shelter erected to protect the men. Two bore-holes, each five inches in diameter, were bored into the separating barrier until they showed damp from brine oozing through. All being ready, the two men gave three blows to one of the bore-holes, which knocked the end out, size unknown—the brine rushing out with a report like a cannon; the other bore-hole was then struck through in like manner, and in the midst of the brine the men rushed out as well as they could, and were wound up the shaft, followed closely by the rising brine. The quantity of brine which came through the two five-inch bore-holes with knocked-out ends took only eight minutes to fill the openings and to rise 67 yards up the shaft, the ultimate height to which it rose being six or seven yards higher. Taking the height to which it rose at 220 feet, it shows a water pressure of about 95 lbs., and adding in proportion of 12 to 10 gives a brine pressure of about 114 lbs. per square inch.

A few other tappings were made in a similar manner, after which this rough and ready process was given up, and the new process of tapping through a stuffing box substituted.

The first tapping made in the improved way was from the British rock salt mine at Wincham, now nearly half a century ago. A drift was driven into the separating barrier of rock salt until the face of the drift (as shown by a five-eighth inch bore-hole in advance) was ten yards from the brine. Into this ten yards a bore-hole eleven inches in diameter was bored until nearly through to the brine; and into the bore-hole was inserted and permanently fixed an iron pipe, the inner end going seven feet into the bore-hole and the outer end projecting three feet into the drift—there being a rim or disc faced with indiarubber round the pipe to make a tight junction at the face of the drift. To the outer end of the pipe was permanently fixed a short pipe with a stop valve, and to it, for the temporary purpose of tapping, was bolted another short pipe containing a stuffing-box. Bore-rods were then inserted through the stuffing-box and the remainder of the barrier bored through to the brine, little if any brine escaping. The bore-rods being withdrawn, the stop valve closed, and the stuffing-box pipe removed, a range of pipes was laid from the stop valve pipe through which the brine was for many years conveyed for use. *(See Diagram.)*

Several other tappings have since been made on the same improved principle, some differences being in the size of the bore-holes and the manner of fixing the pipes.

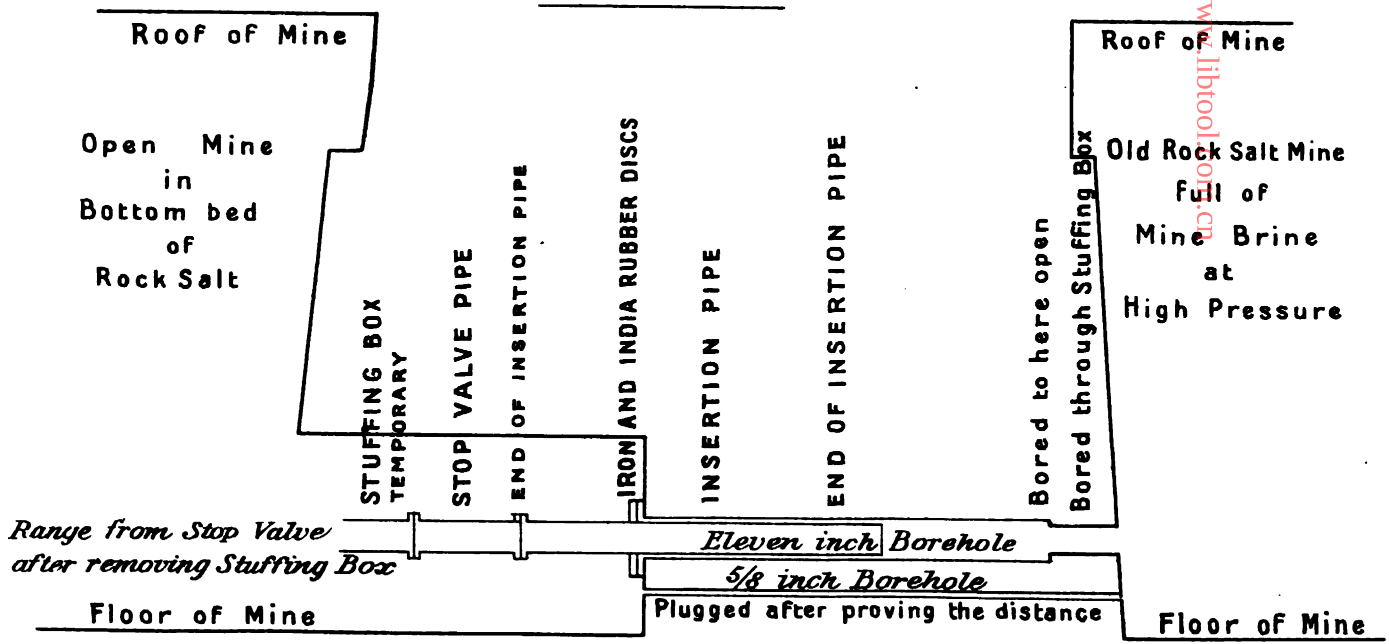
IV.—Tapping Water Mains.

It appears, by *The Times* of Tuesday, March 22, 1904, that recently the improved principle on which high pressure brine has for nearly half a century been tapped through a

Trans. Man. Geol. & Mining Soc., Part XVIII. Vol. XXVIII.
To Illustrate Mr Joseph Dickinson's paper.

TAPPING FLUIDS UNDER PRESSURE.

TAPPING MINE BRINE THROUGH BARRIER OF ROCK SALT.



stuffing-box is being applied to the tapping of high pressure water mains without emptying. The application is described as follows:—

In the first place, a cast-iron sleeve or collar, carrying a sluice valve to control the new branch, was clamped around the main and the joint, securely caulked. Then to the side of the valve, away from the main, an extension piece was bolted, in the place that will be occupied by the first ring of the new branch. Through this extension there passed a horizontal shaft which, at the end next the main, was provided with a drill and a 12 inch circular cutter, while its other extremity projected out through a water-tight stuffing-box, so that it could be turned by a couple of men with a pair of ratchet wrenches. When the machine was started the drill first made a small hole in the main, then the cutter, which was set on the shaft a little behind the drill point, was brought up by the feed-screw, and a circular disc of the required diameter cut out of the main. To provide for the withdrawal of this disc a screw-thread was formed on the drill about half an inch from its tip, and this in turn cut a thread in the metal of the disc and engaged with it as it passed through; hence, when the cutting was finished and the shaft withdrawn, it brought with it the piece cut out of the main. The cutter and the disc having been drawn clear of the valve the latter was closed, and the extension-piece being removed, all that remained to be done was to join up the rings of pipe connecting the valve with the new branch. The metal of the main was found to be seven-eighths of an inch in thickness, and the time that elapsed between the starting of the drill and the removal of the machine was about two hours. During the operation no water escaped, with the exception of an insignificant quantity, which passed into the interior of the extension-piece. Recently, at

Snaresbrook, a 24 inch main, with water at a pressure of 54 lbs. to the square inch, was tapped, and a 12 inch branch attached to it, without any interruption of the supply to the district. The method is considered applicable to mains up to 3 feet in diameter.

V.—Conclusion.

The transitions from the old-fashioned exciting and dangerous methods of tapping high-pressure rock head and mine brines to the safe methods of procedure seemed to have occurred without any special acknowledgment to the originators. The first tappings of mine brine in Cheshire, both by the old method and by the new method through the stuffing-box, were undoubtedly made by Mr. Arthur Anderson, junior, a rock salt and brine engineer, then of Northwich but afterwards of Preesall, and who is generally credited as the inventor of the stuffing-box process. As sometimes happens, however, the idea of the improvement is said to have occurred about the same time to the late Mr. John Thompson, a Cheshire salt proprietor.

The description of the extension of the principle to tapping high pressure water mains through a stuffing-box is taken from the high authority mentioned. It is called the Smith tapping machine, and is an American invention, which in this country is in the hands of Messrs. Clarke W. Harrison & Co., of 72, Fenchurch Street, London.

The principle is adaptable to other processes, but this need not be dwelt upon at present.

The President said: We have had a thoroughly practical paper from Mr. Dickinson, which is both interesting and instructive, and he would ask some one to propose the usual vote of thanks. It was rather astonishing to find that the process of tapping water now in common use was anticipated some fifty years ago.

Mr. HARRISON said he had much pleasure in moving a vote of thanks to Mr. Dickinson for his paper. Like the President, he had thought the process of tapping old workings now in common use was introduced much more recently than fifty years ago, and he had held the view that it was originally introduced in connection with coal mining. It was interesting to hear that the process had been used in connection with salt mines for so long a period.

Mr. LIONEL B. WELLS said he had much pleasure in seconding the motion. Mr. Dickinson's report on the Salt Districts, published in 1873, was regarded as a standard work of reference on salt mining and brine pumping in Cheshire. He (Mr. Wells) had continually to refer to it for many years, and always found the information it contained accurate and most valuable. In that report Mr. Dickinson referred to the tapping of the brine by both the old and the new methods.

The resolution was passed unanimously.

Mr. BERNARD HOBSON asked for further information as to the effect of using the disc in the way mentioned by Mr. Dickinson.

Mr. DICKINSON, in replying, said that he did not profess to give all the details of the tapping of water mains. He gave it as it came to him, and so far as he could gather from the high authority he had quoted it appeared to be something entirely new, whilst it really was only the application of an invention which the miners of this country had long ago devised.

The PRESIDENT said: As regards the water-tapping machine the description of it had been published in the engineering papers, together with drawings showing the general arrangements.

Mr. W. SAINT said that a few years ago, and shortly after the Salt Union, Ltd., acquired some of the Irish rock salt mines, a boring was made by the process referred to by Mr. Dickinson, from the French Park mine, through the rock salt into the adjoining old disused workings, and the tapping of the brine was successfully accomplished, but after a time there was an extraordinary outburst from the shaft of the old mine, when brine and red marl were thrown out in large quantities and covered the vegetation with red mud for hundreds of feet from the shaft. It was supposed that an accumulation of compressed air had, in some manner, been suddenly liberated and thus caused the outburst from the old shaft.

The following paper, on "The Physical and Chemical Properties of the so-called Coal Deposit, exhibited by Mr. Henry Hall," was read by Mr. J. BARNES, F.G.S.:—

THE PHYSICAL AND CHEMICAL PROPERTIES OF THE SO-CALLED COAL DEPOSIT EXHIBITED BY MR. HENRY HALL, I.S.O.*

BY PROF. W. BOYD DAWKINS, M.A., &c., AND MR. J. BARNES, F.G.S.

At the December meeting of this Society Mr. Henry Hall, one of His Majesty's Chief Inspectors of Mines, put forward a now and very bold hypothesis to account for the formation of coal seams. The matter at the time appears to have created a great amount of interest amongst the members present at the meeting who took part in the discussion. A very remarkable absence from the speeches of all who debated the matter was that of any doubt being cast upon Mr. Hall's assumption that the substance he described was coal at all.

A sample of the material, deposited in the water trough, kindly sent by Mr. Hall to Prof. Boyd Dawkins, and mistaken by the latter for anthracite, was ascertained by Dr. G. H. Bailey on analysis in the Chemical Laboratory of Owens College, to consist mainly of iron peroxide. It has been minutely examined by Mr. J. Barnes with the following results.

The examination has been of (1) a physical, (2) a chemical character, and (3) a comparison with coal and another mineral, Limnite.

Physical Properties.—When the so-called coal is powdered and rubbed upon white paper it gives a brown streak.

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* See Trans. Manch. Geol. and Mining Society, Part XII., Vol. XXVIII.

Coal when treated in the same manner streaks the paper dark grey having a drabby tint.

The specimen when crushed (although black *en masse*) gives rise to a brown powder.

Coal when powdered is black.

Specific Gravity.—The relative density to water 15° C. of the specimen is 2·8; that of coal being 1·24.

One cubic yard of this so-called coal having a density of 2·8 would weigh 42 cwts., whilst a cubic yard of coal with a specific gravity of 1·24 would only weigh 18·6 cwts.; thus it will be seen from its physical properties it has no relationship whatever to coal.

Chemical Properties.—On treating the substance with both cold and hot water it does not dissolve, *i.e.*, it is an insoluble body.

The same remark applies to coal.

If a powdered portion be heated in a glass tube, steam is given off, which condenses upon the upper and cool part of the tube into drops of water; with continued heating, no tar or gas is given off, no swelling, no smell; there remains a very dark brown powder.

If coal be treated in the same way, at first water is given off, then tar, and a gas is evolved which when a light is applied burns. Strong smell and a black mass of coke remains behind.

Action of Hydochloric Acid.—A small amount of effervescence, a gas being given off which turns lime-water milky proves the presence of a carbonate or carbonates.

Upon heating with an excess of acid the body dissolves completely, giving rise to a deep orange coloured solution resembling a solution of a persalt of iron.

Coal heated in a similar fashion is scarcely acted upon.

Examination of Hydrochloric Acid Solution.—Sulphuretted hydrogen reduces solution to a colourless liquid, and with a slight precipitate of white sulphur, which indicates a ferric solution.

Another portion of the hydrochloric acid solution with ammonia gave a deep brown precipitate, whilst another part gave with ferro-cyanide of potash an abundant deep blue precipitate quite characteristic of ferric salts.

Sulphocyanide of potash gave a deep blood-red solution. Small amounts of sulphuric acid and lime also in hydrochloric acid solution.

The body heated in contact with air does not burn; it is perfectly inconbustible, whilst we need scarcely be told that coal treated in this manner does burn, and gradually disappears, leaving behind a small amount of ash.

Quantitative Examination.—A weighed quantity lost on strong ignition 25 per cent.

Coal ignited in the same way, that is, in contact with air, lost 97 per cent.

Mr. Hall's specimen contains:—

	Per cent.
Ferric oxide	72·72
Water	24·48
Lime and sulphuric acid	2·80
	100·00

Coal contains:—

Carbon	81·41
Hydrogen	5·83
Oxygen	7·90
Nitrogen	2·05
Sulphur	0·74
Ash	2·07
Water	1·35
	101·35

From the descriptions given above, both the physical and the chemical, it will be seen at once that what Mr. Hall considered to be coal is not coal at all, and has no relationship whatever to this body.

The question therefore is, what is it? It is simply the mineral Limnite, an hydrated oxide of iron in the ferric state, and when pure possesses the chemical formulæ $Fe_2O_3 3H_2O$, and has the following percentage composition:—

	Limnite. Per cent.	Mr. Hall's Specimen. Per cent.
Ferric oxide (Fe_2O_3)	74·8	72·72
Water..	25·2	24·48
Other bodies, carbonates, and sulphates	—	2·80
	100·00	100·00

This body is no doubt produced by the splitting up of a basic persalt of iron, which occurs in almost all waters percolating through shales containing iron pyrites.

The PRESIDENT said that a good deal of scepticism had been expressed as to the carrectness of Mr. Hall's theory that the coal seams had been formed in the way that this supposed coal was formed, and that it was interesting to find that the old views as to the formation of coal seams still held good.

Mr. B. HOBSON, in moving a vote of thanks to the authors of the paper, said he believed the material in question was tested in the chemical laboratory of the Owens College, and similar results obtained to those described by Mr. Barnes. One was glad this question had been cleared up. For his own part he never believed that coal was formed in the way in which the material now under consideration was formed, and one was grateful that Mr. Barnes had gone to the root of the subject and cleared it up so thoroughly.

The motion, having been seconded, was passed unanimously.

Mr. SAINT said that Mr. Hall had written to say that he was unable to be present at the meeting.

Mr. JOSEPH DICKINSON said he thought there ought to be an expression of regret that Mr. Hall is not here to give his explanation, for his statement went a little further than that to which this refutation applies. Mr. Hall led us to infer that the present geological view as to the formation of coal-fields is not such as accords with the opinion formed by many miners who have to work them. They do not believe that the coal has grown on the site of peat marshes, in accordance with the view of the late Sir Roderick Murchison, which he left with us as a sort of legacy shortly before he died. When Mr. Hall has read the paper he may have something to say with reference to Mr. Barnes's conclusion, which certainly appears very forcible.

Mr. HARRISON said he had never doubted that the material shown by Mr. Hall was a piece of coal. It was intensely black and bright, and looked exactly like some of those thin streaks of coal often found in crevices in the rocks, but he had never accepted the new theory of coal formation. With regard to the formation of coal in general he was one of those who did not believe that all coal was formed in any one way. He had seen so many differences in the various seams that he could not accept that view. In some seams we saw abundant signs of vegetation, whilst in others there was none. We have anthracite in Ireland and South Wales, and bituminous coal, and cannel in other places—quite different classes of coal, which seemed to him to indicate a great variation in their mode of deposition.

Mr. WATTS said it would not be wise to close the discussion of this very important paper in the absence of Mr. Hall, who ought to defend his theory in the interests of the Society. He did not agree with Mr. Hall's views which were printed in the "Transactions," but he appeared to give them in the profound belief that the deposit which had accumulated on the side of the cistern was a coal deposit, and he (Mr. Watts) thought the discussion ought to be adjourned. With regard to the formation of coal generally there was, no doubt, that by far the great bulk had been formed *in situ*, and the difference in texture and structure of it was mainly owing to the richness or the poorness of the vegetation from which the coal deposits were formed. We know that some coal seams have been laid down under water; their character is perfectly distinguishable from the character of coal which has been laid *in situ* on the land.

The discussion was adjourned.

Mr. HALL writes that he is very grateful to Professor Boyd Dawkins and Mr. Barnes for the pains they have taken to elucidate the character and properties of the supposed Coal deposit found in a water-trough, and samples of which were submitted to the Society some time ago. He feels that in the light of these investigations that this peculiar formation cannot count either for or against the existing views as to the manner of the deposition of our Coalfields. He states that the matter had also been investigated by Mr. Orsman, whose conclusions were almost identical with those arrived at by the two gentlemen already named. He believes the members will admit that the deposit was so strikingly similar to the "pipers" of true coal found in the roofs of coal seams that his (Mr. Hall's) assumption that it was really coal was a natural one; indeed, this assumption seemed to be shared by those present at the meeting when the specimens were exhibited and examined.

COAL-CUTTING BY ELECTRICITY.

The discussion on Mr. A. J. Tonge's paper, on "Coal-Cutting by Electricity," was resumed. (*See Part XIII., Vol. XXVIII., of the Society's Transactions.*)

Mr. Percy L. Wood said he was disappointed, on reading Mr. Tonge's admirable paper, to find that no comparison had been made of the results of coal-cutting by electricity and compressed air. Mr. Owen Hughes had given a paper on coal-cutting machines driven by compresed air, and Mr. Tonge had described the working by electrically-driven machines, but there had been no comparison between the two types. A good deal had been said lately on the advantages of electricity, and very little about compressed air. As a matter of fact, at the collieries with which he was connected, all the machines were worked by compressed air. It might not be quite as efficient as electricity, but it was making great strides towards greater efficiency. To his mind there were two very strong points in favour of compressed air. The first was its safety for work at the coal face, and the second was the supply of cool fresh air which it ensured. Although he had had no experience of the use of electricity in coal-cutting, he had had considerable experience in sinking with electricity, and a very expensive experience it was. It led his employers to the opinion that electricity in a wet mine, particularly when the water was acidified, was not suitable. In the case he had in mind, the switchboxes, made by a well-known firm, were supposed to be water-tight. In fact they had, he believed, been tested for 24 hours under water and had withstood the test very well. He could, however, only say that when they had been in use a very short time they were anything but watertight. That led him to say that though electricity could be and was worked successfully underground in dry mines, in his opinion it was not suitable for wet mines.

Mr. Pope said that the difficulty of moisture in switch boxes had been entirely overcome by filling certain parts of the boxes with oil. There was none of that trouble now. The switch boxes were differently designed. The trouble that Mr. Wood experienced was some little time ago, and it was the first job of its kind, he believed. The switches would now be enclosed in a cast iron case filled with oil, the cables coming through the under side of a special lip overhanging the end of the case which is filled with a bituminous compound. It was a very different matter, at the date referred to, keeping cables in order in a sinking pit, from what it was on a main road. In this particular case, the motors and switch gear had to be removed out of the way every time there was any shot-firing done. The trouble was not in the motor or permanent cable, but in the switch gear and flexible cables only. Cables can be made perfectly safe under water. Submarine telegraph cables are a proof of this.

Mr. Saint said he thoroughly agreed with Mr. Wood in preferring compressed air to electrical power for driving machinery at the coal face. Where the output of a colliery was dependant upon the regular working of coal-cutting machinery, the most satisfactory machine to adopt, in his opinion, was that which involved the least risk of injury and was capable of working for the longest period without a breakdown, and experience led him to prefer compressed air as the motive power. In the papers read by Mr. Hughes and Mr. Tonge we had valuable evidence of the working of the two systems, and assuming that the cost of repairing the machines, as stated by them, had been carefully ascertained in each case, it would appear that the cost of maintenance was decidedly in favour of the compressed-air driven machines. If we adopted modern, double-stage, air-compressing plant, with intermediate cooling apparatus and large air mains, and take into consideration the degree of safety, the regularity of the working of the coal-cutting machines, the cost of maintenance and supervision, &c., the balance would probably be in favour of compressed-air power rather than electrical power at the coal face.

Mr. Pickstone said it would be very interesting to have this subject fully dealt with, so that we might know definitely the advantage of one system over another in cost and efficiency.

Mr. C. Pilkington said it would be very difficult to decide what was the exact cost. It was not an easy matter to apportion the cost of fuel, steam, and labour, unless we had special boilers for the purpose of generating the electricity or for compressing the air.

Mr. Geo. H. Winstanley said he had read of some men who were taken out of a mine suffering from carbon mon-oxide poisoning. They had been working in a place ventilated by the exhaust from a machine driven by compressed air. The trouble in that case was traced to the lubricant that was used in the compressors.

That was a matter which might be remembered in speaking of the comparative dangers of the two systems.

The following paper, on "A Glacial Boulder from Red Bank, Hanging Ditch, Manchester," was read by Mr. B. Hobson, Lecturer on Petrology, Owens College, Manchester:—

A GLACIAL BOULDER FROM RED BANK, HANGING DITCH, MANCHESTER.

By Mr. B. Hobson,

Lecturer on Petrology at Owens College.

On April 5th, 1904, Mr. W. Blackstock, Secretary of the Manchester Waterworks Department, wrote to inform Prof. W. Boyd Dawkins that "in the course of excavations in Red Bank, in this city, for the purpose of laying water mains, a large boulder stone, about one ton in weight, has been found." The present writer measured the stone (temporarily at the Manchester Town Hall) and found its dimensions to be as follows:—

Length, 3 feet 10 inches;
Breadth, 3 feet 9 inches;
Thickness, 2 feet 4 inches.

The girth in the plane of the length and breadth was about 12 feet, made up of the following items:—3 feet 9 inches at one end, 1 foot 9 inches at the other end, 3 feet 3 inches on one side, 2 feet 11 inches on the other; the shape being quadrangular trapezoidal. No glacial striæ were observed, but the 3 feet 3 inch side was smoothed, probably by ice action. According to Inspector Fowden the boulder, when found, was lying on red sandstone in made-ground, at about 8 feet 6 inches below the road-surface. The locality in Red Bank was opposite the end of Adeline Street (formerly Park Street), 40 paces from the river Irk. The inspector said that at 30 paces from the boulder, and 10 paces from the river Irk, undisturbed gravel was found at nine feet below the surface. According to the Geological Survey Map, on the six inches to one mile scale, the red sandstone, on which the boulder was lying, belongs to the Triassic Pebble Beds. According to the Ordnance Survey plan of Manchester, scale 10·56 feet to 1 mile, surveyed in 1889, sheet CIV., 6. 15., the height at the corner of Park Street (Adeline Street), in Red Bank, is 95·8 feet above Ordnance datum. Mr. Blackstock informs me that the boulder has been weighed, and that its weight is 26 cwt. It is to be placed in Crumpsall Park.

From the small chip, of which a microscopic thin section has been made, I entertain no doubt that the rock is a volcanic rock (probably an Epidotised Rhyolite) from the English Lake District.

Description of the microscopical section:—The rock consists essentially of quartz, felspar, and epidote. The quartz and felspar are in most cases not idiomorphic, *i.e.*, they do not generally show crystal faces, but together form a quartz-felspar mosaic, the felspar of the mosaic being water clear and devoid of twinning. In addition, however, the felspar occurs in long, very narrow veins, traversing the aggregates of epidote and apparently representing the infilling of cracks. In the veins of felspar twinning is shown, the boundaries between the twin lamellæ running generally at right angles to the length of the veins. An idiomorphic porphyritic crystal of felspar was observed in one place.

The epidote forms dense aggregates in some parts of the section, accompanied by a very small amount of the quartz-felspar mosaic, in other cases the epidote and quartz-felspar mosaic are about equal in amount, while in some places the quartz-felspar aggregate occurs to the exclusion of epidote.

There is a close resemblance between the quartz-felspar mosaic of this rock A (from Red Bank) and that of certain fragments contained in an erratic block of Rhyolitic Breccia collected by B. Hobson, from the South side of Dunmail Rise, Lake district (B. Hobson's section, 1681). The same section (1681) also contains epidote, though the epidote is not so idiomorphic as that in section A often is.

Another section (1658) from an erratic block collected by B. Hobson. at Seatoller (between Rosthwaite and Honister Pass), Lake district, shows a still closer resemblance to section A. Section 1658 shows a similar quartz-felspar mosaic and also abundance of idiomorphic epidote, forming aggregates.

The specific gravity of the Red Bank boulder (A) is 2·77 (by Walker's balance). This is a higher specific gravity than that of Rhyolites generally, which, so far as I know, does not exceed 2·70; but the rock of the boulder is evidently much altered, and epidote, which is abundant in it, has a specific gravity of 3·25 to 3·5.

A vote of thanks was accorded to Mr. Hobson for his contribution, and there was a brief conversation in regard to it.

Mr. Hobson, replying to a remark that there was nothing new in the discovery, said he did not claim that there was any novelty in the boulder. He simply called attention to it as an example of a large boulder that had been transported by ice to these parts from the Lake district.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL AND MINING SOCIETY.

PART XIX. VOL. XXVIII. SESSION 1903-1904.

The ORDINARY MEETING of the Members was held on Tuesday, 14th June, 1904, in the Society's Rooms, 5, John Dalton Street, Manchester.

Colonel GEORGE H. HOLLINGWORTH, F.G.S., President, in the Chair.

NEW MEMBERS.

The following gentlemen were balloted for and duly elected Ordinary Members of the Society :—

Mr. G. C. CONSTANTINE, M.Inst.M.E., 17, St. Ann's Square, Manchester.

Mr. THOMAS WOOD, Barley Brook Foundry, Wigan.

THE LATE MR. JAMES TONGE.

The PRESIDENT said that most of the members present would have heard of the death of Mr. James Tonge, a former President of the Society and a very old member.

Mr. W. SAINT: We all very much regret to know that since our last meeting we have lost an old and valued friend and an active member in the person of Mr. James Tonge, F.G.S., Mining Engineer, of Bolton. For many years he took an active part in the work of this Society in many ways and also appreciated and encouraged the efforts of others. He contributed papers and reports and very frequently took part in the discussions at the Society's meetings. He was a Past President and for several years he acted as Honorary Secretary of the Society. We all very much regret the circumstances of his death, which took place very suddenly at Fleetwood, on May 20th. He, Mr. Saint, proposed that a vote of sympathy and condolence be given to the relatives in their sad bereavement.

Mr. JOSEPH DICKINSON said he had much pleasure in seconding the motion which Mr. Saint had proposed. He had known Mr. Tonge about 50 years as a colliery manager, and as a member of this Society he was one whom we should miss from our meetings.

Prof. BOYD DAWKINS said he would like to add his testimony to those which had fallen from the lips of Mr. Saint and Mr. Dickinson as to the regret he felt at the death of Mr. Tonge. Mr. Tonge had been a friend of his ever since he had been in Manchester and he knew the deceased had done his duty in every position in which he had been placed.

The resolution was passed unanimously.

The following paper on "Fossils found above the Four Feet Coal at Bradford Colliery, near Manchester" was read by Mr. JOHN GERRARD, H.M.I.M. :—

NOTES ON FOSSILS FOUND ABOVE THE BRADFORD FOUR FEET COAL AT BRADFORD COLLIERY, MANCHESTER.

By Mr. John Gerrard, H.M.I.M.

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*In papers contributed to this Society by Mr. E. W. Binney, in 1839 and 1840, the correlation of the Bradford four-feet seam with the Pendleton four-feet and the Worsley four-feet was considered, this opinion being expressed "whether these beds (*i.e.*, the Pendleton and Worsley four-feet seams) as is generally supposed, are the same as the Charlotte and Four Feet mines of Bradford, has never been correctly ascertained."

† And Mr. Dickinson in 1863, in his paper on the Coal Strata of Lancashire, states, "But whether the principal seam, known as the Four Feet, be identical with the Worsley or Top four-feet, is not yet sufficiently ascertained to be considered as beyond doubtful. The Four Feet seams at the two places resemble each other both in thickness and appearance, and in being swift burning and hot; also in having sometimes a trace of cannel coal on the top. But it is possible that the Clayton four-feet corresponds with some of the seams which lie above the Worsley four-feet."

‡ Again in 1879 the question was considered in papers by Mr. James Atherton and Mr. Clegg Livesey. The latter stated "The question whether the Bradford four-feet is identical with the Worsley four-feet remains still as far from solution as ever."

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* Trans. Man. Géol. Soc., Vol. I., pp. 35 and 153.

† Trans. Man. Geol. Soc., Vol. IV., p. 167.

‡ Trans. Man. Geol. Soc., Vol. XV., pp. 137 and 161.

The sinking of the new shaft at Bradford Colliery has afforded the opportunity of examining the strata overlying the Bradford four-feet seam, and the collection of a number of fossils—shells, fish remains, and plants.

These being placed on record may afford comparison with the fossils found above the Worsley four-feet seam. At present it is almost impossible to examine the strata overlying the Worsley four-feet, but it is expected a winning will shortly be commenced which will enable this to be done.

The following gives the strata found in sinking the shaft:—

Depth from surface. Yds.	Ft.	Ins.	Strata.	Thickness. Yds.	Ft.	In.
			Clay with stones and gravel	11	2	11
			Sand, bearing water	0	1	6
			Clay with stones	4	2	1
			Fireclay very soft	3	0	0
			Bind, wet, soft	6	2	0
27	0	6	Coal-goaf of *Charlotte* seam originally 3 ft. 5 in.	0	1	0
			Bind, soft, streaky	31	2	8
			Grey rock	1	2	0
			Dark grey shale	3	2	0
			Hard grey rock	0	1	0
64	2	9	Coal	0	0	7
			Black shale with ironstone bands	4	2	2
			Fireclay, soft	0	1	6
			Bind, soft	1	2	0
			Fireclay	1	1	0
			Bind	9	1	10
83	0	3	Coal-goaf of *Three Quarters* seam, originally 1 ft. 7½ ins.	0	1	0
			Fireclay	1	2	0
			Grey shale	6	2	0

Depth from surface. Yds.	Ft.	Ins.	Strata.	Thickness. Yds.	Ft.	Ins.
91	2	3	Rock, white sandstone	1	0	4
			Limestone with *Spirorbis*	0	1	0
			Shale with abundance of plant remains	18	1	0
			Black shale, full of *Anthracomya* ..	0	0	9
			Ironstone with shells and fish remains	0	0	3
			Cannel with fish remains	0	0	5
			Black shale	0	0	3
112	1	3	Coal-goaf of Bradford four-feet, originally 4 ft...	0	2	0
			Fireclay	3	0	0

The want of tipping room at the colliery involved the carting of the debris from the sinking to waste ground some distance away. I had not the opportunity to examine the strata overlying the Charlotte and Three Quarter seams. The strata over the Four Feet seam was well examined, in the shaft and where tipped.

Perhaps the most striking feature is the limestone containing *Spirorbis*; this was one foot thick and about 18 yards above the Four Feet seam.

Under the limestone was a bed of shale about 18 yards in thickness; this contained plant remains in great abundance; about fifty species have been identified. A few of the species occurred in great abundance. Usually fossil plants occur in a very fragmentary condition; here it is different. Some of the plants were in a wonderfully perfect state; calamites with their branches and foliage still attached, leafy branches with the fruit cones united. Large compound leaves of fern-like plants were quite common. True ferns were scarce, the most plentiful being *Pecopteris Miltoni*. Two of the species of ferns are probably new to Britain, these are *Discopteris Ralli* and *Sphenopteris aschenborni*.

Amongst the fern-like plants or Cycadofilices, three species are very common, one especially so, *Neuropteris* *rarinervis*. Some magnificent specimens of this plant were found, illustrating various states of growth; large leaves of the main stem of the type commonly known as Cyclopteris, some three inches in diameter, and from these down to small leaves not more than $\frac{1}{8}$ of an inch in diameter. Two of the species (Cycadofilices) appear to be new to Britain, one of these may be *Neuropteris callosa*, the other may be *Neuropteris Schlehani*.

The calamites occur in great abundance, five species have been identified. Of Calamitean foliage five species also have been identified, but these do not exactly correspond with the calamites. In illustration, the main stems or calamites which produced *Annularia sphenophylloides* and *Annularia radiata* were found to be indistinguishable from each other. The same statement may be made with regard to the main stems which produced *Calamocladus grandis* and *Calamocladus charæformis*, these being of the type commonly known as *Calamites undulatus*.

Annularia sphenophylloides occurred in great abundance and some very beautiful specimens were obtained.

The fruit spikes of *Calamocladus equisetiformis* were also very noteworthy objects, one specimen being nine inches long and not complete.

The most important plant of the group was *Sphenophyllum emarginatum*, abundant, and with the fruit spikes attached; these fruit spikes shewed a feature which has not yet been described. The arrangement of the sporangiophore being different to any described species of this group, and showing affinities with *Calamostachys*.

The Lepidodendra were poorly represented, only a few specimens were found, and these not yet satisfactorily determined, with the exception of *Lepidodendron rimosum*. Another species is evidently the plant recorded as *Lepidodendron lycopodioides* (Sternb.) but it is not

Sternberg's plant; it is probably a form of *Lepidodendron ophiurus* (Brongniart). Another interesting plant, *Bothrodendron minutifolium*, was found, hitherto only met with low down in the Middle Coal Measures.

The genus Sigillaria was conspicuous by its scarcity; it was only represented by one ambiguous species, *Sigillaria* (=*Ulodendron*) *discophora*.

Cordaitaceæ was represented by a single seed of *Cordaicarpus fluitans*.

Several other kinds of seeds were found; they are probably of Cycadofilician origin, one of which is identified as *Rhabdocarpus clavatus*.

Reviewing the list of species, eight (16 per cent.) are typical Upper Coal Measure forms. The remainder are typical Middle Coal Measure plants. Three, or perhaps, four, of those typical of the Upper Coal Measures are not as yet known to pass down into the Middle Coal Measures. Nineteen of the others are not as yet known to pass into the Upper Coal Measures.

It should be observed that some of the plant remains had Spirorbis attached, and amongst the plant remains were Coprolites and fish remains. Also in the same strata three specimens of crustaceans.

Underneath this thick bed of shale is a black shale full of Anthracomya and Entomostraca. Dr. Wheelton Hind has identified *Anthracomya Phillipsi*, and Mr. Roeder has identified *Carbonia*. Beneath this shell shale is an ironstone band about three inches in thickness; this contains shells and fish remains. Under this a Cannel coal about five inches thick, containing fish remains, and immediately over the Four Feet coal a black shale containing roots of plants.

The shells have been identified by Dr. Wheelton Hind, the fish remains by Mr. John Ward and Mr. Herbert Bolton, and the plants by Mr. Walter Hemingway.

The following is a list of the fossils collected :—

Spirorbis.

Anthracomya Phillipsi.

Carbonia, and other Entomostraca.

Leperdita inflata.

Fish Remains.

Elonicthys aitkeni, *Coelacanthus elegans*, *Megalichthys rugosus*, *Strepsodus sauroides*, *Diplodus gibbosus*, *Rhizodopsis sauroides.*

Plants.

Calamites Suckowii (Brong.).
,, *undulatus* (Sternb.).
,, *ramosus* (Artis.).
,, *cistii* (Brong.).
Calamitina Gœpperti (Ett.).
Calamocladus grandis (Sternb.) and its fruit cones, *Calamostachys grandis.*
Calamocladus charæformis (Schl.).
,, *equisetiformis* (Schl.) and its fruit cones.

Annularia radiata (Brong.).
,, *sphenophylloides* (Zenker).

Sphenophyllum emarginatum (Brong.) and its fruit cones.
Sphenophyllum sp.
,, *cuneifolium* (Sternb.).
,, *majus* (Brown).
Sphenophyllostachys sp.

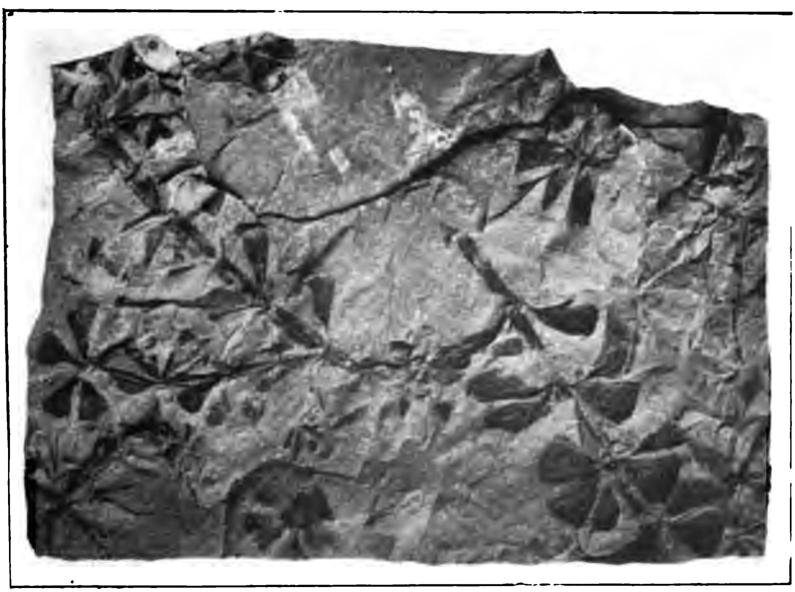
Linopteris munsteri (Eichw.).
,, *obliqua* (Bunbury).

To illustrate Mr. GERRARD'S Paper.

Annularia radiata.

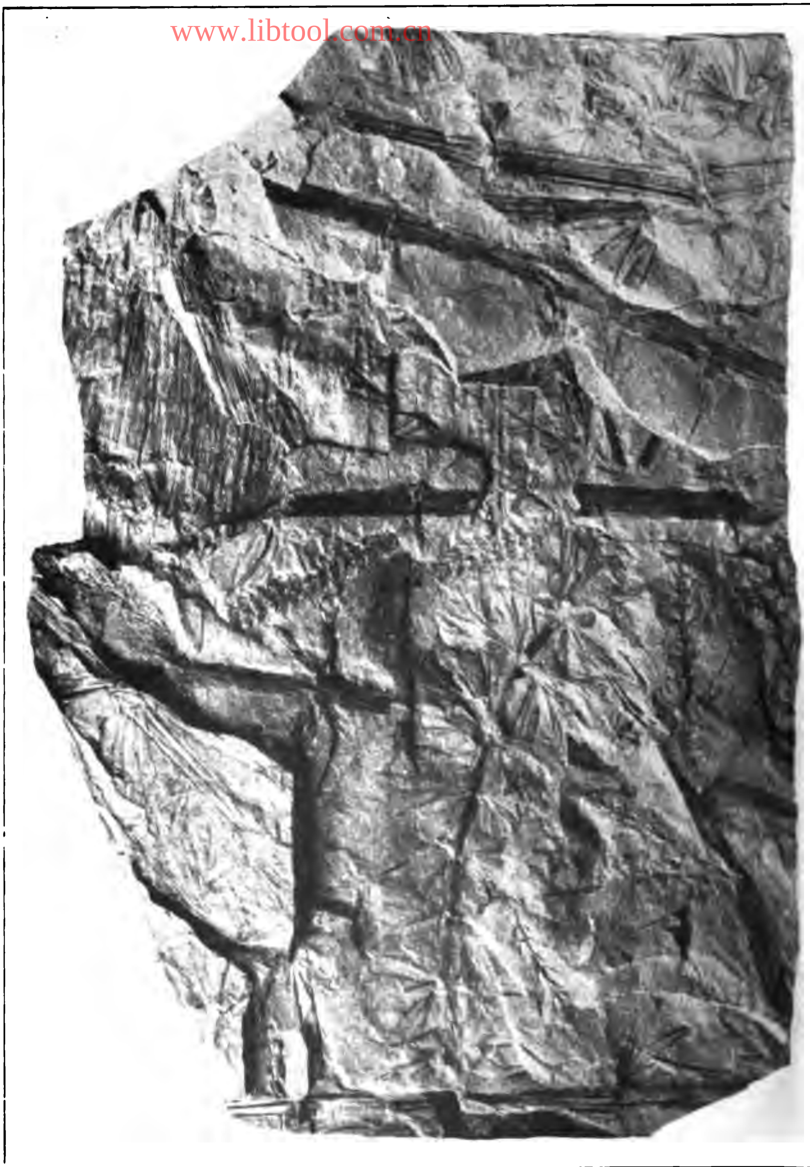
Spirorbis pusillus.

Anthracomya Phillipsi.



Sphenophyllum emarginatum.

Trans. Man. Geol. and Mining Soc., Part XIX., Vol. XXVIII.
To illustrate Mr. GERRARD'S Paper.

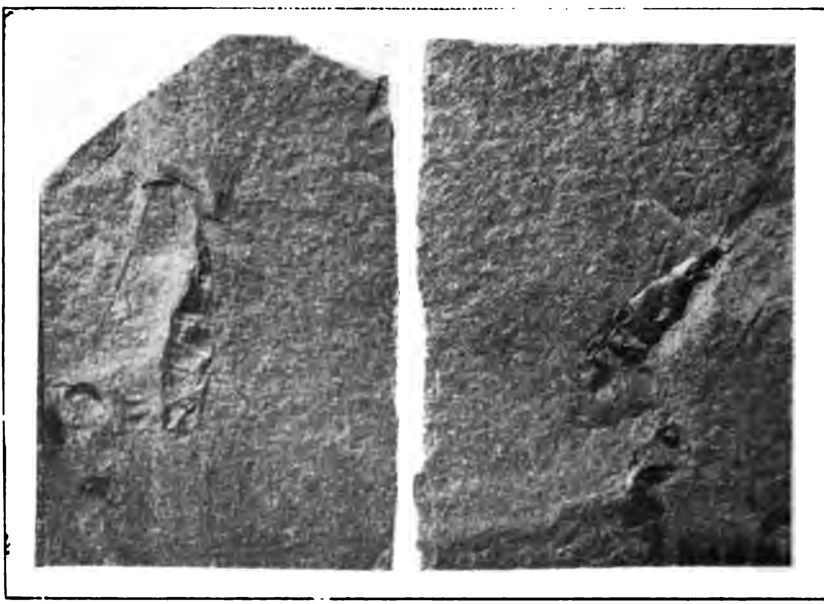


Calamocladus grandis with fruits, *Calamostachys grandis*, also *Sphenopteris* sp.; in centre a pinnule of *Lonchopteris oblonga*.

Linopteris Munsteri.

Sphenopteris c.f. Aschenborni.

Sphenopteris Artemisæfolioides.



Crustacean (enlarged 2 diameters).

Trans. Man. Geol. and Mining Soc., Part XIX., Vol. XXVIII.
To illustrate Mr. GERRARD'S Paper.

Annularia Sphenophylloides.

Annularia radiata (resembling *a. stellata*).

To illustrate Mr. GERRARD'S Paper.

Discopteris Ralli.

Sphenopteris sp. × $1\frac{1}{2}$.

Neuropteris tenuifolia (Schloth).
,, *cf callosa* (Lx.).

,, *cf Schlehani* (Stur.).
,, *gigantea* (Sternb.).
,, *heterophylla* (Brong.).
,, *Scheuchzeri* (Hoffm.).
,, *rarinervis* (Bunbury).
Mariopteris muricata (Schl.).
Sphenopteris obtusiloba.
,, *dilatata.*
,, *artemisæfolioides* (Crepin).
,, *? aschenborni* (Stur.).
,, sp.
Discopteris ? Ralli (Stur.).
Renaultia Schatzlarensis (Stur.).
Asterotheca Miltoni (Artis.).
Aphlebia lineare (Gutb.).
Pecopteris arborescens (Schl.).

Lepidodendron ? ophiurus (Brong.).
,, *rimosum* (Sternb.).
,, *? aculeatum* (Sternb.).
Lepidophloios sp.
Lepidophyllum lanceolatum.
,, *anthemis* (Konig).
Lepidostrobus sp.

Sigillaria discophora (Konig).
Bothrodendron minutifolium.
Stigmaria ficoides (Sternb.).
,, *undulata* (Goep.).

Rhabdocarpus clavatus (Geinitz).
Cardiocarpus fluitans (Dawson).
Carpolithus sp.

The idea in submitting these fossils was to put on record what has been found in connection with the coalfield at Bradford, and when a new pit is sunk to the Worsley four-feet seam we may compare and may establish whether or not the Bradford four-feet corresponds with the Worsley four-feet seam.

The PRESIDENT said: We are all very much indebted to Mr. Gerrard for his very interesting paper and exhibition.

Mr. JOSEPH DICKINSON said he had much pleasure in moving that our thanks be given to Mr. Gerrard for his paper. He mentioned the previous papers that have been read before this Society on the relationship between the Four Feet seams at Worsley and at Bradford. When papers on this question have been before this Society on previous occasions he, Mr. Dickinson, had stated that he never took them to be the same, and Mr. Plant, who was an authority on fossils, told us on one occasion that the fossil remains of the two seams were different and he thought Mr. Gerrard's view confirmed those opinions.

Mr. GERRARD said he did not express his view one way or the other. He was only interested in putting on record what had been found in connection with the Bradford four-feet seam. He had heard it stated, as Mr. Dickinson said, and he found that after the question had been under consideration for 50 years there was still nothing like unanimity of opinion.

Mr. DICKINSON: As they sink to the lower mine it will be seen that the two seams are not identical.

Professor DAWKINS said he regarded this work as most important and as pointing to the only way of solving the question at issue. Mr. Gerrard's work would go very far towards verifying the truth or otherwise of the identity of the two seams.

ERUPTION ATTRIBUTED TO A VACUUM.

By Mr. Joseph Dickinson, F.G.S.

The following incident occurred during a search for brine at Hillside, Moulton, Cheshire, in 1881-2. A shaft was sunk 52 yards through wet, sandy ground to compact marl. Into this compact marl, inside the shaft, was fixed a column of 3 in. water-tight iron tubing extending to 13 yards from the top of the shaft, that being about two yards above the level to which the water rose in the shaft outside the tubing. Then with bore-rods inside the tubing a bore-hole was made down into strata below; the upper part of the bore-hole next the 3-inch tubing being cased with 2¼ inch tubing, the lower part being left untubed.

At 49 yards down the bore-hole—that is at 101 yards below the surface—the bore-rods bottomed a cavity two feet in depth, from which weak brine rose until it found its level about 41 yards up the isolated bore-hole; the level of the shaft water outside the bore-hole and tubing remaining 45 yards higher, at 15 yards from the top of the shaft.

Tests were made by running water into the tubing, but the level of the fluid inside remained at 41 yards above the bottom of the bore-hole, and 45 yards below the level of the water in the shaft. Afterwards a length of about four yards was taken off the top part of the tubing, lowering it to two yards below the shaft water level, allowing the two yards of shaft water and the feeder to flow into the tubing, and down to the isolated brine now reduced to 43 yards below. This flow was varied by plugging and unplugging, the difference between the brine level inside and the water level in the shaft remaining apart.

During one of the unpluggings, when the shaft water was flowing in at the top of the tubing and falling the 43 yards to the weak brine level below, the persons about the top of the shaft were astonished by an eruption of water out of the shaft.

On investigation it was found that when a piece of floating wood interrupted the shaft water entering the tubing, it was followed by a rush of water out of the tubing; the rush extending to the top of the shaft 17 yards above the top of the tubing and onward into the open air.

The cause of the eruption of water was attributed to the piece of wood interrupting the entrance of water into the the tubing, whilst the previously entered water descending caused a vacuum between the wood and the water, resulting in the water being sucked back as described.

Mr. ASHWORTH moved a vote of thanks to Mr. Dickinson for his paper, which was heartily accorded.

Mr. SAINT said it occurred to him while the paper was being read that the water entering at the top of the pipe was probably accompanied by air, and that the air became compressed, then when the flow became suspended, and a partial vacuum formed in the pipe, the imprisoned air was released and rushed back up the pipe accompanied by some water.

Mr. R. WINSTANLEY: But would not that air be liberated as it fell with the water?

Mr. SAINT: No, not while the flow continued. It would be carried down mixed with the water, and when it became stationary the air would effect its escape.

Mr. DICKINSON: The cause may be as stated by Mr. Saint, but at the time of the occurrence it was attributed to the vacuum.

OUTBURST FROM DUNCRUE OLD ROCK SALT MINE AFTER BEING TAPPED FOR BRINE.

By Mr. John Rigby, J.P.

Communicated by Mr. Joseph Dickinson, F.G.S.

Business engagements having prevented Mr. Rigby from attending personally to this paper, he a few days ago sent his notes and drawings to Mr. Joseph Dickinson, who has gone through them and arranged the following brief account, to which is added such portions of the notes made at the time as apply to the outburst.

Passing by the drawing of the machinery and piping used in the tapping and conveying of the brine as sufficient for a separate paper, and not immediately associated with the outburst; the other drawings with the notes and other information show that :—

Soon after the discovery of rock salt in Ireland, in 1851, the Duncrue rock salt mine, near Carrickfergus, was opened by the Belfast Mining Company, and it continued working until about 1867 when it was abandoned. It is from these old workings that the outburst has occurred.

There were two shafts to the mine, each about 567 ft. in depth. The strata sunk through consisted of—drift about 30 ft., red and grey marl (Keuper) 408 ft., impure rock salt 30 ft., marl 1 ft., rock salt 98 ft. Of the 98 ft. bed of rock salt a height of about 36 ft. or 38 ft. at the bottom was worked. The dip of the strata was about 1 in 3 to 1 in 4. The workings were in circular form, extending to about 330 ft. on the dip of the shafts and 165 ft. on the rise, the total area worked being about four statute acres, including 18 pillars of rock salt standing 65 ft. to 75 ft. apart and each varying somewhat in size from 15 ft. to 25 ft.

square, besides seven others partly formed. This proportion of pillar to working is what is now considered insufficient for the depth in question, and it may therefore be in some degree associated with the collapse.

After the abandonment of the mine the shafts in course of time fell in, forming a hole about 80 ft. across and 30 ft. in depth, which became filled with water and was used as a fish pond.

On the dip of the Duncrue mine was afterwards opened the present French Park mine, and also another distinct mine 900 ft. in depth, at Maiden Mount, further on the dip. After working some years in the French Park mine, when the width of the barrier between it and the Duncrue old workings was about 210 ft. in the upper and 247 ft. in the lower part, a tunnel rising about 1 in 4 was driven from French Park Mine into the barrier, and from the end of the tunnel—one bore-hole $2\frac{7}{8}$ in. in dia. tapped the brine and was finished November 19th, 1896, and another bore-hole $3\frac{1}{4}$ in. in dia. for supplying fresh water was finished May 18th, 1898.

Brine was run through the $2\frac{7}{8}$ in. bore-hole and conveyed by piping through French Park Mine up the shaft and thence by piping to Carrickfergus, where it was evaporated into white salt. The brine at all times during the working proved beautifully clear, the water used for solution being rain water kept as pure as possible.

Water was run through the $3\frac{1}{4}$ inch bore-hole into the Duncrue old mine workings in quantity to keep up the supply of brine, and regulated to keep the pressure at about 50 lbs. per square inch.

From the time of tapping the brine to the time of the outburst at Duncrue saturated brine had been extracted from the disused workings sufficient to produce 9,000 tons of white salt per annum.

The solution of rock salt in the old workings was followed by further subsidence of the surface, the area of which was about the size of the mine.

The withdrawal of brine would tend to cause a vacuum in the old workings; but the subsidence would counteract and cause pressure. The notes show clearly that pressure prevailed, the idea being that the air and brine in the old workings were compressed mainly by subsidence and that the pressure became suddenly increased by a large fall of roof. Saliferous strata seldom give off much gas; but the water sent in for solution at 80 lb. pressure per square inch may have contributed. The conclusion is to have an escape for air, and fill the old workings with water or brine.

The following is a copy of the NOTES MADE AT THE TIME BY MR. RIGBY, so far as they relate to the out-burst:—

"On Sunday morning, June 11th, 1899, I received the following telegram: 'Rigby, Winsford, Cheshire, 9.25 a.m., Duncrue Mine, Carrickfergus: Compressed air burst through old shafts, scattered stones over 100 yards surface, continues to fall in.'

"I crossed over by the night boat on Sunday evening viâ Larne, and arrived at Carrickfergus at 8-30 a.m. on the 12th. I found that the shafts of the old mine which were closed about thirty years ago, and which had crowned in at the top, forming a hole about eighty feet across and about thirty feet deep, which was full of water and used as a fish pond, had at six o'clock on Saturday evening suddenly burst upwards, throwing out the whole of the water and fish and covering the whole surface of four acres of mowing grass with a coating of red marl from $\frac{1}{8}$ to $\frac{1}{4}$ inch thick, and scattering stones, some weighing 1 cwt., 60 to 80 feet up in the air, and as much as 100 yards away from the top of the shafts. Some of the stones flew over the houses, but no one was hurt. The chickens in the back-yards however were killed.

Women living in the houses were attracted by the noise, which they described as being like a traction engine, and on turning round they saw this immense quantity of water and stones flying up in the air to a distance of quite 80 feet. Taken from the point where they stood in the backyards, and looking over the roofs of the cottages, it must have been quite 80 feet. The rush of water, mud and stones, continued so far as I could ascertain for about four minutes, and accompanied by very loud rumbling noises. The sides of the hole afterwards commenced to fall in, and when I arrived on Monday morning the hole, although not having extended at the surface, was, so far as I could judge, about 40 yards deep, and at the bottom probably about 20 feet by 30 feet. The timbers out of the shafts seemed to have gone down into the mine, and the metals between the shafts also, so that the hole at the bottom was formed into an oblong. The upper strata for about 30 feet is composed of drift lying on the top of solid red and grey marls. The ground seemed to be continually on the move, falls taking place every three or four minutes, and, from the distance, I should say the shafts were open to a depth of at least 300 feet.

"The position of things at the time the explosion occurred was that the pressure gauge in the tunnel stood at 41¾ lbs. When I examined the gauge it stood at 34¼ lbs., showing that the air in the old mine had been under compression to the extent of 7½ lbs. to the square inch. As this scarcely represents a pressure of 4½ tons to the square yard, it is not sufficient in my mind to account for the force exerted, and I think there may have been a fall in the old mine of a very extensive nature, which was the prime cause of the blowing out of the rubbish in the old shafts.

"I have seen in coal mines where a fall of a portion of roof in a flat mine, some 50 yards square and eight or ten feet thick, has had the effect in the workings of an explosion, blowing the whole of the doors and stoppings away.

"We continued to run water into the mine, so as to prevent the bore-hole from being stopped up with the mud, and also tried the brine by running a small quantity through the pipe, but finding it to be very muddy we did not wind any, so as not to damage the brine in stock.

"The top of the old shafts continued to fall in during Monday, and on Tuesday morning we found that the shafts were filling up, and at three o'clock in the afternoon they had so far filled up that we could see the debris as it fell from the sides resting over the site of the old shafts.

"The people in the vicinity are very greatly alarmed, and two of the tenants moved out of the houses on Monday. I assured them on Tuesday that they had nothing to fear, and recommended the remainder to stay.

"On Tuesday, at noon, I went down the French Park Mine, and found the gauge still at 34¼ lbs., with a small run of water continuing to go in the mine to keep the pipe open. I also found that the cement, which had been put on the face of the tunnel at my last visit, a week ago, was set perfectly hard, and has evidently completely stopped any moisture from coming through. I instructed them to put on another coating of cement, and this being so satisfactory, I decided for the present not to go on with the intended alterations with a view of strengthening the end of the tunnel by building it up.

"We resumed drawing brine at three o'clock on Tuesday. The first few tubs were of the consistency of puddle, being so mixed with very fine marl, but in the course of winding 12 or 14 tubs the condition became very greatly improved, and I am hoping to hear that by to-day (Wednesday) the brine will have become perfectly clear again.

"It would appear from the amount of material thrown up out of the shaft that the shafts must have been open excepting the sealing at the top, as the total weight of stones and marl thrown up could not have exceeded four tons, but strange to say no timber of any kind was thrown out. It seems difficult to imagine how the shafts could have been sealed up without some timbers being over the top. The grass surrounding the mine for a distance on one side of 100 yards was flattened down to the ground with the weight of water and marl which had gone over it. On the other side of the shafts, although the surface is covered to a like distance of 100 yards with stones varying from 1 lb. to 100 lbs., the grass shows no evidence of water or marl, and is perfectly green and uninjured.

"It remains to be seen what may further transpire at these old shafts, but I hope that we shall now have an escape for the air out of the mine and be able to fill it up with water, so as to melt the upper rock salt.

"Considering the enormous quantity of stuff that has gone down, it seems surprising that both bore-holes have remained open.

"In the Maiden Mount mine where workings exceed 900 feet in depth, on the dip of French Park mine, there is a crack and one shaft is crushing.

A vote of thanks was accorded to Mr. Rigby for his Paper and to Mr. Dickinson for bringing it before the Society.

The following Paper on "Mining Examinations, with special reference to the Board of Education Examination in Mining" was read by Mr. GEORGE H. WINSTANLEY, F.G.S.:—

MINING EXAMINATIONS, WITH SPECIAL REFERENCE TO THE BOARD OF EDUCATION EXAMINATION IN MINING.

By Mr. GEORGE H. WINSTANLEY, F.G.S. (of the Wigan Mining College).

In connection with nearly all industrial pursuits in recent years, there has grown a demand for what Mr. Hall, in his Presidential Address two years ago, called Industrial Education.

To meet this demand Technical Schools and Colleges have been established throughout the land, in which instruction is given in Science and Technology to students of all classes.

For nearly half a century the Wigan Mining School—now the Wigan Mining and Technical College—has endeavoured, with some degree of success, to provide educationally for the great industry with which this Society is so closely identified, and the example set so long ago has been followed by almost every mining district in Great Britain.

For the purpose of gauging the character and usefulness of the instruction given, and for the purpose of ascertaining the progress made by the student, examinations are conducted by various authorities, at which many thousands of students present themselves annually.

Mining students, particularly those engaged in coal mining, can avail themselves of two examinations, viz., those conducted in the various districts under the Coal Mines Regulation Act, success in which carries with it a Mine Manager's Certificate of Competency; and the South Kensington examination conducted by the Board of Education.

It might be supposed, that dealing with the same subject, these two examinations would have much in common. As a matter of fact, however, whilst the former—the examinations under the Coal Mines Regulation Act—are pre-eminently practical and generally satisfactory, the latter—the Board of Education examinations—are singularly inadequate and inefficient. Indeed, a perusal of the paper of questions would appear to indicate on the part of the examiner, an entire absence of practical knowledge of mining operations, suggesting rather an acquaintance with mining only through the pages of text books and Patent Office records.

In Lancashire, under the Coal Mines Regulation Act, there are two Examination Boards holding annual examinations, one at Wigan for Mr. Hall's district, in June (indeed this examination is actually in progress at the present moment in the Wigan Mining College), and the other, for Mr. Gerrard's district in Manchester, in December.

The thoroughly practical character of the questions set, has always been a prominent feature in these two examinations, and although improvements might be suggested with regard to the arrangements for the examinations, it would scarcely be possible to compile more satisfactory questions, or questions better calculated to indicate the candidate's proficiency or otherwise in mining principles, and his fitness to assume the responsibility of a first or second class colliery manager. Indeed the careful selection made by the Examination Board from time to time, of gentlemen to act in the capacity of examiners, must inevitably have this result.

The Board of Education, however, does these things differently, and, it would almost appear, selects a Mining Examiner with little or no practical knowledge of mining—

possibly with the idea of securing a man with a free and open mind.

When it is explained that in the recent examination, held last month, in the higher stages there were no questions bearing upon the most important of mining operations, it will be seen how totally inadequate are the provisions made by the Board of Education for encouraging education in mining.

It may appear scarcely credible, but it is nevertheless true, that in the examination paper for the Honours stage—the high water mark of the mining student—a paper which, surely, ought to be comprehensive and practical in the highest degree, there were no questions whatever bearing upon any of the following matters, viz.:—The geology of coal, the chemistry of coal, explosives and blasting, mechanical coal cutting, shaft equipment, lighting and safety lamps, ventilation, mine gases, haulage, winding, pumping and mine drainage, applications of electricity, coal screening and washing, power generation and transmission, the Coal Mines Act, surveying and planning.

To refer to the other stages of the examination would be tedious repetition, it will suffice to say that they are almost equally innocent of practical mining questions.

In the absence of all these highly important matters, what, it might well be asked, remains—upon what subjects *are* questions put. A few are almost childishly simple, many are exceedingly vague, and some are either not practical or wholly irrelevant.

The effect upon the students is anything but encouraging, whilst those who are responsible for the instruction given must either relinquish the hope of good examination results or must place before their students a fare which will be neither palatable nor useful.

Examinations are not the end and aim of, but incidental to technical education, and in the mining course at the Wigan Mining College the object in the past has been to assist the student in fitting himself for positions of responsibility at mines and collieries, rather than simply to pass examinations.

Still, it would be a source of considerable satisfaction to hundreds of mining students in Lancashire if some responsible mining body—why not the Manchester Geological and Mining Society?—would institute an annual examination, and grant certificates which would carry with them greater credit than those obtained as a result of success in the Board of Education examinations.

The education and training of the mining student must be of a two-fold character, and must consist of practical experience in the mine, together with study in the college. A certain necessary portion of his training can only result from actual personal experience in the mine—for this there can be no possible substitute, not even the elaborate model mines with which some educational institutions have been equipped.

On the other hand there are important matters a knowledge of which cannot be acquired in the mine, and for which a course of study in the technical school or college is indispensable.

A question often raised is, which should come first, the college training or the mine. Some advise the college course to commence with, whilst others insist that practical acquaintance with the mine must be the foundation for the mining student's training. My own humble opinion is that the two are inseparable and should be taken concurrently. Only in this way can there be a perfect blending of the two, an intelligent application of the scientific principles expounded in the college to the operations carried out practically in the mine. Whilst the value of those scientific principles will be more fully appreciated and better understood if the student has some personal acquaintance with the conditions prevailing in the mine, and the nature of the operations carried on in mine working.

The PRESIDENT said that the Society was obliged to Mr. Winstanley for his very interesting Paper on the Board of Education Examinations in Mining. It seemed little short of a scandal that the examinations in the subject of mining should be so futile, and he thought it must be that they were carried on as a relic and not with a view of fostering and encouraging the technical education in mining. At any rate he hoped the public ventilation of the question would have some good effect.

Mr. SAINT said he had much pleasure in moving a hearty vote of thanks to Mr. Winstanley for his very interesting Paper, and he asked Mr. Winstanley as to whether, at the commencement of a session, the Board of Education gave the teachers any directions as to the lines on which they should train the students for the examinations. He had been told by two or three of the candidates who sat at the recent examinations at Wigan, that they were very much disappointed with the questions put before them, that the teaching they had received in the Wigan Mining College had little relation to the questions that had been set, and that the questions were not of the practical nature one would expect to be set before candidates entering the examinations for the various classes of certificates.

The Rev. E. C. COLLIER said he had pleasure in seconding the motion, and he thought the Department might be presented with a copy of the paper. He knew something about examinations, and could not understand why examiners should entertain the theoretical part and omit the practical, which is the most important of all.

The motion was passed.

Mr. Dickinson said he was rather pleased to hear that Mr. Winstanley approved of the mode of controlling the examinations for colliery managers' certificates under the Coal Mines Regulation Act, but that he disapproved of some other examinations that are being held independently of the examinations under the Act. Now when the Bill for the Coal Mines Act of 1872 was brought into Parliament, the Government proposed that they should appoint the examiners and have the examinations under their own control. The mine owners entirely disapproved of the Government taking the control, or deciding what class of man was fit to be the colliery manager. They said: "We will not have the Government appointing our colliery managers." The consequence was they raised such an opposition in the House that they defeated the Government on that point in the Bill. The Government then asked the coal owners to frame a clause which would meet the case. They framed the clause as it now stands in the Act. It is rather cumbersome, but it does leave the control of the appointment of the managers in the hands of those who have to be responsible for their doings. I am very glad to find Mr. Winstanley approves of what was the wisdom of the Legislature of those days.

Mr. Winstanley, in replying, said in answer to Mr. Saint that no encouragement or assistance was given by the Board of Education in any useful shape or form. The syllabus, which, though modified and brought up to date a few years ago, still include appliances and operations which were entirely obsolete. The examinations as conducted under the Coal Mines Regulation Act have always been much more satisfactory to work for than the Board of Education examinations, for we have the satisfaction of knowing that the students will be dealt with by practical gentlemen who understand the subject which is being dealt with, while, on the other hand, the Board of Education people do not appear to consider the actual work of the mine in framing their examination papers. And when they take any practical examples they do not take them from Great Britain but from some distant part of the world.

The following paper on "The Palæontology of the Lancashire Coal Measures," part II., by Mr. H. Bolton, F.R.S.E., the Museum, Bristol, was read by Mr. W. Saint in the absence of the author :—

THE PALÆONTOLOGY OF THE LANCASHIRE COAL MEASURES.

Mr. H. Bolton, F.R.S.E.,

The Museum, Bristol.

PART II.

The Middle Coal Measures.

The attempt to work out the palæontology of the Middle Coal Measures of Lancashire has proved a task of considerable difficulty for a variety of reasons, not the least of which has been my removal to a distance from the coalfield. One fact which has become increasingly impressed upon me is, that, the material facts I have obtained, although large, are yet inadequate to justify any wide systematic correlation of the various seams.

These facts will prove, nevertheless, of the greatest possible value to mine managers and others, as guides in their search for various seams.

The present paper I regard as marking a real starting point in the working out of the palæontology of the Middle Measures, rather than its end, and further work can only be prosecuted successfully by a cordial co-operation between the mine manager and the palæontologist. Co-operation can be effected by diligent collecting of fossils, and the accurate determination of their position with reference to a particular seam, or stratum on the one hand, and on the other of a careful identification of the specimens so collected.

The best work will be done, if, at any particular colliery where fossil collecting is taken in hand, the collector makes a systematic examination of the strata from above downwards wherever possible, giving a number to each level where fossils occur, and placing the same number upon the fossils obtained at that horizon. The collector ought also to take especial care to get fossils out with a fair amount of the matrix attached, so that no possible doubt can afterwards be raised as to the character of the stratum. The association of the matrix with the fossil will enable the palæontologist to determine with more accuracy the circumstances and conditions in which the particular fossil lived or was entombed. The determination as to whether a fossil was of freshwater, estuarine, or marine habit is helped considerably by an examination of the rock in which it occurs, and only in this way can it be settled whether a fossil is derived from older rocks, drifted from another area, or actually lived in situ.

The best example I know of what may be done by careful collecting, and accurate measurement during sinking operations, is the paper and table of strata given by the late George Wild in Vol. XVIII. of the Society's Transactions. A perusal of that paper will show that the occurrence of fossils has been carefully noted, and most important of all, the depth below, or height above some well-known seam or datum line. That excellent paper emphasises one feature in the description of a section which creates considerable difficulties when correlation of seams is attempted. I allude to the varied terms used throughout the coalfield to describe the various strata met with between the seams; "blue metal," "strong blue metal," "rag" or "gritty metal," "shale," "bing," &c., are all terms] capable of several meanings, according to the district in which they are used. If a standard series of specimens of the strata intervening between coal seams could be secured, and a distinctive descriptive title applied to each, it would almost certainly help in the correlation of strata, and prove a more effective guide to miners than the mass of varied terms used at present. Before proceeding further, I must express the warm thanks which I owe and feel to many members of the Manchester Geological Society whose generous help made my work possible.

To Mr. Mark Stirrup, F.G.S., I and others owe very much because of his earnest insistence for many years upon the necessity for systematic fossil collecting. His efforts bore fruit during the presidency of the late Mr. James Tonge, F.G.S., when the latter with a number of members including Messrs. Atherton, Jones, Howell, Kearsley, Grundy, Mehers, Walls, and Barton, diligently collected a large series of specimens of plant and animal fossils which were presented to the Manchester Museum.

About the same time, Messrs. Cairns, Grundy and Moss, of Ashton-under-Lyne, generously gave me access to their collections, and also gave a valuable series to the Manchester Museum.

The gift of the Kay-Shuttleworth collection, and the purchase of the Wild collection made, with those already mentioned and the previously large nucleus at the Owens College, an assemblage of Middle Coal Measure forms never before equalled. The main bulk of my notes were made when classifying, identifying and arranging these collections, and for the opportunity to do this, I must record my deep indebtedness to Prof. W. Boyd Dawkins, Dr. W. E. Hoyle, and the Council of the Manchester Museum.* To these, I added as opportunity served, notes of the specimens in

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* Whilst these notes have been passing through the press, I have received the assistance of Mr. S. S. Platt, F.G.S., of Mr. W. Baldwin, F.G.S., who has added several notes of fossils found by him and Mr. W. H. Sutcliffe, F.G.S., at Sparth Bottoms, Rochdale, of Mr. John Gerrard, H.M.I.M., who has paid considrable attention to the sinking at the Bradford Colliery, Manchester, and of Mr W. Saint, H.M.I.M., who has devoted a considerable amount of time and labour to work connected with this paper.

various private and public museums in the county, and finally I have checked my results by an examination of the whole of the Transactions of the Society from the first volume onwards, and of the Geological Survey Memoirs. As far as possible, with all the species, localities, and horizons mentioned, I have added the name of my authority, or given a reference to the whereabouts of the specimen, and the collection of which it forms a part.

It will be noted that not merely have I recorded known species but also the occurrence of specimens, the species of which have not been determined.

This has been done either because I could not determine the specific identity of the fragments, whilst there was no doubt of the genus, or that I have quoted some authority who did not give the species.

Even without specific identity, the records of these specimens are useful, inasmuch as they indicate the occurrence of certain genera at certain definite horizons. In the present state of our knowledge these unknown species represent determinative work yet to be done. Further research on these horizons, and at these localities, may perhaps prove that no further species have to be added to the list here given, but it is far more likely that other species besides those recorded in this paper will reward the diligent student. The observations made by Mr. George Wild in the Transactions of this Society, Vol. XVII., p. 225, on the nature of the measures in which fossils occur, scarcely needs any addition. Speaking generally, animal fossils are most abundant in the black shales, and less so in the blue shales. The black shales most frequently lie upon the coal seams, often forming the roof, and there seems no question in regard to the Middle Coal Measures at any rate, but that the majority of the animal fossils do occur in close relation to the seams. Between a typical black shale, and an equally typical blue shale, there is a great lithological difference, implying an equally great difference in origin. The mineral constituents of a black shale are finer, more bituminous and coherent than those of a blue shale, and the latter is often more or less micaceous.

It seems natural to assume that the areas of deposition of black shales were areas of almost stagnant water into which only the finest particles of mineral matter could be carried, and where deposition was very slow.

Probably such areas were lagoon-like in character, possessing an intermittent connection only with freely moving waters, and, bearing in mind their common position over the coal, it may well be that the areas represented portions of the coal forests which had become submerged by greater growth at their edges, blocking the natural drainage and converting the interior into swamps in which the vegetation died, so giving place to extensive shallow lagoons, having a very slight circulation of the contained water.

The presence of the teeth, scales, and defensive spines of the large predatory marine fish of the Coal Measures, such as Megalichthys and Rhizodopsis sufficiently indicate that these areas of deposition were not under fresh water, but possessed at times sea connections.

It must not be lost sight of however, that the Middle Measures do not possess, except in one strange and solitary instance, a clear and strong marine phase. This, the well known, but little understood "Marine Band," seen in the river Tame at Dukinfield, furnishes by its isolation, we think, the most conclusive testimony of a greater development of what may be termed the lagunal phase in the period represented by the Middle Measures, than in that of the Lower series. One other point must be mentioned before we leave the black shales. Where Anthracosia (olim Carbonicola) occur in them, they usually do so in large groups or even extensive beds such as the "mussel-bands." In the blue shales, they are more sporadic.

In the following pages, the same plan has been adopted as in Part I., viz., the various fossils are enumerated in ascending zoological order, the various horizons and localities of occurrence of each being indicated by reference to specimens or authorities.

The several horizons at which fossils are found are afterwards dealt with and in order to simplify matters, these are arranged under districts. The questions of range of fossils in time and kindred topics are dealt with in the concluding part of the paper.

Vermes.

Examples of worm castings and tracks seem practically unknown, whilst the only species of Spirorbis known appears to have a limited range. This is probably due to neglect in collecting.

Spirorbis pusillus (Martin).

Foot Coal below Fairbottom Mine, Bankfield Clough, Fairbottom. (W. 1838, e. coll. Wild, M.M.)

From roof of Rams Mine at Agecroft sinking. (Stirrup, Trans. Manch. Geol. Soc., Vol. XXVI., p. 95.)

From railway section, Chip Hill, half-a-mile S.E. of Bolton, from 30 yards above the Arley Mine. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 40.)

From between the Bone and Yard Coals in bass at Freeman's Colliery. (Salter in Geol. Surv. Mem., Geology of Country around Wigan, p. 36.)

Brachiopoda.

The two representatives of this group are restricted to the Marine band of Dukinfield and Audenshaw. As the stratum in which they occur possesses a fauna widely different to the rest of the Middle Measures, and closely akin to that of the Lower series, whilst it is also purely local, we may regard the Brachiopoda for all practical purposes as non-existent in the fauna of the ordinary strata of the Middle series.

Discina orbicularis (Bolton).

"Marine Band," Ashton Moss Colliery, Audenshaw. (L. 2620, e. coll. Cairns, M.M.)

Lingula sp.

Ashton Moss Colliery, Audenshaw. (e. coll. Cairns, M.M.) No horizon is given with this fossil. Probably L. 3545, 3546 and 3547, e. coll. Cairns, also belong to the same horizon and place but no history is attached to them.

PELECYPODA.

The general character of the molluscan fauna is similar to that of the Lower Measures. The number of genera and species has increased. Eliminating all doubtful forms, we find that eight genera, and twenty species of bivalves are present in the Lower Coal Measures, whilst the Middle possess thirteen genera and thirty-eight species. Four genera and twelve species come up from the Lower into the Middle Measures. The main increase of species is in the three genera Naiadites (Anthracoptera), Carbonicola (Anthracosia), and Anthracomya, the members of which are especially characteristic of the Middle Coal Measures, occur over a wide area, and have a considerable range. The Carbonicola (Anthracosia) are of extreme interest owing to the association of several species at the same horizon, and the great extent of varietal development. Several species can be linked up by means of varietal forms, and there seems no doubt that a considerable amount of interbreeding existed between the forms now regarded as valid species. In the accompanying list, certain forms are noted as "Modiola," "Orthonota," &c. It has not been possible to identify these as yet with known genera, but as they mark definite localities and horizons it has been thought best to mention them in this paper.

AVICULOPECTEN.

Aviculopecten papyraceous (Sow).

In the "Marine Band." Banks of river Tame at Dukinfield. (Trans. Manch. Geol. Soc., Vol. IV., p. 70.) (Also Prof. Hull, Trans. Manch. Geol. Soc., Vol. III., p. 348.)

Aviculopecten fibrillosus (Salter).

Found in the "Marine Band" of the Middle Coal Measures on the banks of the river Tame at Dukinfield (e. coll. Cairns, M.M.). The "Marine Band" is placed by Salter about 150 yards above the Great Mine. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 64.)

Aviculopecten Cairnsii (Bolton).

Found in the "Marine Band" of the Middle Coal Measures on the banks of the river Tame at Dukinfield. (L. 3544, 3549, and 3550, e.coll. Cairns, M.M.)

Avicula tenua (Brown).

From above the Arley Mine at Duxbury Colliery. (Salter, Geol. Surv. Mem., Geology of Country around Wigan, p. 36.)

"*Modiola*."

In blue shale below the Cannel Coal at 162 yards, Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 184.)

From dark shale over the Low Bottom Bed at Fulledge Colliery. (Op. cit., p. 184.)

From black shale over 5½ inch coal, 75 yards below the New Mine, Bardsley Colliery. (George Wild, Trans. Manch. Geol. Soc., Vol. XVIII., p. 446.)

A few specimens in black shale roof over the Five and a half-inch coal at 636 yards, Bardsley Colliery. (George Wild, Trans. Manch. Geol. Soc., Vol. XVIII., p. 462.)

In blue shale below the Cannel Coal at 162 yards, Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 184.)

From dark shale over the Low Bottom Bed at Fulledge Colliery, Burnley. (Op. cit., p. 184.)

NAIADITES (olim ANTHRACOPTERA).

Naiadites modiolaris (Sow).

From the Stubbs Mine, Ashton-under-Lyne. (Dr. Hind, Pal. Soc. Monog. Carbonicola, &c., p. 133.)

Naiadities quadrata (Sow).

From the Middle Coal Measures of Prestolee, horizon not stated. (L. 3256, e. coll. Roeder, M.M.)

From the Stubbs Mine, Bardsley Colliery (W. 619, e. coll. Wild, M.M.).

Naiadites Browniana (Salter).

In impure cannel, black bass and ironstone at Pendleton and Agecroft Collieries. Binney, Trans. Manch. Geol. Soc., Vol. IV., p. 220. The horizon is probably that mentioned by Salter in the Geol. Surv. Mem., Geology of Country around Bolton-le-Moor, p. 41, namely, the Four Foot Mine of Pendleton.

From Vitriol Works, two miles S.E. of Bolton, no horizon stated. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 41.)

As "Avicula Browniana" from the Three Yards' Mine (Albert and Crumbouke Mines?) at Leadbetter Fold, Little Lever, Bolton. (Salter, Geol. Surv. Mem., Geology of Country around Wigan, p. 36.) (Salter, op. cit., p. 41.)

Between the Bone and Yard Coals in dark bass at Freeman's Colliery, Copall. (Salter, Geol. Surv. Mem., Geology of Country around Wigan, p. 36.)

Naiadites triangularis (Sow).

From the Middle Coal Measures of Burnley, horizon not stated. A specimen in the Kay-Shuttleworth collection at the Manchester Museum.

Naiadites carinata (Sow).

From the Fairbottom Mine of Hill Pit (Bardsley) (W. 615, e. coll. Wild, M.M.)

Also from the Fairbottom Mine of Knott Lane, (W. 616, e. coll. Wild, M.M.).

Naiadites elongata (Hind).

From the ironstone band in the Middle Coal Measures, Prestolee. (Dr. Hind, Pal. Soc., Monog. Carbonicola, &c. Explanation to pl. XVIII., fig. 22.)

Naiadites sp.

A specimen from Alkrington Colliery, Middleton, is in the Wild Collection (W. 622) of the Manchester Museum. It is labelled, "Found in sinking tip."

Two other specimens, the species of which I have not been able to determine, are from the Five and a half-inch coal of Bardsley (W. 596, e. coll. Wild, M.M.) and from the Nield Mine of Bardsley (W. 617, e. coll. Wild, M.M.).

From the Yard Mine at Hulton Colliery, three miles S.W. of Bolton. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 41.)

From 30 yards above the Arley Mine in railway section, Chip Hill, half-a-mile S.E. of Bolton. Salter op. cit., p. 41. "Thin oblique species" from the Ten Feet Mine (White and Black seams) at Lomax Fold, Little Lever, Bolton. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 41.)

From the Cannel Mine at Moss House, 3½ miles S.W. of Bolton. (Salter, op. cit., p. 40.)

From the Three Yard Mine at Hulton Colliery, 3 miles S.W. of Bolton. (Salter, op. cit., p. 40.)

From the Black Mine at Mill Lane, 3 miles N.E. of Stockport. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 64.)

Chænocardiola Footi.

From the Coal Measures of Burnley. (Recorded by Dr. Hind, Pal. Soc., Monog. Carbon. Lamell, p. 475.)

Ctenodonta sp.

From over the Great Mine at Ashton-under-Lyne. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 64.)

Tellinomya robusta (Bolton).

This species is remarkable for its constant occurrence in the roof of the cannel coal over the whole of the Bolton district. It first came to the notice of the writer in the collections made by members of the Geological Society, and forwarded to the Manchester Museum by Mr. Mark Stirrup and Mr. James Tonge, senior. The species was figured and described by the writer in the Manchester Memoirs of the Lit. and Phil. Soc., Vol. XLI., No. 6 (1897).

From the Cannel Mine of Watergate Colliery, Middle Hulton. (L. 3493, M.M.)

From the Cannel Mine of Hulton Park, Bolton. (W. 623 e. coll. Wild, M.M.)

From the Cannel Mine of Worsley Tunnel. (M.M.)

From the Cannel Mine of Tyldesley. (L. 1049, M.M.)

From the Cannel Mine of Bank Colliery. (L. 1052, M.M.)

From the Cannel Mine of Chequerbent, Bolton. (L. 1058, M.M.)

From the Cannel Mine of Mill Hill Bleach Works. (L. 3331, M.M.)

Tellinomya n. sp.

Three specimens of what I believe to be an undescribed species from the Cannel Mine of Watergate Colliery are in the Manchester Museum. (L. 3332, M.M.)

Nucula lævirostrum (Portlock).

From over the Great Mine at Ashton-under-Lyne. (Dr. Hind, Pal. Soc., Monog. Carbon. Lamell., p. 184.)

Schizodus sp.

From Worsley, no horizon stated. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 41.)

CARBONICOLA (olim ANTHRACOSIA).

Carbonicola robusta (Sow).

An interesting suite of specimens of this species are in the Wild Collection of the Manchester Museum, having been obtained from about six inches over the Five and a half-inch coal in the Diamond shaft, Bardsley. The coal occurs at 636 yards from the surface. The interest of the specimens lie in the fact that they show varietal development, which would seem to indicate that they merge on the one hand into Carbonicola acuta, and on the other into the more typical C. robusta, such as is found at Burnley.

Typical forms of C. robusta are found in the roof shales of the Lower Yard Bed, Fulledge Colliery, Burnley. (W. 511 and W. 512, e. coll. Wild, M.M.)

From the Bastard Cannel at 16 yards in the Fulledge Colliery, Burnley. (W. 515, e. coll. Wild, M.M.)

From the "Mussel-bed" of the Pendleton Colliery. Examples in the Manchester Museum.

From the Middle Coal Measures of Hulton, near Bolton. (e. coll. Tonge, M.M.)

From the Arley Mine at Gidlow Colliery, Standish. (L. 1053, M.M.) Collected by Mr. Higson.

From the roof of the Cannel or Two Feet Mine at Dukinfield. (W. 521, e. coll. Wild, M.M.)

In the roof of uppermost 6 inches at Fulledge Colliery, Burnley. (George Wild, Trans. Manch., Geol. Soc., Vol. IV., p. 183.)

As "Unio robustus" from 200 yards above the Habergham or assumed Arley Mine at Fulledge. (Binney in "Excursion to Burnley," Trans. Manch. Geol. Soc., Vol. II., p. 51.)

As Unio robustus from 47 yards above the Arley Mine at Wigan. (Binney in "Excursion to Burnley," Trans. Manch. Geol. Soc., Vol. II., p. 51.)

As Anthracosia robusta in black shale roof over the Five and a half-inch coal at 636 yards. Bardsley Colliery. (George Wild, Trans. Manch. Geol. Soc., Vol. XVIII., p. 462.)

From 30 yards above the Arley Mine in railway section, Chip Hill, half-a-mile S.E. of Bolton. (Salter, Geol. Surv. Mem. Geology of Conntry around Bolton-le-Moors, p. 41.)

Carbonicola acuta (Sow).

From roof shales above the New Mine, Bardsley. Five-and-a-half inches above the coal. (W. 528, e. coll. Wild, M.M)

Fifteen inches above the coal, some horizon. (W. 533, e. coll. Wild, M.M.).

Thirty to thirty-six inches above the coal, same horizon. (W. 535, e. coll. Wild, M.M.)

In Bastard Cannel associated with Ostracods, Nield Mine, Glodwick, Oldham. (W. 537, e. coll. Wild, M.M.) Curiously elongated valves approaching *C. aquilina*.

Roof of the Orrel five-feet mine at Wigan. (L. 3320, M.M.)

From the Middle Coal Measures of Kersley, horizon not stated. Specimens in the Manchester Museum.

In Bastard Cannel under the Trencherbone seam at St. George's Pit, Tyldesley, associated with *Rhizodopsis sauroides*.

From Ashton Moss Colliery, Audenshaw, horizon not stated. (L. 3532, e. coll. Cairns, M.M.)

From the Cannel Mine, Moss House, 3½ miles S.W. of Bolton. (Salter, Geol. Surv. Mem. Geology of Country around Bolton-le-Moors, p. 41.)

From the Five Quarters Mine at Lomax Brow, Peel, 4 miles south of Bolton. (Salter, op. cit., p. 41.)

From Alkington, Middleton, no horizon stated. (Salter, op. cit., p. 41.)

From 30 yards above the Arley Mine in railway section, Chip Hill, half a mile S.E. of Bolton. (Salter, op. cit., p. 41).

From the Three Yard Mine of Hulton Colliery, 3 miles S.W. of Bolton. (Salter, op. cit., p. 41.)

From the Black Mine at Dukinfield. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 63.)

From Sparth Bottoms, Rochdale, between the Neddy and Royley Mines, about 60 yards above the latter. (Baldwin, Trans. Manch. Geol. Soc., Vol. XXVII., p. 152.)

From Sparth Bottoms, at about 45 yards above the Royley Mine. (Baldwin, Trans. Manch. Geol. Soc., Vol. XXVIII., p. 198.) Specimens in Rochdale Museum.

Carbonicola acuta, var ovalis (Martin).

Brassey Mine of Tyldesley. Specimens in Manchester Museum.

From the Middle Coal Measures of Middleton, horizon not stated, M.M.

From the Californian or Thin Bed of Burnley. (W. 561, e. coll. Wild, M.M.)

From the New Mine of Bardsley Colliery. (W. 564, e. coll. Wild, M.M.)

As "Anthracosia ovalis" from the Ashclough or Bin Coal at Shore top, one mile S.E. of Little Lever. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 41.)

As "Anthracosia ovalis" from the Three Yard Mine at Lomax Fold, Little Lever, Bolton. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors p. 41.)

From the Seven Feet or Rams Mine at Pendleton Colliery. (Salter, op. cit. p. 41.)

From above the Trencherbone seam at Green near Bolton. (Salter, op. cit. p. 41.)

From the Cannel Mine at Moss House, 3½ miles west of Bolton. (Salter, op. cit. p. 41.)

From the Thin Mine, (Californian, H.B.) of Kaysand Ford, Burnley. (W. 562, e. coll. Wild, M.M.)

From the Black Mine of Nat Bank. (Salter, Geol. Surv. Mem., Geology of Country around Oldham p. 63.)

From the Black Mine of Mill Lane, 3 miles N.W. of Stockport. (Salter, op. cit. p. 63.)

From the Black Mine at Dukinfield. (Salter, op. cit. p. 63.)

As "Anthracosia ovata" recorded as follows:—In blue shale below the Cannel Coal at 162 yards. Fulledge Colliery Burnley. (Geo. Wild, Trans. Manch. Geol. Soc. Vol. IV. p. 184.)

As "Anthracosia centralis" from the Three Yard Mine at Hulton Colliery, 3 miles S.W. of Bolton. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors p. 41.)

As "Anthracosia centralis" from the Cannel Mine at Moss, House, 3½ miles S.W. of Bolton. (Salter, op. cit. p. 41.)

Carbonicola acuta, var rhomboidalis (Hind).

From the Middle (?) Coal Measures of Burnley. (L. 2866 e. coll. Kay-Shuttleworth, M.M.)

Carbonicola rugosa (Brown).

A specimen of these species is recorded by Dr. Hind from Cant Clough near Burnley, and the horizon as doubtful.

I am strongly inclined to think that the specimens recorded as C. rugosa and which are all more or less eroded, will yet prove to be examples of C. robusta.*

The specimen from Cant Clough, figured by Dr. Hind in his monograph on Carbonicola, pl. II. fig. 7, is much more likely to be from the Middle or Lower Coal Measures than from the Yoredales.

Carbonicola nucularis (?) (Hind).

From the Stubbs Mine at Bardsley. (W. 542, e. coll. Wild, M.M.)

From "Mountain Mine" of Wigan. (Dr. Hind, Pal. Soc., Mong. on Carbonicola, &c,, p. 63.)

Carbonicola aquilina (Sow).

From over the Stubbs Mine at Bardsley Colliery. (W. 545-550 e. coll. Wild, M.M.)

From 12 inches above the Stubbs Mine at Banksfield Tunnel, Bardsley. (W. 555., e. coll. Wild, M.M.†)

From the Yard Coal at Old Hall, three-quarters of a mile S.W. of Little Lever. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 41.)

From the Cannel Mine at Moss House, 3½ miles S.W. of Bolton. (Salter, op. cit., p. 41.)

From the Ashclough or Bin Coal at Shoretop, one mile S.E. of Little Lever. (Salter, op. cit., p. 41.)

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* Since writing the above I have found the following note: "It appears to me, judging from all the specimens I saw at Manchester, certain that A. rugosa of Brown is the same species," *i.e.*, A. robusta. (Salter, Geol. Surv., Mem., Geology of Country around Wigan, p. 36.)

† These seven specimens are of special interest as they were found in association with 13 specimens of C. turgida, in nine square inches of space. The growth of various species of Carbonicola in close association will probably be found to have an important bearing upon the validity of several forms now regarded as distinct species, the more so because in any large collection of Carbonicola, it is easily possible to arrange gradational series between two and even more species. This is especially true of the species, C. acuta, C. aquilina, and C. turgida, and the sub-species of C. acuta, all of which are linked up by intermediate varietal forms.

From the Three Yard Mine at Hulton Colliery, three miles S.W. of Bolton. (Salter, op. cit., p. 41.)

From ten inches above the Stubbs Mine at Bardsley. (W. 655, e. coll. Wild, M.M.)

From the Stubbs Mine at Ashton-under-Lyne, associated with C. acuta, var ovalis, and a species of Naiadites (Anthracoptera.) (W. 560, e. coll. Wild, M.M.)

From the Stubbs Mine of Betony Brow, Bardsley. (W. 522, e. coll. Wild, M.M.)

From a depth of 300 to 350 yards in shaft of Ashton Moss Colliery. (W. 558, e. coll. Wild, M.M.)

From the Seven Feet Mine of Linnyshaw Colliery. (L. 1054, M.M.)

From the Brassey Mine of Tyldesley. Specimens in the Manchester Museum.

From the Rams Mine of Tyldesley. (L. 1059, M.M.)

From the New Mine at Bardsley. (Recorded by Dr. Hind, Pal. Soc., Monog. Carbonicola, &c., p. 75.)

Carbonicola obtusa (Hind).

From over the Trencherbone seam at Kersley Colliery. (L. 1048, M.M.)

From the Middle Coal Measures of Hindley. (M.M.)

From the Black Mine of Ashton Moss Colliery, Audenshaw. (W. 541, e. coll. Wild, M.M.)

Carbonicola subconstricta (Sow).

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (W. 563 and W. 565, e. coll. Wild, M.M.) These specimens are internal casts which were labelled as A. ovalis by Wild, and figured by Dr. Hind as Carbonicola subconstricta. It would be interesting if these casts could be compared with similar internal casts of C. robusta.

From the Wigan Nine-feet Mine of Ince, near Wigan. (L. 1041 and L. 1052, M.M.)

From the Middle Coal Measures of Hindley, horizon not stated.

Carbonicola subrotunda (Brown).

From Nield Mine of Bardsley, associated with Beyrichia. (W. 544, e. coll. Wild, M.M.)

Carbonicola turgida (Brown).

From the Black Mine of Ashton Moss Colliery. (W. 576, e. coll. Wild, M.M.)

From the Stubb's Mine of Banksfield Colliery, Bardsley. (W. 568, e. coll. Wild, M.M.)

From 12 inches above the Stubb's Mine at Banksfield Tunnel, Bardsley. (W. 575, e. coll. Wild, M.M.*)

From the Stubbs Mine at Bardsley Colliery. (W. 566 and W. 1218, e. coll. Wild, M.M.) The latter (W. 1218) is associated with a spine of Gyracanthus formosus.

Carbonicola similis (Brown).

From the Nine-inch Coal at 622 yards, Bardsley Colliery. (W. 582, e. coll. Wild, M.M.)

Carbonicola angulata (de Ryckholt).

From the Low Bottom Bed of the Fulledge Colliery, Burnley (W. 588, e. coll. Wild, M.M.) Specimens from this horizon and locality are figured by Dr. Hind, Pal. Soc., Monog. Carbonicola, &c. pl. XI., figs. 3, 4.

Carbonicola sp. indet.

From 15 inches above the New Mine at Bardsley Colliery (W. 530, e. coll. Wild, M.M.)

From soapy stone, over the nine-inch coal at 621 yards, Bardsley Colliery. (W. 599, e. coll. Wild, M.M.)

From the roof of the Black Mine at Bardsley. (W. 591, e. coll. Wild, M.M.)

From the Nield Mine of Bardsley. (W. 657, e. coll. Wild, M.M.)

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* Some specimens from the roof of the Stubbs Mine are very short and rounded and show a tendency to pass into C. ovalis.

From roof of the Black Mine, Ashton Moss Colliery.

From roof of the Fairbottom Mine at Hill Colliery. (W. 594, e. coll. Wild, M.M.)

In roof of the Cannel Coal at 162 yards, Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 184.)

From dark shale over the Low Bottom Bed at Fulledge Colliery, Burnley. (Op. cit., p. 184.)

In shale over the Great Mine, Fulledge Colliery, Burnley. (Op. cit., p. 185.)

Two species at two feet above a nine-inch coal at 622 yards deep, Bardsley Colliery. (George Wild, Trans. Manch. Geol. Soc., Vol. XVIII., p. 461.)

From inferior Cannel called the "Lower Cannel" at 525 yards from surface. Section at Bardsley Colliery. (Op. cit., p. 458.)

A few flattened forms at 27 yards below Old Mine at Bardsley Colliery. (Op. cit., p. 460.)

Fifteen inches and 36 inches above New Mine at Bardsley Colliery. (Op. cit., p. 446.)

In dark blue soapy stone over nine-inch coal, Bardsley Colliery. (Op. cit., p. 446.)

Two beds of Anthracosia at 15 yards below Old Mine at Bardsley Colliery. (Op. cit., p. 459.)

In black shale below the Lower Cannel at 525 yards, Bardsley Colliery. (Op. cit., p. 458.)

Anthracosia sp., distinct from A. aquilina, from the Ten Foot Mine at Lomax Fold, Little Lever, Bolton. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 41.)

From the Black Mine at Mill Lane, three miles N.W. of Stockport. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 63.)

Edmondia, short sp.

From Worsley tunnel, no horizon stated. (Salter, Geol. Surv. Mem. Geology of Country around Bolton-le-Moors, p. 41.)

Orthonota sp.

From Fulledge Colliery, Burnley, at 15 yards deep. (W. 653, e. coll. Wild, M.M.)

From dark shale over the Low Bottom Bed at Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 184.)

Anthracomya Wardi (Salter).

From the Middle Coal Measures of Burnley, horizon not known. (L. 2070, e. coll. Kay-Shuttleworth, M.M.)

From Bastard Cannel over the Low Bottom Bed of the Fulledge Colliery, Burnley. (L. 2071 and 2069, e. coll. Kay-Shuttleworth, M.M.)

From the Low Bottom Bed, Fulledge Colliery, Burnley. (W. 602, e. coll. Wild, M.M.)

Anthracomya modiolaris (Sow).

From the Fairbottom Mine at Hill Colliery. (W. 612, e. coll. Wild, M.M.)

From the Stubbs Mine at Bardsley Colliery. (W. 608 and 609, e. coll. Wild, M.M.) Associated with C. aquilina and C. turgida.

From the Black Mine of Oldham. (Recorded by Dr. Hind, Pal. Soc. Monog., Carbonicola, &c., p. 96.) Also recorded by Salter from the same horizon. (Salter, Geol. Surv. Mem. Geology of Country around Oldham, p. 63.)

Anthracomya dolabrata (Sow).

From the Stubbs Mine of Bardsley. (W. 605, e. coll. Wild, M.M.)

From the Great Mine of Bardsley, associated with Carbonicola. (W. 613, e. coll. Wild, M.M.)

From the Black Mine of Oldham. (Recorded by Dr. Hind, Pal. Soc. Monog., Carbonicola, &c., p. 94; also recorded by Salter from the same horizon. Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 63.)

Anthracomya minima (Ludwig).

Recorded from the Middle Coal Measures of Prestolee by Dr. Hind, Pal. Soc. Monog., Carbonicola, &c., p. 117 (e. coll. Roeder, M.M.).

Anthracomya minima, var. carinata (Hind).

From the Middle Coal Measures of Prestolee. (L. 3255, e. coll. Roeder, M.M.)

Anthracomya lævis, var. Scotica (Dawson).

Roof of the Cannel Coal, Wigan. (Recorded by Dr. Hind, Pal. Soc. Monog., Carbonicola, &c., p. 124.)

From the Middle Coal Measures of Burnley. (L. 2074 and 2072, e. coll. Kay-Shuttleworth, M.M.)

From the Low Bottom Bed of the Fulledge Colliery, Burnley. (W. 661, e. coll. Wild, M.M.) This is possibly a new species. Also from this locality and horizon. (W. 611, e. coll. Wild, M.M.)

From the Stubbs Mine of Bardsley, Lancs. associated with C. aquilina and C. turgida. (W. 610, e. coll. Wild, M.M.)

Anthracomya sp.

From above the Trencherbone Coal at Green, near Bolton, on the river Irwell. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 41.)

GASTEROPODA.

This group is represented by three genera, of unknown species.

Pulmoniferous gasteropods (Spiroglyphus).

From Sparth Bottoms, Rochdale. (Baldwin, Trans. Manch. Geol. and Min. Soc., Vol. XXVIIII, Part XVII.)

Serpulites, wavy sp.

From over the Great Mine at Ashton-under-Lyne. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 63.)

Turitella sp.

Marine Band, Dukinfield. (M.M.)

Cephalopoda.

Representatives of this division seem entirely absent from the Middle Coal Measures if we except the remarkable "Marine Band," at Dukinfield and Ashton Moss Colliery, Audenshaw. A number of specimens mainly, I believe, collected by Mr. R. Cairns, of Ashton-under-Lyne, are in the Manchester Museum, but cannot be identified; Salter has described one species of Discites, and indicated the existence of two more. From this horizon also, Mr. J. W. Salter recorded the following:—

Nautilus precox (Salter).
Goniatites sp. inc.
Discites rotifer (Salter).
Discites sp.
Discites sp.
Orthoceras, thin sp.

All these species are also stated to occur over the Great Mine at Ashton-under-Lyne. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 64.)

Crustacea and Myriopoda.

These groups include no less than five genera of considerable interest, in addition to Ostracods. One rare form, Limulus trilobitoides, seems to have been wholly lost until re-discovered by Mr. Walter Baldwin, F.G.S., at Sparth Bottoms near Rochdale.

The presence of such crab-like forms as Cyclus, Limulus, and Prestwichia has hardly been suspected in the Middle

Coal Measures, or closer search would have been made for more of them.

The two species of Euphoberia, and an unknown species of Xylobius belong to the Myriopoda, a group not usually supposed to be represented in the Lancashire coalfield.

Beyrichia arcuata (Bean).

Low Bottom Bed at Fulledge Colliery, Burnley. (W. 507, e. coll. Wild, M.M.)

From the * Six Quarters Mine at Lomax Brow, Peel, four miles south of Bolton. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 40.)

From above the Doe Coal at Stone Clough, near Farnworth. (Salter, op. cit., p. 40.)

Beyrichia Binneyana (Jones).

From Rainford. No horizon. (Salter, Geol. Surv. Mem., Geology of Country around Wigan, p. 36.)

Cytheropsis sp.

From Rainford. No horizon stated. (Salter, Geol. Surv. Mem., Geology of Country around Wigan, p. 36.)

(*? Cypris.*)

From dark shale over the Low Bottom Bed at Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 184.)

Estheria striata, (Munster).

From two places in Lancashire, in Cannel coal of the Middle Coal Measures. (Prof. Rupert Jones, Pal. Soc. Mon., Fossil Estheriæ, p. 24.)

From the Cannel at Moss House, Wigan. (Salter, in Geol. Surv. Mem., Geology of Country around Wigan, p. 36.)

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* Probably the Five Quarter Mine is meant.

Estheria striata, var. Beinertiana (Jones).

This variety was found by Mr. E. W. Binney in Mr. Hulton's Cannel Coal at Hulton Lane Ends, near Bolton-le-Moors. Also at Moss House, 2½ miles south-west of Bolton. (Salter.)

Also from the Cannel Coal at Ince, near Wigan. (Binney.)

Estheria sp

From Royley (Arley) Mine at Nat Bank. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 63.)

* *Belinurus bellulus* (Konig) (*olim Limulus trilobitoides*).

From Oldham, no horizon stated. The original specimen was deposited in the Natural History Museum, Manchester, but has disappeared. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 63.)

From 135 feet above Royley (Arley) Mine at Sparth Bottoms, Rochdale. (Baldwin and Sutcliffe, Abstract of Proceedings, Geol. Soc., London, No. 794, p. 81. Also Trans. Manch. Geol. Soc., Vol. XXVIII., p. 198. The specimen is now in the Rochdale Museum, e. coll. Baldwin and Sutcliffe.)

Prestwichia rotundata (Prestwich).

From shale below the Doe Mine on the banks of the Irwell at Clifton Hall. (P. 812, e. coll. Dawkins, M.M.)

From shale behind the fossil tree trunks at Dixon Fold, on the Lancashire and Yorkshire Railway.

Found by Mr. J. W. Croston. (L. 2785 M.M.)

From below the Neddy Mine and probably about 60 yards above the Royley or Arley Mine. (Baldwin., Trans. Manch. Geol. Soc., Vol. XXVII., p. 149.)

From 135 feet above the Royley (Arley) Mine at Sparth Bottoms, Rochdale. (Baldwin & Sutcliffe's Abstract of

* Dr. F. A. Bather suggests that this specimen ought to be called *Bellinurus lunatus* (Martin), having been described by Martin in his "Petrificata Derbiensia," published in 1809.

Proceedings, Geol. Soc. London, No. 794, p. 81. Also Trans. Manch. Geol. Soc., Vol. XXVIII., p. 198.)

Cyclus Johnsoni.

From roof of the Fairbottom Mine at Bardsley. Two halves of nodule showing rim of carapace. (W. 1223, e. coll. Wild, M.M.)

Arthropleura (*olim Eurypterus*) *mammatus* (Salter).

This species was described from fragments referred to the head, the lateral portions of the body segments, and parts near the tail, found at the pit top of Pendleton Colliery by Messrs. Gibbs & Rhind, and the collectors of the Geological Survey. Quart. Journ. Geol. Soc., Vol. XIX., p. 85. The exact horizon was found to be the "Ferny Metal" under the "Big Coal" or Rams Mine, which is also styled the "Seven-foot Coal," by Salter, op. cit., p. 86.

Pygocephalus Cooperi (Huxley).

From coal shale at Medlock Park Bridge, Ashton-under-Lyne. A remarkable form found by Mr. Cooper of Bilston, and described by Professor Huxley, Quart. Jour. Geol. Soc., Vol. XIII., p. 363. Type specimen in the Manchester Museum. Salter states that the specimen was probably from the Black Mine. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 63.)

From Sparth Bottoms between the Neddy and Royley Mine at about 60 yards above the latter. The specimen is in the Rochdale Museum.*

ARACHNIDA.

Eoscorpius Sparthensis (Baldwin).

From 135 feet above the Royley (Arley) Mine at Sparth Bottoms, Rochdale. (Baldwin & Sutcliffe, Abstract of

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* I have recently had an opportunity of examining Mr. Baldwin's specimen, and am of opinion that it is more nearly related to Anthrapalæmon than to Pygocephalus. It is in all probability a new species of the former genus.

Proceedings, Geol. Soc. London, No. 794, p. 81.) (L. 6271, e. coll. Baldwin, M.M.)

MYRIOPODA.

Euphoberia Browni (Woodward).

From shale behind the fossil tree trunks at Dixon Fold on the Lancashire and Yorkshire Railway. (p. 813, e. coll. Dawkins, M.M.)

Euphoberia ferox (Salter).

Found amongst a collection of specimens collected at the pit top, Pendleton colliery, by Messrs. Gibbs and Rhind. Dr. H. Woodward, "Pal. Soc. Mon., British Fossil Crustacea." Specimen in the Jermyn Street Museum. The exact horizon was afterwards proved to be the "Ferny metal" under the "Big coal," or Rams Mine. (Quart. Journ. Geol. Soc., Vol. XIX., p. 86.)

From Sparth Bottoms, Rochdale, 45 yards above the Royley Mine. The specimen is in the Rochdale Museum, and is represented by a few segments.

Xylobius sp.

A specimen from the Ashton Moss Colliery at Audenshaw is referred by me to this genus, but the species is indeterminable. It is in the Cairns collection of the Manchester Museum.

Insecta.

This group is represented by an imperfect specimen of a Neuropterous insect from 47 yards above the Royley Mine at Sparth Bottoms, Rochdale, and a doubtful larval form of Etoblattina from about 60 yards above the Royley Mine at the same place. Both specimens are in the Rochdale Museum. (Baldwin, Trans. Manch. Geol. & Mining Soc., Vol. XXVIII., Part XVII.)

PISCES.

Fishes may be said to have dominated the Middle Coal Measure period, as no less than 40 species are known, belonging to 25 genera.

The Lower Coal Measures have only yielded 17 species belonging to 13 genera, and of these no less than 12 species and 10 genera live on into the Middle Coal Measures.

A remarkable feature in connection with the occurrence of fish remains is their prevalence in the roof shales of coal seams, or in the case of Cannel, in the coal itself. Wherever a black shale lies upon a coal seam, there fish teeth and scales may be looked for with a considerable likelihood of success. Very rarely are fishes found whole, more usually they are represented by teeth, isolated scales and defensive spines.

Diplodus gibbosus (Binney).

From 400–500 yards deep at Ashton Moss Colliery, Audenshaw. (L. 2591 and L. 2599, e. coll. Cairns, M.M.)

From Fulledge Colliery, Burnley. Horizon not known. (e. coll. Kay-Shuttleworth, M.M.)

From the Cannel Seam of Wigan. (e. coll. Bowman, M.M.)

From the Middle Coal Measures of Peel, Little Hulton. Horizon not known (M.M.)

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (W. 907 and 902, e. coll. Wild, M.M.)

From shale below the Stubbs Mine at Bardsley. (W. 901, e. coll. Wild, M.M.)

From eight yards above the Old Mine at Bardsley. (W. 904, e. coll. Wild, M.M.)

From the Nield Mine of Glodwick, Oldham. (W. 1203, e. coll. Wild, M.M.)

From Bispham Colliery. (Salter, Geol. Survey. Geology of the Country around Wigan, p. 35.)

From the black bass over the Four Feet Mine at Pendleton. (Binney, Trans. Manch. Geol. Soc., Vol. I.)

The following specimens differ in some particulars from the typical form of Diplodus gibbosus, but are probably referable to that species:—

From the Cannel Seam of Wigan, marked "sp. n. (A.S.W.") Specimen in Manchester Museum.

From the Stubbs Mine at Bardsley Colliery. (W. 1850, e. coll. Wild, M.M.)

From the Two Feet Mine at Bardsley Colliery, associated with *Strepsodus sauroides*. (W. 809, e. coll. Wild, M.M.)

From the Californian or Thin Bed of Burnley. (W. 1848, e. coll. Wild, M.M.)

Diplodus tenuis (Woodward).

From Ashton Moss Colliery, Audenshaw. Horizon not known. (L. 2590, e. coll. Cairns, M.M.)

Diplodus sp.

In roof of Cannel Coal at 162 yards, Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 184.)

In shale over Californian or Thin Bed, Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 185.)

Pleuracanthus lævissimus (Agassiz).

From the Californian or Thin Bed of the Fulledge Colliery, Burnley. (W. 911, e. coll. Wild, M.M.)

From the Two Feet Mine of Bardsley. (W. 912, e. coll. Wild, M.M.)

From the Arley Mine of Burnley. (W. 910, e. coll. Wild, M.M.)

Pleuracanthus alatus (Davis).

From the Arley Mine, probably of Burnley. (W. 915, e. coll. Wild, M.M.) Labelled "Spine of selachian fish."

Pleuracanthus cylindricus (Davis).

From the Middle Coal Measures of Fulledge Colliery, Burnley. (L. 2175, e. coll. Kay-Shuttleworth, M.M.)

From the Middle Coal Measures of Peel, Little Hulton. (M.M.) No horizon known in either case.

Pleuracanthus undulatus (Davis).

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (L. 1620, e. coll. Kay-Shuttleworth, M.M.)

Same locality and horizon. (e. coll. Wild, M.M.)

Pleuracanthus erectus (Davis).

From the Two Feet Mine of Bardsley. (W. 916, e. coll. Wild, M.M.)

Pleuracanthus serratus (Davis).

From the Middle Coal Measures, probably of Burnley. No horizon stated. (L. 2323, e. coll. Kay-Shuttleworth, M.M.)

Pleuracanthus denticulatus (Davis).

From the Two Feet Mine of Bardsley. (W. 913, e. coll. Wild, M.M.)

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (W. 914, e. coll. Wild, M.M.)

Pleuracanthus sp. indet.

From the Nield Mine of Glodwick, Oldham (W. 1106, e. coll. Wild, M.M.)

In Shale, over the Californian or Thin Bed, Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 185.)

From the Two Feet Mine of Bardsley. (W. 912, e. coll. Wild, M.M.)

Ctenoptychius apicalis (Agassiz).

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (W. 875, e. coll. Wild, M.M.) Associated with *Pleuroplax Rankinei*.

From the same locality and horizon. (W. 878 and W. 884, e. coll. Wild, M.M.) Associated with *Callopristodus pectinatus*.

From Ashton Moss Colliery, Audenshaw, at 400-500 yards deep. (L. 2605, e. coll. Cairns, M.M.)

From the Middle Coal Measures of Burnley. Horizon not stated. (L. 2216, e. coll. Kay-Shuttleworth, M.M.) Associated with Rhizodontoid vertebræ.

From the Arley Mine at Fulledge Colliery, Burnley. (W. 1853, e. coll. Wild, M.M.)

From shale over the Californian or Thin Bed, Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 185.)

From black bass over the Four Feet Mine at Pendleton. (Binney, Trans. Manch. Geol. Soc., Vol. I.)

Ctenoptychius sp.

In the Cannel Mine at Haigh. (Binney, Trans. Manch. Geol. Soc., Vol. I., p. 157.)

From the Cannel of Wigan. (Salter, Geol. Surv. Mem., Geology of Country around Wigan, p. 36.)

Callopristodus pectinatus (Agassiz).

From the Californian or Thin Bed of Burnley. (W. 884 and 878, e. coll. Wild, M.M.) Associated with *Ctenoptychius apicalis*.

Same locality and horizon. (W. 1069, e. coll Wild, M.M.) Associated with *Acanthodes*.

From eight yards above the Old Mine at Bardsley. (W. 1081, e. coll. Wild, M.M.)

From the Middle Coal Measures of Ashton Moss Colliery, Audenshaw. (e. coll. Cairns, M.M.) Horizon not stated.

As "Ctenoptychius pectinatus." In shale over the Californian or Thin Bed, Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 185.)

As "Ctenoptychius pectinatus." From black bass over the Four Feet Mine at Pendleton. (Binney, Trans. Manch. Geol. Soc., Vol. I.)

Helodus simplex (Agassiz).

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (W. 893, e. coll. Wild, M.M.) Probably L. 2319 and L. 2321 in the Kay-Shuttleworth collection of the Manchester Museum are from the same horizon at Fulledge colliery, although this is not stated.

From the Arley Mine of Fulledge Colliery, Burnley. (W. 892, e. coll. Wild, M.M.)

Pleuroplax (olim Pleurodus) Rankinei (Hancock & Atthey).

From the foot coal below Fairbottom Mine at Pickford Wood Colliery. (W. 1839, e. coll. Wild, M.M.)

From the Two Feet Mine of Bardsley Colliery. (W. 1855, e. coll. Wild, M.M.)

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (W. 934, e. coll. Wild, M.M.)

From over a coal seam at 530 to 531 yards deep in the Victoria shaft, Bardsley. (W. 933, e. coll. Wild, M.M.)

From the Two Feet Mine of Burnley. (W. 928, e. coll. Wild, M.M.)

From the Arley Mine of Fulledge Colliery, Burnley. (W. 925, e. coll. Wild, M.M.)

From the "Calamite bed" at 640 yards, Bardsley Colliery. (W. 900, e. coll. Wild, M.M.) This specimen is a tooth of abnormal size, being about one inch long, and half-an-inch broad and high. A similar tooth is in the Kay-Shuttleworth collection, and bears the register number L. 1700.

From 400–500 yards deep in shaft of Ashton Moss Colliery, Audenshaw. (L. 2604, e. coll. Cairns, M.M.)

From Fulledge Colliery, Burnley, probably from the Californian or Thin Bed. (L. 1699, e. coll. Kay-

Shuttleworth, M.M.) Associated with a small fish spine of the Sphenacanthus type, and similar to those described as *Hoplonchus elegans* by the late J. W. Davis. (Quart. Journ. Geol. Soc., Vol. XXXV., p. 181.)

From over a half-inch coal at 604 yards at Bardsley. (W. 930, e. coll Wild, M.M.)

From the Middle Coal Measures of Oldham, horizon not stated. (e. coll. Williamson, M.M.)

From over seven-inch Bastard Cannel in the Diamond Shaft, Bardsley. (W. 932, e. coll. Wild, M.M.) Associated with *Megalichthys Hibberti*.

(W. 1079, e. coll. Wild, M.M.) From the same horizon and locality is associated with shagreen.

Pleuroplax Attheyi (Barkas).

From the Middle Coal Measures of Ashton Moss Colliery, Audenshaw. Horizon not stated. (L. 2603, e. coll. Cairns, M.M.)

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (W. 1854, e. coll. Wild, M.M.)

Pleuroplax sp.

In shale over the Great Mine, Fulledge Colliery, Burnley. (Geo. Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 185.)

In shale over the Californian or Thin Bed, Fulledge Colliery, Burnley. (Op. cit., p. 185.)

In shale over the Two feet Mine at 475 yards from surface, Bardsley Colliery. (George Wild, Trans. Manch. Geol. Soc., Vol. XVIII., p. 457.)

Roof of half-inch coal at 18 yards above a nine-inch coal, the latter at 622 yards deep, Bardsley Colliery. (Op. cit., p. 461.)

Roof of nine-inch coal at 622 yards deep, Bardsley Colliery. (Op. cit., p. 461.)

In black stone roof over seven-inch inferior Coal, the latter at 646 yards deep, Bardsley Colliery. (Op. cit., p. 462.)

From 78 yards below the New Mine, Bardsley Colliery. (Op. cit., p. 446.)

In Bastard Cannel at 647 yards deep, Bardsley Colliery. (Op. cit., p. 463.)

Psephodus magnus (McCoy).

From over the Arley Mine at Burnley. (Recorded by Capt. J. Aitken in one of the earlier volumes of the Society's Transactions.)

Sphenacanthus hybodoides (Egerton).

This species is represented by spines and teeth.

From the Low Bottom Bed of Whittlefield Colliery. (L. 2185, e. coll. Kay-Shuttleworth, M.M.) Spine.

From the Pomfret Mine of Bardsley. (W. 1516, e. coll. Wild, M.M.) Fragment of spine in block of Cannel coal.

From the Arley Mine of Rowley Colliery, Burnley. (W. 935, e. coll. Wild, M.M.) Spine.

From the Two Feet Mine of Bardsley. (W. 939, e. coll. Wild, M.M.) Spine.

From the Low Bottom Bed of Fulledge Colliery, Burnley. (W. 945, e. coll. Wild, M.M.) Spines.

From the Californian or Thin Bed at Fulledge Colliery, Burnley. (W. 950 and 948, e. coll. Wild, M.M.) Spines and teeth.

From the Arley Mine of Fulledge Colliery, Burnley. (L. 2166, e coll. Kay-Shuttleworth, M.M.) Spine.

From the Cannel seam of Wigan. (e. coll. Bowman, M.M.) Spine.

From Ashton Moss Colliery, Audenshaw. Horizon not stated. (L. 2398, e. coll. Cairns, M.M.) Teeth.

Sphenacanthus sp. indet.

From Ashton Moss Colliery, Audenshaw. Horizon not stated. (L. 2613, e. coll. Cairns, M.M.)

Dorsal Rays (*Sphenacanthus, H.B.*)

In shale over the Californian or Thin Bed of Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 185.)

(*Large Dorsal Ray*), *Sphenacanthus* (?) *H.B.*

In the Cannel Mines at Haigh. (Binney, Trans. Manch. Geol., Soc., Vol, I., p. 157.)

Ctenacanthus sp. (? *Sphenacanthus, H.B.*)

In shale over the Californian or Thin Bed at Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 185.)

Stemmatodus.

From Bastard Cannel at 647 yards. Diamond Shaft, Bardsley. (W. 1096, e. coll. Wild, M.M.)

From over the Royley (Arley) Mine at Nook Colliery, Broad Oak, Ashton-under-Lyne. (W. 1066, e. coll. Wild, M.M.)

From the Arley Mine of Burnley. (W. 1076, e. coll. Wild, M.M.)

Acanthodes Wardi (Egerton).

From the Middle Coal Measures of Middleton, Manchester. (M.M.)

From Ashton Moss Colliery, Audenshaw, Middle Coal Measures. (L. 2608, e. coll. Cairns, M.M.)

In neither of these cases can the horizon be determined.

From 360 yards deep at Ashton Moss Colliery, Audenshaw. (W. 956, e. coll. Wild, M.M.)

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (W. 1069, e. coll. Wild, M.M.) Associated with *Callopristodus pectinatus.*

Acanthodes sp. indet.

From 360 yards deep at Ashton Moss Colliery, Audenshaw, and also from the "Marine band" of the River Tame, Dukinfield. I am uncertain now whether (W. 757, e. coll. Wild, M.M.) is from the former or the latter locality and horizon, and I am too far away to refer to the specimens.

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (W. 954 and W. 1069, e. coll. Wild, M.M.) The latter specimen is associated with *Callopristodus pectinatus.* In black stone roof over seven inch inferior Coal, the latter at 646 yards deep, Bardsley Colliery. (George Wild, Trans. Manch. Geol. Soc., Vol. XVIII., p. 426.)

Hoplonchus elegans (Davis).

This beautiful little fish spine, much like that of Sphenacanthus hybodoides in miniature, has not hitherto, I believe, been recorded from Lancashire, but I was able to prove its occurrence in the Middle Coal Measures of Lancashire by direct comparison with plaster casts of the types, kindly sent to me whilst at Owens College, by Dr. A. Smith Woodward.

From the Arley Mine of Burnley. (W. 1104, e. coll. Wild, M.M.)

From Fulledge Colliery, Burnley. (L. 1699, e. coll. Kay-Shuttleworth, M.M.) Horizon not stated but probably the Arley Mine. The specimen is associated with a tooth of *Pleuroplax Rankinei.*

From over the Royley (Arley) Mine of Hurst, Ashton-under-Lyne. (W. 1093, e. coll. Wild, M.M.)

Lepracanthus Colei (Egerton).

From the Arley Mine of Burnley. (W. 1103, e. coll. Wild, M.M.)

From Towneley Colliery, Burnley. Horizon not stated. (W. 957, e. coll. Wild, M.M.)

Cladodus.

This generic term has been frequently applied to teeth of Sphenacanthus hybodoides, which see.

Gyracanthus formosus (Agassiz).

This species is remarkable in that it evidently possessed two forms of spines, one form robust and elongated, and probably borne in pairs on the front edge of the paired fins, the other laterally compressed and broadly triangular in outline. The latter are usually called "free spines." Free spines are rare in the Lancashire Coal Measures, I only know of the following:—

From the Stubbs Mine of Bardsley. (L. 2622, e. coll. Cairns, M.M.)

From the Middle Coal Measures of Burnley. Horizon not stated. (e. coll. Kay-Shuttleworth, M.M.)

From black bass over the Four Feet Mine at Pendleton. (Binney, Trans. Manch. Geol. Soc., Vol. I.)

Paired Spines.

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (W. 968 and W. 972, e. coll. Wild, M.M.)

From the roof of the Arley Mine, Burnley. (W. 971, e. coll. Wild, M.M.) Associated with a quartzite pebble.

From the Two Feet Mine of Bardsley. (W. 937, e. coll. Wild, M.M.)

From Ashton Moss Colliery at 400-500 yards. No horizon stated. (L. 2612, e. coll. Cairns, M.M.)

From the Stubbs Mine of Bardsley. (W. 1218, e. coll. Wild, M.M.) Associated with Carbonicola.

In shale over the Californian or Thin Bed, Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 185.)

Listracanthus sp. n.

From the "Marine Band," River Tame, Dukinfield. (e. coll. Cairns, M.M.)

Euctenius unilateralis (Barkas).

The curious structures known by this name are very rare in the English Coal Measures, and little is known respecting them. They are regarded as dermal defences. A specimen from the Nield Mine of Glodwick, Oldham, is in the Wild collection (W. 801) of the Manchester Museum. It is the only known specimen from Lancashire, and is associated with remains of *Strepsodus sauroides*.

Ctenodus cristatus (Agassiz).

Three specimens from the Two Feet Mine of Bardsley. (W. 974, e. coll. Wild, M.M.)

Ctenodus sp. indet.

Scale from the Californian or Thin Bed of Burnley. (L. 2262, e. coll. Kay-Shuttleworth, M.M.) Dental plate from the same horizon and locality. L. 2314, M.M.)

From black bass over the Four Feet Mine at Pendleton. (Binney, Trans. Manch. Geol. Soc., Vol. I.)

In shale over the Two Feet Mine at 475 yards from surface, Bardsley Colliery. (George Wild, Trans. Manch. Geol. Soc., Vol. XVIII., p. 457.)

Sagenodus inæqualis (Owen).

From the Nield Mine of Glodwick, Oldham. (W. 977, e. coll. Wild, M.M.)

Megalichthys Hibberti (Agassiz).

From Fulledge Colliery, Burnley. No horizon stated. (e. coll. Kay-Shuttleworth, M.M.)

From 400-500 yards deep in shaft at Ashton Moss Colliery, Audenshaw. (L. 2614, e. coll. Cairns, M.M.)

From the Cannel or Two Feet Mine of Dukinfield. (W. 849, e. coll. Wild, M.M.)

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (W. 850 and W. 815, e. coll. Wild, M.M.)

From the Two Feet Mine of Bardsley. (W. 820 and W. 306, e. coll. Wild, M.M.) W. 306 is a micro-section of a scale.

From the Bastard Cannel of the Fulledge Colliery, Burnley. (W. 840, e. coll. Wild, M.M.)

From the Arley Mine of Fulledge Colliery, Burnley. (W. 846 and W. 855, e. coll. Wild, M.M.)

From the Cannel Seam of Wigan. (e. coll. Bowman, M.M.)

From the Seven Inch Bastard Cannel of Bardsley. (W. 858 and 859, e. coll. Wild, M.M.)

From below the Stubbs Mine of Bardsley. (W. 856 and 857, e. coll. Wild, M.M.)

From eight yards above the Old Mine, Bardsley. (W. 1078, e. coll. Wild, M.M.)

From Broad Oak Colliery, Ashton-under-Lyne. Horizon not stated. (L. 2944, M.M. Donor, Mr. Grundy.)

From the Cannel seam of Haigh, near Wigan. (e. coll. Bowman, M.M.)

From Peel Delph. Horizon not stated.

From Black Bass over the Four Feet Mine, Pendleton. (Binney, Trans. Manch. Geol. Soc., Vol. I.)

From above the Trencherbone Coal at Green, near Bolton. Section on the river Irwell. (Salter, Geol. Surv. Men., Geology of Country around Bolton-le-Moors, p. 41.)

From over the Great Mine at Ashton-under-Lyne. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 64.)

From the Cannel of Wigan. (Salter, Geol. Surv. Mem., Geology of Country around Wigan, p. 36.)

Megalichthys intermedius (Woodward).

From Fulledge Colliery, Burnley. Horizon not stated. (e. coll. Kay-Shuttleworth, M.M.)

From Bradford, near Manchester. Horizon not stated. M.M.)

Megalichthys pygmæus (Traquair).

From Fulledge Colliery, Burnley. Horizon not stated. (e. coll. Kay-Shuttleworth, M.M.)

From below the Stubbs Mine of Bardsley. (W. 851, e. coll. Wild, M.M.)

From Middleton. Horizon not stated. (e. coll. Williamson, M.M.)

From the Cannel Coal of Wigan. (e. coll. Bowman, M.M.)

Megalichthys sp.

In shale over Two Feet Mine at 475 yards from surface, Bardsley Colliery. (George Wild, Trans. Manch. Geol. Soc., Vol. XVIII., p. 457).

Roof of half-inch coal at 18 yards over a 9 inch coal, the latter at 622 yards deep, Bardsley Colliery. (Op. cit., p. 461.)

Roof of nine-inch coal at 622 yards deep, Bardsley Colliery. (Op. cit.)

In blackstone roof over seven-inch inferior Coal, the latter at 646 yards deep, Bardsley Colliery. (Op. cit.)

In Bastard Cannel at 647 yards deep, Bardsley Colliery. (Op. cit.)

In roof of the Cannel Coal at 162 yards, Fulledge Colliery, Burnley. (Op. cit.)

In shale over the Californian or Thin Bed at Fulledge Colliery, Burnley. (Op. cit.)

In shale over the Great Mine, Fulledge Colliery, Burnley. (Op. cit).

In the Cannel Mines at Haigh. (Binney, Trans. Manch. Geol. Soc., Vol. I., p. 157.)

As "Diplopterus" from 400-500 yards deep in shaft at Ashton Moss Colliery, Audenshaw. (e. coll. Cairns, M.M.)

As "Diplopterus" from Bradford, Manchester. Horizon not stated. (e. coll. Williamson, M.M.)

As "Diplopterus" said to occur in the Cannel Mines at Haigh. (Binney, Trans. Manch. Geol. Soc., Vol. I., p. 157.)

As "Diplopterus" from the Cannel of Wigan. (Salter, Geol. Surv. Mem., Geology of Country around Wigan, p. 36.)

As "Diplopterus" from black bass over the Four Feet Mine at Pendleton. (Binney, Trans. Manch. Geol. Soc., Vol. I.)

Strepsodus sauroides (Binney).

From Bradford, near Manchester. Horizon not stated. (e. coll. Bowman, M.M.) Associated with minute cyprids.

From the Cannel seam of Wigan. (e. coll. Bowman, M.M.)

From 400-500 yards deep in shaft at Ashton Moss Colliery, Audenshaw. (L. 2603, e. coll. Cairns, M.M.)

From the Californian or Thin Bed at Fulledge Colliery. (L. 2203, e. coll. Kay-Shuttleworth, M.M.) Associated with *Rhizodopsis sauroides.*

From below the Stubbs Mine at Bardsley. (W. 810, e. coll. Wild, M.M.)

From the Two Feet Mine at Bardsley. (W. 809, e. coll. Wild, M.M.) W. 873 e. coll. Wild, same locality and horizon, is associated with Ostracods.

From the Cannel Mine of Dukinfield. (W. 807, e. coll. Wild, M.M.)

From the Nield Mine of Glodwick, Oldham. (W. 802 and W. 801,* e. coll. Wild, M.M.)

From the Great Mine of Fulledge Colliery, Burnley. (W. 799, e. coll. Wild, M.M.)

From below the Two Feet Mine at Woodpark, Bardsley. (W. 798, e. coll. Wild, M.M.)

From the Fairbottom Mine of Bardsley. (W. 797, e. coll. Wild, M.M.)

From Ashton Moss Colliery, Audenshaw. Horizon not stated. (W. 794, e. coll. Wild, M.M.)

From Bastard Cannel at 647 yards, Burnley or Bardsley. (W. 806 e. coll. Wild, M.M.), a tooth labelled "Rhomboptychius."

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* W 801 is associated with an impression of Euctenius unilateralis.

From about 60 yards above the Royley Mine at Sparth Bottoms, Rochdale. Specimen in the Rochdale Museum.

Strepsodus sulcidens (Hancock & Atthey).

From the Nield Mine of Glodwick, Oldham. (W. 793, e. coll. Wild, M.M.)

From the Middle Coal Measures of Lancashire. No horizon or locality. (e. coll. Williamson, M.M.)

From the Arley Mine of Fulledge Colliery, Burnley. (e. coll. Kay-Shuttleworth, M.M.)

Strepsodus sp. indet.

From shale below the Doe Mine, River Irwell, Clifton Hall. (e. coll. Dawkins, M.M.)

From Astley Pit, Dunkinfield. No horizon stated. (L. 2602, e. coll. Cairns, M.M.)

As "Holpoptychius" from the Cannel of Wigan. (Salter, Geol. Surv. Mem., Geology of Country around Wigan, p. 36.)

Rhizodopsis sauroides (Williamson).

This species was usually described by older geologists as "Rhizodus," "Rhizodus granulatus" and "Holoptychius."

From 400-500 yards deep in shaft at Ashton Moss Colliery, Audenshaw. (L. 2600, e. coll. Cairns, M.M.)

From the Arley Mine of Fulledge Colliery, Burnley. (L. 2387, e. coll. Kay-Shuttleworth, M.M.) Associated with Strepsodus sauroides. (W. 789, e. coll. Wild, M.M.)

From the Four Feet Mine of Pendleton. (M.M.)

From below the Stubbs Mine of Bardsley Colliery. (W. 791, e. coll. Wild, M.M.)

From the Nield Mine of Glodwick, Oldham. (W. 780, e. coll. Wild, M.M.)

From the Cannel Coal of Peel Delph, Bolton. (e. coll. Williamson, M.M.)

From the Californian or Thin Bed of Burnley. (L. 2203, e. coll. Kay-Shuttleworth.)

From 400-500 yards deep in shaft at Ashton Moss Colliery, Audenshaw. (L. 2602, e. coll. Cairns, M.M.) Associated with an unknown and possibly new fish spine, the "Strepsodus" of George Wild, in Trans. Manch. Geol. Soc., Vol. XXII., p. 449.

From Bastard Cannel forming the floor of the Trencher-bone seam at St. Cerges Pit, Tyldesley. This Cannel also contains *Carbonicola acuta* in its upper portion, viz., close against the bottom of the Trencherbone.

As "Holoptychius sauroides," from black bass, over the Four Feet Mine at Pendleton. (Binney, Trans. Manch. Geol. Soc., Vol. I.)

As "Rhizodus granulatus," from the Three Yard Mine at Hulton Colliery, three miles S.W. of Bolton. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 41.)

As "Rhizodus granulatus," from Vitriol Works, two miles S.E. from Bolton. (Salter, op. cit., p. 41.)

As "Rhizodus granulatus," from Black Mine at Dukinfield Hall. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 64.)

Rhizodontoid vertebræ.

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (e. coll. Kay-Shuttleworth, M.M.)

From above the Royley Mine at Nook Colliery, Broad Oak, Ashton-under-Lyne. (W. 1061, e. coll. Wild, M.M.)

From the Pomfret Mine of Bardsley Colliery at 170 yards. (W. 1179, e. coll. Wild, M.M.)

From the Two Feet Mine of Bardsley Colliery. (W. 1180, e. coll. Wild, M.M.)

Ditto. (W. 1181, e. coll. Wild, M.M.*)

From 400-500 yards deep in shaft of Ashton Moss Colliery. (W. 1182, e. coll. Wild, M.M.)

* Associated with ribs of "Ctenodus," *i.e.*, Archegosaurus.

Rhizodus (*Rhizodopsis*) *sp.*

In Bastard Cannel at 647 yards deep. Bardsley Colliery. (George Wild, Trans. Manch. Geol. Soc., Vol. XVIII., p. 463.)

In shale over the Californian or Thin Bed, Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 185.)

In roof of Cannel Coal at 162 yards, Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 184.)

In the Cannel Mine at Haigh. (Binney, Trans. Manch. Geol. Soc., Vol. I., p. 157.

As "Rhizodus" n. sp. from above King Coal at Whittle Green Colliery. (Salter, Geol. Surv. Mem., Geology of Country around Wigan, p. 36.)

Cœlacanthus elegans (Newberry).

From below the New Mine at Dukinfield. (W. 864, e. coll. Wild, M.M.)

From 415 yards deep in shaft of Ashton Moss Colliery. (W. 867, e. coll. Wild, M.M.)

Also (L. 2589, e. coll. Cairns, M.M.) at 400-500 yards deep in shaft. (This latter specimen is No. 8 of Wild, in Trans. Manch. Geol. Soc., Vol. XXII., p. 448.)

From the Arley Mine of Burnley. (W. 862, e. coll. Wild, M.M.) and (L2421, e. coll. Kay-Shuttleworth, M.M.)

From the Four Feet Mine of Pendleton (e. coll. Bowman, M.M.) Associated with *Rhizodopsis sauroides.*

From the Cannel seam of Peel, Bolton. (e. coll. Bowman, M.M.)

From Bastard Cannel of New Copy Colliery, Clivger. (W. 870, e. coll. Wild, M.M.)

In the Wild collection of the Manchester Museum are two specimens (W. 866 and W. 865), one marked "Blend-fire Mine of Glodwick, Oldham," the other the "Neild Mine of Glodwick, Oldham." As the specimens are counterparts, one horizon must be wrong.

As "Coelacanthus lepturus" from Wigan. No horizon stated. (Salter, Geol. Surv. Mem., Geology of Country around Wigan, p. 36.)

Cœlacanthus sp.

From the "Marine band" of Ashton Moss Colliery, Audenshaw. (W. 755, e. coll. Wild, M.M.)

From black bass over the Four Feet Mine at Pendleton. (Binney, Trans. Manch. Geol. Soc., Vol. I.)

From the Cannel Coal (?) of Peel, Bolton. Originally labelled "Holoptychius."

In Shale over the Californian or Thin Bed, Fulledge Colliery, Burnley. (George Wild, Trans. Manch. Geol. Soc., Vol. IV., p. 185.)

Rhadinichthys Wardi (Traquair).

From 400–500 yards deep in shaft of Ashton Moss Colliery, Audenshaw. (L. 2587, e. coll. Cairns, M.M.) This specimen is No. 5 of Wild, Trans. Manch. Geol. Soc., Vol. XXII., p. 448.

From Collyhurst, Manchester. Horizon not stated. (L. 3186, e. coll. Salford Museum, M.M.)

Rhadinichthys Planti (Traquair).

This species is recorded from Collyhurst. Horizon not stated. The type specimen should be in the collections of the Salford Museum, but I failed to find it when rearranging the geological collections there. Specimens of this species are, however, there in the duplicate series.

Elonichthys Aitkeni (Traquair).

From the Arley Mine of Rowley Colliery. (e. coll. Kay-Shuttleworth, M.M.)

From the Arley Mine of Burnley. (W. 1013 and W. 1014, e. coll. Wild, M.M.)

Elonichthys striolatus (Agassiz).

From the Arley Mine of Burnley. (W. 1020, e. coll. Wild, M.M.)

Elonichthys (*olim Palæoniscus*) *Egertoni* (Agassiz).

From black bass over the Four Feet Mine at Pendleton. (Binney, Trans., Manch. Geol. Soc., Vol. I.

Elonichthys sp. indet.

From the Californian or Thin Bed of Burnley. (e. coll. Kay-Shuttleworth, M.M.)

As "Palæoniscus sp." from between the Yard and Bone Coals at Freeman's Colliery. (Salter, Geol. Surv. Mem., Geology of Country around Wigan, p. 36.)

Acrolepis (?).

From the Middle Coal Measures of Burnley. Horizon not stated. (e. coll. Kay-Shuttleworth, M.M.)

Mesolepsis scalaris (Young).

From the Middle Coal Measures of Burnley. Horizon not stated. (e. coll. Kay-Shuttleworth, M.M.)

From the Arley Mine of Burnley. (W. 1012, e. coll. Wild, M.M.) This specimen is doubtfully referred by me to M. scalaris.

Cheirodus granulosus (Traquair).

From 400-500 yards deep in shaft at Ashton Moss Colliery, Audenshaw. (e. coll. Cairns, M.M.)

From the Middle Coal Measures of Higham Hill Park, Padiham. Horizon not stated. (L. 2326 and 2341 e. coll. Kay-Shuttleworth, M.M.)

A splenial or pterygoid element of the skull of this species is in the Wild Collection of the Manchester Museum. (W. ·994, e. coll. Wild, M.M.), but with no horizon or locality. It is almost certainly Lancashire.

Platysomus parvulus (Agassiz).

From the Four Feet Mine of Pendleton Colliery. (M.M.)

From the Middle Coal Measures of Burnley. Horizon not stated. (e. coll. Kay-Shuttleworth, M.M.)

Platysomus (*parvulus, H.B.)*

From black bass over the Four Feet Mine at Pendleton. (Binney, Trans. Manch. Geol. Soc., Vol. I.)

Palæoniscus sp.

"Holoptychius." From bituminous schists of the Black and White Mine at Peel. (Williamson, Brit. Assoc. Report, Liverpool, quoted by Binney, Trans. Manch. Geol. Soc., Vol. I., p. 157.)

Roof of half inch coal at 18 yards over a 9 inch coal, the latter at 622 yards deep, Bardsley Colliery. (George Wild, Trans. Manch. Geol. Soc., Vol. XVIII., p. 461.)

Fish Remains (Gen. and spec. indet.).

Over coal 6 inches above the Water Mine, the latter at 517 yards from surface, Bardsley Colliery. (George Wild, Trans. Manch. Geol. Soc., Vol. XVIII., p. 458.)

Scarce in inferior Cannel called the Lower Cannel at 525 yards from surface, Bardsley Colliery. (George Wild, op. cit.)

In brown shale 5½ yards below the Lower Cannel, the latter at 525 yards from surface. (George Wild, op. cit.)

In black bassy shale 12 yards below the Lower Cannel, the latter at 525 yards from surface. (George Wild, op. cit.)

Above half-inch coal at 639 yards, Bardsley Colliery. (George Wild, op. cit.)

In hard black shale over one and a half-inch Bass Coal, the latter at a depth of 678 yards, Bardsley Colliery. (George Wild, op. cit.)

In a micaceous shale over Coaly Bass at 115 yards, Bardsley Colliery. (George Wild, Trans. Manch. Geol. Soc., Vol. XVIII., p. 446)

Shagreen.

In a micaceous shale over Coaly Bass at 115 yards, Bardsley Colliery. (George Wild, Trans. Manch. Geol. Soc., Vol. XVIII., p. 446.)

Coprolites.

From the Californian or Thin Bed of Fulledge Colliery, Burnley. (W. 1858, e. coll. Wild, M.M.)

From the Stubbs Mine of Bardsley. (W. 1857, e. coll. Wild, M.M.)

AMPHIBIA.

Archegosaurus (?).

Fragment of rib from the Californian or Thin Bed of Burnley. (W. 1221, e. coll. Wild, M.M.)

Amphibian remains from the Two Feet Mine of Bardsley. (W. 1220, e. coll. Wild, M.M. and L. 947, M.M.)

The remains consist of ribs, vertebræ and (?) shoulder girdle.

Impression of ribs and vertebræ from Bastard Cannel of Cliviger near Burnley. (W. 1159, e. coll. Wild, M.M.)

Having enumerated the fossil fauna of the Middle Coal Measures, and indicated the horizons and localities in which each species occurs, it is now necessary to consider the faunal development of each horizon, by which the range of each species can be determined, and the data made readily available to the needs of the practical miner and field geologist.

It will be noted that undetermined species of most genera are indicated in the range columns.

The need to record the genus, where the species is yet unknown, arises from the fact that frequently examples of the genus are recorded from an horizon from which no known species has yet been obtained. An example will make this clear. Sphenacanthus sp. is recorded from the Royley or Arley Mine of the Oldham, Barnsley, and Ashton-under-Lyne district, but no known species.

Sphenacanthus hybodoides does occur in the Two Feet and Pomfret Mines of Bardsley. Did we fail to record Sphenacanthus sp. from the Royley Mine, it would naturally be assumed that the genus was restricted to the two seams mentioned. In tabulating the range of species, it has been found necessary to divide the coalfield into districts, and deal with the faunal horizons of each separately. The districts are as follows:—Burnley, Bolton, Wigan, and Bardsley, Oldham and Ashton-under-Lyne.

BURNLEY DISTRICT.

HORIZONS.

	Bastard Cannel at 15-16 yds. Full Edge.	Lower Yard Bed.	Bastard Cannel.	Low Bottom Bed.	Cannel Bed at 162 yds.	Californian or Thin Bed.	Great Mine.	Arley Mine.	Unknown Horizons.
Modiola	..	..	..	×	×	..	..	..	..
Naiadites (olim Anthracoptera) triangularis ..	..	..	..	..	..	..	..	..	×
Chaenocardiola Footi	..	..	..	..	..	..	..	..	×
Carbonicola (olim Anthracosia) robusta	×	×	..	..	..	..	..	×	..
,, ,, acuta var ovalis	..	..	..	..	..	×	..	..	..
,, ,, subconstricta ..	..	..	..	..	..	×	..	..	..
,, ,, angulata	..	..	..	×	..	..	..	..	..
,, ,, sp.	..	..	..	×	..	..	×	..	..
Orthonota	×	..	..	×	..	..	..	..	..
Anthracomya Wardi	..	..	\	..	..	..	..	..	×
,, dolabrata	..	..	..	..	..	..	×	..	..
,, sp.	..	..	..	×	..	..	..	..	..

Beyrichia arcuata	..	..	..	×	..	..	..	..	..
Cyprina	..	..	..	×	..	..	..	..	..
Ostracods	..	..	×	..	..	..	..	..	..
Diplodus gibbosus	..	..	..	..	..	×	..	..	×
,, sp.	..	..	..	..	×	×	..	..	..
Pleuracanthus lævissimus	..	..	..	..	..	×	..	×	..
,, alatus	..	..	..	..	..	..	..	×	..
,, cylindricus	..	..	..	..	..	..	..	..	×
,, undulatus	..	..	..	..	..	×	..	..	..
,, serratus	..	..	..	..	..	..	..	..	×
,, denticulatus	..	..	..	..	..	×	..	..	..
,, sp.	..	..	..	..	..	×	..	..	..
Ctenoptychius apicalis	..	..	..	..	..	×	..	×	..
Callopristodus pectinatus	..	..	..	..	..	×	..	..	..
Helodus simplex	..	..	..	..	..	×	..	×	..
Pleuroplax (olim Pleurodus) Rankinei	..	..	..	..	..	×	..	×	..
,, ,, Attheyi	..	..	..	..	..	×	..	..	..
,, ,, sp.	..	..	..	..	..	×	×	×	..
Psephodus magnus	..	..	..	..	..	..	..	×	..
Sphenacanthus hybodoides	..	..	..	×	..	×	..	×	..

BURNLEY DISTRICT, HORIZONS.—*Continued.*

	Bastard Cannel at 15-16 yds. Full Edge.	Lower Yard Bed.	Bastard Cannel.	Low Bottom Bed.	Canal Bed at 63 yds.	California or Thin Bed.	Great Mine.	Arley Mine.	Unknown Horizons.
Stemmatodus	..	..	..	..	..	..	..	×	..
Acanthodes Wardi ..	..	..	..	..	..	×	..	..	..
,, sp. ..	..	..	..	..	..	×	..	..	..
Hoplonchus elegans ..	..	..	..	..	..	..	..	×	..
Lepracanthus Colei ..	..	..	..	..	..	..	..	×	×
Gryacanthus formosus	..	..	..	..	..	×	..	×	×
,, sp.	..	..	..	..	..	×	..	..	..
Megalichthys Hibberti	..	..	×	..	..	×	..	×	×
,, intermedius	..	..	..	..	..	..	..	..	×
,, pygmæus	..	..	..	..	..	..	..	..	×
,, sp.	..	..	..	..	×	×	×	..	..
Strepsodus sauroides ..	..	..	..	..	..	×	×	..	..
,, sulcidens	..	..	..	..	..	..	..	×	..

Rhizodopsis sauroides..	..	..	..	..	..	×	..	×	..
,, sp.	..	..	..	..	×	..	..	..	..
Rhizodontoid vertebræ	..	..	..	..	..	..	..	×	×
Coelacanthus elegans	..	..	×	..	..	..	..	×	..
Elonichthys Aitkeni	..	..	..	..	..	..	..	×	..
,, striolatus	..	..	..	..	..	..	..	×	..
,, sp.	..	..	..	..	..	×	..	..	..
Cheirodus granulosus	..	..	..	..	..	..	..	..	×
Platysomus parvulus	..	..	..	..	..	..	..	..	×
Coprolites	..	..	..	..	..	×	..	..	..
Archegosaurus	..	..	..	..	..	×	..	..	..

The Middle Measures of the Burnley district have yielded, if we eliminate doubtful genera such as "Modiola" and "Orthonota," no less than 27 genera and 38 species belonging to the following groups:—Pelecypoda, four genera, eight species. Crustacea, one genus and one species. Pisces 20 genera and 29 species. Amphibia one genus.

The dominant forms are fishes, which come in at the very bottom of the Coal Measures, no less than 16 species occurring in the roof of the Arley Mine, and 15 in the roof of the Californian or Thin Bed. Cephalopoda and Brachiopoda appear to be absent, whilst Crustacea and Pelecypoda are less abundant in numbers as well as species than in the Lower Coal Measures.

Most of the genera and species of fossils in the Burnley district come from the black shale roofs over the lower seams, the Californian or Thin Bed being most prolific.

The Bastard Cannel at Fulledge Colliery, and the Lower Yard Bed show a remarkable falling off, only one species of mollusca (C. robusta) being recorded from both if we except the form named by the late George Wild as "Orthonota." Mollusca and Crustacea are characteristic of the Low Bottom Bed.

Bolton District.

An examination of the following table shows a marked difference to what we find in the Burnley area. There is a greater molluscan development, and a more general distribution of fossils through the whole Coal Measure series. Only in the case of the Pendleton or Worsley Four Feet Mine do we find a marked occurrence of fish remains, and these do not equal in genera and species what are found in the Burnley area.

BOLTON DISTRICT.

Horizons.

	Pendleton Four feet. Worsley Four Ft. Bilams Mine.	Ashclough or Bin Coal.	Brassey Mine.	Three Yard Mine of Bolton. Crumbourke & Brassey Mines.	Seven Feet, Rams Mine, or Big Coal.	Yard Mine.	White and Black Mines.	Ten feet Mine (White and Black Mines.)	Doe Coal.	Shale below Doe Coal.	Five Quarters Mine.	Trencherbone Mine.	Cannel forming floor of Trencherbone.	Cannel Mine.	20 yards above Arley Mine.	Horizon unknown.	"Mussel-bed," Pendleton.	Impure Cannel, Pendleton and Agecroft Collieries.
Spirorbis pusillus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..
Naidites (olim Anthracoptera)–																		
Browniana	×	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	×
sp.	..	..	..	×	..	×	..	×	..	..	..	..	..	×	×	..	..	..
Schizodus sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..
Carbonicola (olim Anthracosia)–																		
robusta	..	..	..	..	..	..	..	..	..	..	.	..	..	..	×	×	×	..
acuta	..	..	..	×	..	..	..	..	×	..	..	..	×	×	×	×	..	..
,, var ovalis	..	×	×	×	×	..	..	..	..	..	..	×	..	×	..	..	..	..

BOLTON DISTRICT, HORIZONS.—*Continued.*

	Pendleton Four Feet. Worsley Four Ft. Ellams Mine.	Ashclough or Bin Coal.	Brassey Mine.	Three Yard Mine of Bolton. Crumbourke & Brassey Mine.	Seven Feet, Rams Mine, or Big Coal.	Yard Mine.	White and Black Mines.	Ten Feet Mine (White and Black Mines.)	Doe Coal.	Slate below Doe Coal.	Five Quarries Mine.	Trencherbone Mine.	Cannel forming floor of Threncherbone.	Cannel Mine.	20 yards above Arley Mine.	Horizon unknown.	"Mussel-bed," Pendleton.	Impure Cannel, Pendleton and Agecroft Collieries.
Carbonicola (olim Anthracosia)–																		
aquilina	..	×	×	×	×	×	..	..	..	..	..	..	..	×	..	..	..	..
obtusa	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..
centralis	..	..	..	×	..	..	..	..	..	..	..	..	..	×	..	..	..	..
sp.	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..
Edmondia	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..
Anthracomya sp.	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..
Beyrichia arcuata	..	..	..	..	..	..	..	..	×	..	×	..	..	..	..	..	..	..
Estheria tenella	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ostracods	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..
Prestwichia rotundata	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..

Arthropleura (olim Eurypterus)–																		
mammatus	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..
Euphoberia ferox	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..	..	..
,, Browni	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Diplodus gibbosus	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..
Pleuracanthus cylindricus ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..
Ctenoptychius apicalis	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Callopristodus pectinatus ..	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Gyracanthus sp.	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Ctenodus sp.	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Megalichthys Hibberti	..	..	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..
,, sp.	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	×	..	..
Strepsodus sp.	..	..	..	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Rhizodopsis sauroides	..	..	..	×	..	..	..	..	..	..	..	..	×	..	..	×	..	..
,, sp.	×	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..
Coelacanthus sp.	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rhadinchthys sp.	..	..	..	..	..	..	×	..	..	..	..	..	..	..	..	..	..	..
Elonichthys Egertoni	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Platysomus parvulus	×	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

WIGAN DISTRICT.

Horizons.

	Wigan Nine Feet Mine.	Cannel Coal.	Above King Coal.	Between Bone and Yard Coals	Smith Coal (Orrel Five Feet).	47 yard above Orrell Four Feet (Arley Mine).	Above Orrell Four Feet (Arley Mine).	Horizon unknown.
Spirorbis carbonarius	..	..	..	×	..	..	..	..
Avicula tenua	..	..	..	..	..	..	×	..
Naiadites (olim Anthracoptera) Browniana	..	..	..	×	..	..	..	..
Tellinomya robusta	..	×	..	..	..	..	..	..
,, n. sp.	..	×	..	..	..	..	..	..
Carbonicola (olim Anthracosia) robusta	..	×	..	..	..	×	..	..
,, ,, acuta	..	..	..	..	×	..	..	..
,, ,, obtusa	..	..	..	..	..	..	..	×
,, ,, subconstricta	×	..	..	..	..	..	..	×
Anthracomya lævis var. scotica	..	×	..	..	..	..	..	..
Beyrichia Binneyana	..	..	..	..	..	..	..	×
Cytheropsis	..	..	..	..	..	..	..	×

Estheria striata	..	×	..	..	..	..	..	..
,, ,, var. Beinertiana	..	×	..	..	..	..	..	..
Diplodus gibbosus	..	×	..	..	..	..	..	..
,, sp.	..	..	..	..	..	..	..	×
Ctenoptychius sp.	..	×	..	..	..	..	..	..
Callopristodus pectinatus	..	..	..	..	..	..	..	×
Sphenacanthus hybodoides	..	×	..	..	..	..	..	..
Megalichthys Hibberti	..	×	..	..	..	..	..	..
,, pygmæus	..	×	..	..	..	..	..	..
Strepsodus sauroides	..	×	..	..	..	..	..	..
Rhizodopsis sauroides	..	×	..	..	..	..	..	×
,, sp.	..	..	×	..	..	..	..	..
Coelacanthus elegans	..	×	..	..	..	..	..	×
Elonichthys sp.	..	..	..	×	..	..	..	..

The writer cannot but feel that the record of fossils from the Wigan district is an unsatisfactory one, and that much remains to be done in this area in the way of collecting. From the well known Cannel seam, a fair series of fish remains have been derived, and as noted elsewhere it is remarkable for the widespread occurrence of Tellinomya robusta, which is peculiar to the roof shales of the Cannel seam.

BARDSLEY, OLDHAM, AND ASHTON-UNDER-LYNE.

HORIZONS.

	Great Mine, Ashton-under-Lyne.	Above Stubbs Mine.	Below Stubbs Mine.	Fairbottom Mine.	Foot Coal below Fairbottom Mine.	Nield Mine or Upper Chamber Mine.	Pomfrey or Lower Chamber Mine.	Blenfire Mine.	Marine Band.	Black Mine.	New Mine.*	Old Mine.†	Royley or Arley Mine.	Ashton Moss, 400-500 yds.
Spirorbis pusillus	..	..	..	..	×	..	..	..	×	..	..	..	..	..
Discina orbicularis	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Aviculopecten papyraceous	..	..	..	..	..	..	..	..	×	..	..	..	..	..
,, fibrillosus	..	..	..	..	..	..	..	..	×	..	..	..	..	..
,, Cairnsii	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Naiadites (olim Anthracoptera) modiolaris	..	×	..	..	..	..	..	..	..	..	..	..	..	..
,, (,,) quadrata	..	×	..	..	..	..	..	..	..	..	..	..	..	..
,, (,,) carinata	..	..	..	×	..	..	..	..	..	..	..	..	..	..
,, (,,) sp.	..	..	..	..	..	×	..	..	..	×	..	..	..	..

* "The New Mine lies 100 to 120 yards above the Royley or Arley Mine." Hull. Geol. Surv. Mem., Geology of the Country around Oldham, p. 26.

† "The Hurst Old Mine is of importance in the Ashton district. It is probably either the Neddy Mine or one of the thin seams below it." Hull. op. cit., p. 26.

Ctenodonta sp.	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Nucula lævirostrum	×	..	..	..	..	..	..	..	..	..	..	..	..	..
Carbonicola (olim Anthracosia) acuta	..	..	..	..	..	..	..	..	..	×	..	..	×	×
,, (,,) acuta var. ovalis	..	..	..	..	..	..	..	..	..	×	×	..	..	..
,, (,,) nucularis	..	×	..	..	..	..	..	..	..	..	..	..	..	..
,, (,,) aquilina	..	×	..	..	..	..	..	..	..	..	×	..	..	×
,, (,,) obtusa	..	..	..	..	..	..	..	..	..	×	..	..	..	..
,, (,,) subrotundata	..	..	..	..	..	×	..	..	..	..	..	..	..	..
,, (,,) turgida	..	×	..	..	..	..	..	..	..	×	..	..	..	..
,, (,,) sp.	..	..	..	×	..	×	..	..	..	×	×	..	..	..
Anthracomya modiolaris	..	×	..	×	..	..	..	..	..	×	..	..	..	..
,, dolabrata	..	×	..	..	..	..	..	..	..	×	..	..	..	..
,, sp.	..	×	..	..	..	..	..	..	..	..	..	..	..	..
Serpulites, wavy sp.	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Orthoceras, thin sp.	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Nautilus precox	..	..	..	..	..	..	..	..	×	..	..	..	..	..
[illegible]														

BARDSLEY, OLDHAM, AND ASHTON-UNDER-LYNE, HORIZONS.—(*Continued.*)

	Great Mine, Ashton-under-Lyne.	Above Stubbs Mine.	Below Stubbs Mine.	Fairbottom Mine.	Foot Coal below. Fairbottom Mine.	Nield Mine or Upper Chamber Mine.	Pomfrey or Lower Chamber Mine.	Blenfire Mine.	Marine Band.	Black Mine.	New Mine.	Old Mine.	Royley or Arley Mine.	Ashton Moss, 400-500 yds.
Discites sp.	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Ostracods	..	..	..	..	×	..	..	..	..	..	..	..	..	..
Estheria sp.	..	..	..	..	..	..	..	..	..	..	..	..	×	..
Cyclus Johnsoni	..	..	..	×	..	..	..	..	..	..	..	..	..	..
Prestwichia rotundata	..	..	..	..	..	..	..	..	..	..	..	..	×	..
Bellinurus bellulus	..	..	..	..	..	..	..	..	..	..	..	..	×	..
Eoscorpius sparthinsis	..	..	..	..	..	..	..	..	..	..	..	..	×	..
Pygocephalus Cooperi	..	..	..	..	..	..	..	..	..	×	..	..	..	..
Xylobius sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Euphoberia	..	..	..	..	..	..	..	..	..	..	..	..	×	..
Neuropterus insect	..	..	..	..	..	..	..	..	..	..	..	..	×	..
Diplodus gibbosus	..	..	×	..	..	×	..	..	..	..	..	×	..	×

Diplodus tenuis	..	..	..	..	..	..	..	..	..	..	..	..	..	×
,, *sp.*	..	×	..	..	..	..	..	..	..	..	..	..	..	..
Pleuracanthus lævissimus	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,, *erectus*	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,, *denticulatus*	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,, *sp.*	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Ctenoptychius apicalis	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Callopristodus pectinatus	..	..	..	..	..	..	..	..	..	..	..	×	..	×
Pleuroplax (*olim Pleurodus*) Rankinei	..	..	..	..	×	..	..	..	..	..	..	..	..	×
,, (,,) Attheyi	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Sphenacanthus hybodoides	..	..	..	..	..	..	×	..	..	..	..	..	..	..
,, sp.	..	..	..	..	..	..	..	..	..	..	..	..	×	×
Stemmatodus	..	..	..	..	..	..	..	..	..	..	..	..	×	..
Acanthodes Wardi	..	..	..	..	..	..	..	..	..	..	..	..	..	×
,, sp.	..	..	..	..	..	..	..	..	×	..	..	..	..	..
Hoplonchus elegans	..	..	..	..	..	..	..	..	..	..	..	..	×	..
Gyracanthus formosus	..	×	..	..	..	..	..	..	..	..	..	..	..	×

	Great Mine, Ashton-under-Lyne.	Above Stubbs Mine.	Below Stubbs Mine.	Fairbottom Mine.	Foot Coal below Fairbottom Mine.	Nield Mine or Upper Chamber Mine.	Pomfrey or Lower Chamber Mine.	Blenfire Mine.	Marine Band.	Black Mine.	New Mine.	Old Mine.	Royley or Arley Mine.	Ashton Moss, 400-500 yds.
Ctenodus cristatus	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Sagenodus inæqualis	..	..	..	..	..	×	..	..	..	..	..	..	..	..
Megalichthys Hibberti	..	..	×	..	..	..	..	..	×	..	..	..	..	×
,, pygmæus	..	..	×	..	..	..	..	..	..	..	..	..	..	×
Strepsodus sauroides	..	..	×	×	..	×	..	..	..	..	..	..	×	×
,, sulcidens	..	.	..	..	..	×	..	..	..	..	..	..	..	..
Rhizodontoid vertebræ	..	..	..	..	..	..	×	..	..	..	..	..	×	×
Coelacanthus elegans	..	..	..	..	..	×	..	×	..	..	..	×	..	×
Rhadinichthys Wardi	..	..	..	..	..	..	..	..	..	..	..	..	..	×
Coprolites	..	×	..	..	..	..	..	..	..	..	..	..	..	..
Archegosaurus	..	..	..	..	..	..	..	..	..	..	..	..	..	..

BARDSLEY, OLDHAM, AND ASHTON-UNDER-LYNE

In this district the shales above and below t Mine and the Black Mine have proved especiall mollusca, whilst the Two-Feet Mine of Bardsley productive in fish remains. Fossils from over seams are scanty. The most striking feature is the Band," discovered by Professor Green during the the Geological Survey, and located by Professo over the Great Mine. The fossils obtained from th in the River Tame near the bend, west of Dunkirk received special attention from the Survey Palæ Mr. J. W. Salter, who described three new sp indicated the existence of several more. At a l the same band was cut through in the Ashton Mos and a fine series of specimens obtained from th waste heap by Mr. Robert Cairns, who afterwards g presented them to the Manchester Museum College.

Mr. Salter regarded the fauna of this horizon as c to that of the Lower Coal Measures of Shropshi markedly different from the Lower Coal Me Lancashire. This can now hardly be said to be the observations of the writer have shown that t Band has yielded several species of fossils charac the Lancashire Lower Coal Measures. The most example is that of a new species of Listracanthus other known species of which occurs in the L Lower Coal Measure series. We believe that the the Marine Band most closely approximates to th Bullion and Mountain Four Feet Mines, and differences are those naturally due to a later develo

By the industry of Messrs. Cairns, Moss and fine series of specimens were obtained from the s of the Ashton Moss Pit, when sinking operations were proceeding between the 400 and 500 yard levels. These are tabulated in a special column, as it is impossible to fix their horizon with accuracy.

Range in Time.

Whilst in the case of the Lower Coal Measures, the mollusca were the dominant forms, both in numbers and species, the Middle series show an even more pronounced development of fishes.

The highest division of animal life represented is the amphibia. The late Mr. George Wild collected rib fragments and vertebræ, of a distinctly amphibian character, from the Thin Bed of Fulledge, the Bastard Cannel of Cliviger, and the Two Feet Mine of Bardsley.

Taking the coalfield as a whole, it may be said that fish remains are equally abundant from the Arley Mine to the Worsley and Pendleton four-feet mines.

This does not seem to be the case in the various districts.

In the Burnley district, fish remains are mainly confined to the lower seams and are very scanty above the Californian or Thin Bed.

Fish remains in the Oldham district are fairly generally distributed, no seam showing such a preponderance as is seen in the case of the Arley and Thin seams at Burnley.

In the Wigan and Bolton districts, fish remains are mainly restricted to the Cannel, and the Pendleton and Worsley four-feet mines.

Cephalopoda and Brachiopoda are entirely restricted to the Marine Band.

The Bolton and Oldham districts are alike in the occurrence of rare forms of Crustacea and Myriopoda.

Ostracods occur in the measures of each district.

The mollusca occur on the whole but sporadically until the higher seams are reached. This is noticeable in each district.

List of Fossils Found in the Lower and Middle Coal Measures.

The accompanying list includes all the genera and species from the Lower and Middle Coal Measures which are known to the writer.

It will be seen that the list comprises about 75 genera and 137 species. Of these 42 genera and 73 species occur in the Lower series, and 60 genera and 106 species in the Middle, whilst no less than 28 genera and 36 species are common to the two, or in other words, 28 genera and 36 species pass up from the Lower into the Middle Coal Measures. As stated elsewhere, the fish fauna dominate the Middle series, and inasmuch as this development is shown in the roof of the Arley Mine, the lowest seam and the base of the series, it follows that the latter constitutes, not only an account of its constant character over the whole coalfield, but also on account of its palæontological features, a good line of demarcation between the Lower and Middle Coal Measures. The question of where the Upper limit of the Middle Measures must be drawn cannot be dealt with until we are able to tabulate the fossils of the Upper Series.

At present, the Upper limit is recognised as the Worsley four-feet, but a tendency has been shown latterly by palæobotanists to split up the Upper series, putting the lower portion with the Middle Measures, and adding the upper portion to the Permian.

The writer hopes in a subsequent paper to consider the question more fully, and to also complete this Palæontological survey of the Lancashire Coal Measures. In conclusion, we would gladly record the help and courtesy received during the preparation of this paper from the Honorary Secretary of the Society, Mr. William Saint, both in the supply of volumes of the transactions and in other ways. Finally, a word must be said of the splendid services rendered to Geological Science by the late Mr. George Wild, who brought together the largest and best located collection of coal fossils ever collected.

Without the opportunity of working over that collection, this paper could not have been written, and the writer would also add his testimony to the singular unselfishness and kindly character Mr. Wild always displayed in rendering help or supplying information.

Fossils of the Lower and Middle Coal Measures.

Vermes.

Arenicola carbonaria, (*Binney*)
Spirorbis pusillus, (*Martin*)

Brachiopoda.

Discina orbicularis, (*Bolton*)
Lingula mytiloides, (*Sow.*) or L. Credneri, (*Geinitz*)
Lingula sp.

Pelecypoda.

Aviculopecten papyraceus, (*Sow.*)
,, fibrillosus, (*Salter*)
,, Cairnsii, (*Bolton*)
Posidoniella lævis, (*Brown*)
,, minor, (*Brown*)
,, subquadrata, (*Hind*)
,, lævigata
Avicula tenua, (*Brown*)
Modiola
Naiadites (olim Anthracoptera) modiolaris, (*Sow.*)
,, ,, quadrata, (*Sow.*)
,, ,, Browniana, (*Salter*)
,, ,, triangularis, (*Sow.*)
,, ,, carinata, (*Sow.*)
,, ,, elongata, (*Hind*)
,, ,, crassa, (*Fleming*)
Chænocardiola Footi.
Ctenodonta sp.
Tellinomya robusta, (*Bolton*)
,, n. sp.
Nucula lævirostrum, (*Portlock*)

Fossils of the Lower and Middle Coal Measures.	Lower Coal Measures.	Middle Coal Measures.
Schizodus deltoideus	×	..
,, sp.	..	×
Carbonicola (olim Anthracosia) robusta, (*Sow.*)	×	×
,, ,, acuta, (*Sow.*)	×	×
,, ,, ,, var. ovalis, (***Martin***)	×	×
,, ,, ,, ,, rhomboidalis, (***Hind***)	×	×
,, ,, rugosa, (***Brown***)	×	×
,, ,, nucularis, (***Hind***)	×	×
,, ,, aquilina, (***Sow.***)	×	×
,, ,, obtusa, (***Hind***)	..	×
,, ,, subconstricta, (***Sow.***)	×	×
,, ,, subrotunda, (***Brown***)	..	×
,, ,, turgida, (***Brown***)	..	×
,, ,, similis, (***Brown***)	..	×
,, ,, angulata, (***de Ryckholt***)	..	×
"Edmondia"	..	×
"Orthonota"	..	×
Solenomya primæva, (***Phillips***)	×	..
Monotis obtusa, (*Brown*)	×	..
Anthracomya Wardi, (***Salter***)	×	×
,, modiolaris, (***Sow.***)	..	×
,, dolabrata, (***Sow.***)	..	×
,, minima, (***Ludwig***)	..	×
,, ,, var. carinata, (***Hind***)	..	×
,, lævis var. Scotica, (***Dawson***)	..	×
GASTEROPODA.		
Serpulites, wavy sp.	..	×
Turitella sp.	..	×
Raphistoma (?) ornata, (***Bolton***)	×	..
Naticopsis globularis, (***Bolton***)	..	×

Fossils of the Lower and Middle Coal Measures.

CEPHALOPODA.

Discites rotifer, (*Salter*) .. ..
,, sp. .. ..
,, sp... .. ..
Nautilus precox, (*Salter*) .. ..
Ephippoceras costatum, (*Foord*). .. ..
,, clitellarium, (*Sow.*) . .. .
Coelonautilus subsulcatus, (*Phillips*). .. ..
,, quadratus, (*Fleming*) .. ..
Pleuronautilus falcatus, (*Sow.*) .. ..
Temnocheilus concavus, (*Sow.*) .. ..
,, carbonarius, (*Foord*) .. ..
Orthoceras teres, (*Sow.*) . .. .
,, cintum, (*de Koninck*) = O. discrepans, (*de Kon*
,, obtusum, (*Brown*) .. ..
,, sp... .. ..
Glyphioceras (olim Goniatites) sp. near truncatum.. ..
,, ,, reticulatum, (*Phillips*).
,, ,, diadema, (*Beyrich*) .. ..
,, ,, paucilobum, (*Phillips*).
Dimorphoceras Gilbertsoni, (*Phillips*). .. ..
Gastrioceras (olim Goniatites) carbonarium, (*Von Buch*)
,, ,, Listeri, (*Martin*) .. ..
,, ,, coronatum, (*Foord & Cric*
Goniatites sp. .. ..

CRUSTACEA.

Beyrichia arcuata, (*Bean*).. .. ..
,, Binneyana, (*Jones*). .. ..
Cytheropsis .. ..
Cypris (?).. .. ..

Fossils of the Lower and Middle Coal Measures.	Lower Coal Measures.	Middle Coal Measures.
Estheria striata, (*Munst.*)	×	×
,, ,, var. Beinertiana, (*Jones*)	×	..
Belinurus bellulus, (*Konig*) (olim Limulus trilobitoides) ..	..	×
Prestwichia rotundata, (*Prestwich*)	×	×
,, Birtwelli, (*Woodward*)	×	..
Architarbus subovalis, (*Woodward*)	×	..
Cyclus Johnsoni	..	×
,, Scotti, (*Woodward*)	×	..
Arthropleura (olim Eurypterus) mammatus, (*Salter*)	..	×
Pygocephalus Cooperi, (*Huxley*)	×	×
Anthrapalæmon Etheridgii, (*Peach*)	×	..
Arachnida.		
Eoscorpius Sparthensis, (*Baldwin*)	..	×
Myriopoda.		
Euphoberia Brownii, (*Woodward*)	..	×
,, ferox, (*Salter*)	..	×
Xylobius sp...	..	×
Insecta.		
Neuropteris insect	..	×
Etoblattina (?)	..	×
Pisces.		
Diplodus gibbosus, (*Binney*)	..	×
,, tenuis, (*A. S. Woodward*)..	..	×
Pleuracanthus lævissimus, (*Agassiz*)	..	×
,, alatus, (*Davis*)	..	×
,, cylindricus, (*Davis*).	..	×
,, undulatus, (*Davis*)	..	×

Fossils of the Lower and Middle Coal Measures.

Pleuracanthus erectus, (*Davis*) .. ..
,, serratus, (*Davis*) .. ..
,, denticulatus, (*Davis*) .. ..
Ctenoptychius apicalis, (*Agassiz*) .. ..
Callopristodus pectinatus, (*Agassiz*) .. ..
Helodus simplex, (*Agassiz*). .. ..
Pleuroplax (olim Pleurodus) Rankinei, (*Hancock & Att*
,, ,, Attheyi, (*Barkas*).. ..
Psephodus magnus, (*McCoy*) .. ..
Hybodopsis Wardi, (*Barkas*) .. ..
Sphenacanthus hybodoides, (*Egerton*) .. ..
Stemmatodus .. ..
Acanthodes Wardi, (*Egerton*) .. ..
Hoplonchus elegans, (*Davis*) .. ..
Lepracanthus Colei, (*Egerton*) .. ..
Gyracanthus formosus, (*Agassiz*) .. ..
Listracanthus spinatus, (*Bolton*) . .. .
,, n. sp. .. ..
Euctenius unilateralis, (*Barkas*) .. ..
Ctenodus cristatus, (*Agassiz*).. .. ..
Sagenodus inæqualis, (*Owen*) .. ..
Megalichthys Hibberti, (*Agassiz*).. .. ..
,, intermedius, (*A. S. Woodward*). .. ..
,, pygmæus, (*Traquair*) .. ..
Strepsodus sauroides, (*Binney*).. .. ..
,, sulcidens, (*Hancock & Atthey*) .. .. .
Rhizodopsis sauroides, (*Williamson*) .. ..
Coelacanthus elegans, (*Newberry*). .. ..
Rhadinichthys Wardi, (*Traquair*) .. ..
,, Planti, (*Traquair*) .. ..

Fossils of the Lower and Middle Coal Measures.	Lower Coal Measures.	Middle Coal Measures.
Rhadinichthys monensis	×	..
Elonichthys Aitkeni, (*Traquair*)	×	×
,, Egertoni, (*Agassiz*)	×	×
,, striolatus, (*Agassiz*)	..	×
,, semistriatus, (*Traquair*)	×	..
Acrolepis (?)	..	×
Mesolepis scalaris, (*Young*)	..	×
Cheirodus granulosus, (*Traquair*)	..	×
Platysomus parvulus, (*Agassiz*)	..	×
Coprolites	×	×
AMPHIBIA.		
Archegosaurus	..	×

Mr. HARRISON, in moving a vote of thanks to Mr. Bolton, spoke of the Society's obligation to him for the immense pains he had taken in compiling so large and so valuable a record.

Mr. SAINT, who seconded the motion, said the thanks of the Society were specially due to Mr. Bolton for his valuable work. A further instalment dealing with the fossils of the Upper Coal Measures would be read shortly, and when Mr. Bolton had completed his work the Society would have in its Transactions an account of the fauna of the Lancashire coal measures such as no other Society in England possessed in relation to any other coalfield.

The motion was passed with acclamation.

TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL AND MINING SOC

PART XX. VOL. XXVIII. SESSION

The ORDINARY MEETING of the Members w
Tuesday, 9th August, 1904, in the Society
5, John Dalton Street, Manchester.

Colonel G. H. HOLLINGWORTH, F.G.S., Pre
in the Chair.

The following paper on "Practical compariso
tinuous-current and polyphase electrical systems
to British Collieries," by Mr. PHILIP C. POPE
NORMAN D. CAMERON, was read by Mr. POPE :—

PRACTICAL COMPARISONS OF CONTINUOUS-CURRENT AND POLYPHASE ELECTRICAL SYSTEMS AS APPLIED TO BRITISH COLLIERIES.

By Mr. Philip C. Pope and Mr. Norman D. Cameron.

In introducing this paper it is not our object to discuss the suitability of electricity as a means of transmitting power about a colliery. That is a well-worn subject which has already been threshed out many times over, and, on the whole, we believe that the balance of decisions is in favour of the newer power-agent. It is rather our purpose now to elicit such a discussion as will be likely to assist a colliery manager, who has already decided to adopt electrically-driven machinery, in settling which of the two electrical systems he should employ at his own pit. A few years ago we had only one practicable system for use in a mine, viz., continuous-current, but more recently our engineers have brought the three-phase alternating-current system to such a state of perfection that its practical utility can no longer be questioned. It is now incumbent, therefore, on every prospective user of electrical power to seriously consider which of these two systems will meet his requirements most satisfactorily and economically.

That the three-phase system is thoroughly reliable and practically economical is amply demonstrated by the fact that the large power supply companies, who have had the very best of reasons for carefully studying the present problem, have decided without exception to generate three-phase current only. Thus, those of their customers who require a supply of continuous-current can only obtain it by means of a motor generator (that is, an alternating-current motor

driving by direct coupling a continuous-current d
a rotary converter. In either case the cost of
consumed is enhanced, and there are capital
charges to be met. The North-Eastern Ra
Lancashire and Yorkshire Railway, and the vari

ground lines and "tubes" in London are further v
the advances of three-phase working. All these con
installing or have installed for their electrical lin
ting-current generating plant, from which t
current is transmitted to their outlying sub-station
is converted into continuous-current for supply to
rail from which the motor cars or locomotives co
current. The result is a very large gain both
outlay and in efficiency. In addition to the
there are very many large industrial concerns, an
number of collieries which have three-phase
considerable size in successful daily operation.

In considering alternating-current plant, we p
speak only of polyphase, as although single-phase n
traction work have been of late developed with s
siderable degree of success, they can hardly as yet l
have reached a stage when they can be practically
for general work in a pit.

In deciding which system to adopt at a colliery,
consider their relative advantages under three main l
First, which will give the greatest freedom from bre
and consequently the maximum economy in mai
expenses; secondly, which will be most efficient i
mission, distribution, and transformation of energ
thirdly, which is cheapest to install, given equal
material and workmanship in each case.

Let us, then, first consider the question of rel
Starting with the generating plant, we need hardly
the engines or boilers, since these will be practic

same in either case. Steam turbines can be more easily and successfully used in conjunction with alternating-current generators than with continuous-current machines on account of the difficulties of commutating continuous-current at such high speeds as are associated with steam turbines. On the other hand, gas engines are better suited to the driving of continuous-current machines, as these have less exacting requirements in the way of speed regulation. But we will leave turbines and gas-driven plant out of the present discussion, and base our comparisons on the ordinary engine-driven plant. The question of how to drive our electrical generating plant would require a paper to itself.

With the continuous-current dynamo, the parts likely to give most trouble are the brush gear and commutator. This is owing to the difficulty of combining good mechanical construction with efficient electrical insulation of numerous parts. The armature has, moreover, a large number of small coils embedded in the slots of the core. Against this, in the alternating-current machine, the field magnets take the place of the armature as the revolving element, which greatly simplifies the construction. The insulation of the conductors in the revolving field is a simple matter in comparison with a continuous-current armature, not only because the mechanical construction is simpler, but also because the voltage is usually lower, and there is a very slight difference of potential between adjacent turns in the winding. The only part of an alternating-current machine in which the full voltage is on the conductors is the stationary member, and the conductors are much more easily insulated under these circumstances than when they are revolving at a high peripheral velocity, as in a continuous-current armature, and stresses due to centrifugal force must be taken into account. In a comparison of the two types of machine then, the following important points are to be considered:—In the one case we have the conductors which require the r insulation placed in the position where it is most electrically and mechanically protect them, toget commutator, built up of a large number of sepa lated segments, and the brush gear, all of which

causes of breakdowns. In the alternator, on the the conductors carrying current at the full vol plant are placed in the stationary portion of th where insulation troubles are easily overcome and protection presents no difficulty, while the conduc revolving element are at a low voltage and so tected; further, the machine has no commutator brush gear. Of course, a continuous-current required to work with the alternator, but this machine, and usually built for a low voltage, same voltage as is used on the fields of the altern great simplicity of the winding of alternators a that the voltage between adjacent conductors ca but a small fraction of the total E.M.F. of th renders it practicable to build such machines higher generating pressures than are possible tinuous-current. In fact, there are now plenty where alternating-current is generated direct at 1l and over, whilst 650 volts is practically the continuous-current generators. How this is freq advantage will be pointed out later.

Turning now to consider the switchboard in the g station, we find that the continuous-current l instruments have the advantage of being simpler expensive. For instance, true readings of pow taken direct from the ammeter and voltmeter, wh the case with polyphase plant, owing to the fact alternating-current phenomenon known as Pow has to be taken into account when working on loads such as motors. To describe the precise technical significance of the term Power Factor would take too long. We may say, however, that its occurrence is due to the fact that an alternating-current is set up, not by a steady pressure in one direction, but by a series of alternating pressure waves of opposite signs. Accordingly, the current also flows in alternating waves of opposite signs, growing from zero to maximum positive, back again to zero, then down to maximum negative, and back to zero, to recommence the same cycle. The frequency with which these cycles occur in a commercial machine is generally from 25 to 60 times per second. Now if there is no inductive effect in the circuit, or in the generator, the curves of voltage and of current will be coincident, and then the ammeter reading multiplied by the voltmeter reading will give the true power in watts of the circuit. But the effect of induction is to cause the current wave to lag behind the voltage wave, to a more or less extent, and as the curves will not then be coincident, the real power in watts will only be a certain percentage of that indicated by the volt and ammeter readings. It is this percentage that is called the Power Factor, and it varies with the amount and nature of the load; in a colliery plant working under ordinary conditions, it is generally somewhere in the neighbourhood of 80 per cent. Of course, instruments such as Power Factor Indicators and Indicating Watt-meters can be used, which show the true power at a glance, but unfortunately these are rather expensive instruments for the average colliery.

As far as the cables are concerned, there is practically no difference in the two systems, when both are working at the same voltage, except that three cables are required for three-phase and four for two-phase, as against two only for continuous-current transmission, but the total sectional area

of copper is nearly the same in each system f
voltage. The polyphase cables require to be
larger, as, owing to the Power Factor, rather r
must be conveyed for the same power. The surp
form what is known as wattless current.

It is, however, in the motors that we find t
difference, the polyphase motor with its very sim
and total absence of commutator, and consequen
spark, being much more free from breakdowns.
motors are of two kinds, those with wound roto
rings, and those with short-circuited or squirrel-
Perhaps it would be as well to explain to the
that the revolving element, or rotor, of a polyph
in no way connected with the external circuit.
ary element, or stator, is the only part in conn
the mains from the generating plant. Alternati
being supplied to the windings on the stat
currents in the windings on the rotor, wh
close proximity, but there is no actual contact or
between the two. An important fact consequent o
an accidental "earth" upon the secondary or ro
will not injure the primary nor affect the insula
ance of the rest of the plant. The action that
between the two windings is identically the sa
which occurs between the primary and seconda
of an alternating-current transformer; in fact,
motor is nothing more or less than a transfor
rotatable secondary. In the slip-ring motor, the
rotor windings—this motor has wound and insu
coils, as opposed to the short-circuited rotor wind
squirrel-cage motor—are brought out on to ring
from the machine and from each other, and
the shaft of the motor. These rings in turn are
by means of collecting brushes to an external

the amount of resistance to be inserted in the path of the current being varied by a starting switch much in the same way as in the case of the continuous-current motor, except that the voltage to be dealt with is not so high as that supplied to the machine. These slip-rings are of course solid and not divided up into sections like a commutator, there is therefore no liability of sparking at the collector brushes. When current at full voltage is switched on to the stator winding, induced currents are set up in the windings of the rotor, but are checked as to volume and pressure by the starting resistance. This resistance is cut out gradually, as the motor speeds up, by the starting switch, till eventually the rings are short-circuited when the motor is running at full speed, and capable of doing its full amount of work. As a matter of fact, the slip-ring motor operates in a manner as nearly as possible identical with the continuous-current shunt-wound motor, having constant voltage on the field, and regulation by inserting the resistance in the armature circuit; the curves of the two motors might, moreover, be almost mistaken for each other. Slip-ring motors are largely used for driving machinery where variable speed is required, or which must be started smoothly and gradually under full load without drawing an excessive amount of current from the mains.

Two types of the short-circuited or squirrel-cage motor are built; the constant speed and the variable speed. Both are similar in construction and winding, and the rotors have no slip-rings or external connections of any kind. The stator windings of the slip-ring and squirrel-cage motors are the same, but the rotor of the latter is simpler. Both types of rotor consist of sheet-steel punchings built up side by side on the shaft, and having partially closed slots running parallel to the shaft and close to the periphery. In these slots (in the case of the squirrel-cage motor) are placed bars, lightly insulated from the punchings, but all bolted and so electrically connected to solid copper rings at each end of the laminated core. There is no suspicion of delicacy in the construction of the revolving part of this type of machine, as is necessarily the case in the continuous-current armature, and the liability to break down is reduced to a minimum. Even should the machine be so overloaded as to damage the insulation on the bars of the rotor, it would not very materially affect the performance of the motor, as the voltage is so low (only one or two volts) that the leakage through contact with the core discs is inappreciable.

The variable-speed short-circuited motor differs only from the constant-speed in that the end rings, instead of being solid copper rings, are so formed as to interpose resistance between the adjacent bars of the rotor winding. These motors are not generally suitable for continuous working, but are, on the other hand, well adapted for such work as cranes, hoists, main haulages, &c.

We can now turn to continuous-current motors. Though, as has already been pointed out, alternating motors have certain advantages in construction and reliability from the practical working point of view, continuous-current motors have also their good points, which at first sight and taken alone make them appear more suitable for many purposes than alternating-current motors. These features, which include power to develop high starting torque with low initial current, and facility for economical variations of speed, must be carefully considered alongside the greater reliabilty and flexibility of the alternating-current system generally before a decision is made.

Continuous-current motors are divided under three heads according to the method of winding adopted, namely, shunt, series, and compound. The shunt motor has characteristics very similar to the slip-ring polyphase machine, but has the additional advantage that the speed can be increased when required above the normal without appreciable loss of efficiency by inserting resistance in the field circuits, and so weakening the field. The series motor is more economical than any other type in giving high starting torque with reasonable current; it is, however, liable to run away on light loads. It is almost universally adopted for electric traction on account of its enormous power of acceleration, and its principal utility at a pit is for the driving of coal-cutters and winding engines. The compound-wound motor, which combines in some measure the good regulation of the shunt with the starting torque of the series machine, is probably and best adapted for all round work in collieries. It is largely used for driving pumps, for endless rope haulages, and, where friction clutches are not used on the rope drums, for main and tail rope haulage also. The *only* structural advantage which can be claimed for the continuous-current motor is that it has a larger air gap between the rotating and stationary members.

With reference to starting switches, the advantage lies with alternating-current as regards simplicity and cost of maintenance. Squirrel-cage motor starters have the advantage of being less liable to damage by disturbances on the line, as after starting up, the windings are completely cut out of circuit; with continuous-current starters the resistance coils are short-circuited, but not absolutely cut out as a rule.

With reference to lighting, which of course is practically confined to pit bottoms and the surface, with continuous-current 500 volts is employed, as for motors, but with alternating-current, transformers may be installed and as low a voltage used as is permitted by consideration of the distance between the lamps. A noticeable point is that earthing of an alternating-current lighting wire, with transformers in circuit, does not affect the whole system, there being no metallic connection between the secondary, which supplies the la primary coils of the transformer. Of course, tl the case of continuous-current can be reduc transformers, but these are generally undesira and require considerable attention. Static tra

the other hand, require very little attention, an rule, immersed in oil, are impervious to damp about an earth occurring on the lighting wi affecting the rest of the system, is a most impo all will agree that it is far more difficult to lighting circuits from faults than the power account of the number and smallness of th fittings employed on the former class of work.

We now come to consider our second and that is, relative efficiencies and capital costs.

On the point of efficiency, given equal genera on the two systems there is very little difference when the distance, over which it is necessary to power, is such as to make it commercially pract high tension that the efficiency of the three-pha clearly demonstrated.

To shew this more distinctly and at the sa exemplify the saving in cost of cables on a scheme let us imagine a case. We will suppose to transmit power down a shaft and undergr distance of 2,000 yards to a group of small moto ing 100 brake horse power. Take the volt continuous-current generator as 500 and that o nating current plant as 3,000. The efficiency of may be taken as the same for either system, viz. the alternating-current case it will be necessary bank of transformers at the end of the power lin the voltage, as we are dealing with small m efficency of these transformers will be about load. Power factor also must be taken into account when calculating the size of the alternating-current cables and this we may take as 91% on full load. In the alternating-current plant we will take our cables as having a current density of 1,000 amps. per square inch. In the continuous-current system we will take two sizes of cables, one having a current density of 750 amps. per square inch and the other 1,000 amps. per square inch.

In the alternating-current case our drop in voltage on the cables will be 120 volts or 4%, and we shall have to send out 125 E.H.P. from the generator switchboard to obtain 100 B.H.P. from the motors, or an over-all efficiency of 80%.

In the continuous-current case, using the larger cable, the drop in voltage will be 75 volts or 15%, and the power distributed from the generator switchboard 136½ E.H.P., or an over-all efficiency of 73%. If, however, we use cables at the same current density as in the polyphase case, the drop in voltage is 100 volts or 20%, and the power drawn from the generator switchboard 146 E.H.P., or an over-all efficiency of 68½%.

The cost of cables and transformers in the polyphase instance is £400; in the first continuous-current case £950, and in the second £750.

Speaking generally on the question of the comparative capital cost of the two systems, given equal voltage in each case, the alternating-current electrical plant usually costs from 8% to 10% less than the continuous-current, but where the distance necessary to transmit power is considerable, and high tension polyphase current can be used, the difference is even more markedly in favour of the latter on account of the saving in cables.

A case which came before the author's attention for estimating purposes lately well illustrates this. It was as follows:—

A power-house was to be placed on the p taining two 500 kilowatt steam-driven gen Ten motors, aggregating 200 B.H.P., were the surface for screening, etc. Cables were down the shaft 500 yards in depth to a distri at the pit bottom, and nine power circuits run drive three 100 B.H.P. pumps, each 1,400 y one 140 B.H.P. pump 1,800 yards in-bye, th plants of 75 B.H.P. each, all of which were a 300 yards from the pit bottom, one haulage of situated 400 yards in-bye and power cables run in-bye having sufficient capacity for driving s cutters. In addition to this about 35 H.P. was lighting. We made up two different estimates above requirements; one for a continuous-cu generating at 500 volts and the other for a three generating at 3,000 volts and using transform down the pressure for lighting and for the s on the surface, also a bank of transformers yards in-bye to reduce the voltage for the coal- the boilers, steam piping, engines, haulage g and coal-cutters cost the same in each insta purpose of this paper we simply give the comp of the purely electrical plant. This in both ca of generators, switchboards, cables, starting de lighting and wiring, together with labour for same, but in the polyphase estimate the cost of th exciters and transformers was also included. estimates worked out roughly at £12,000 for the current plant, as against £8,400 for that on the current system.

It would be all too easy a matter to prolong th on these lines for several hours and go more fully but one cannot in a paper of this nature touch o the leading points of comparison between the two systems. The authors will be more than gratified if they have been able to throw any light on a problem, the knowledge of which has hitherto been mostly confined to electrical engineers; it would also be interesting if any member would, in the discussion, bring forward any points of comparison which have not been touched upon in this paper.

The President said he had been much interested and instructed by Messrs. Pope and Cameron's paper, and no doubt the members would appreciate the points better when they had them in print and could study them at leisure.

Mr. Unsworth moved a vote of thanks to the authors of the paper, and said: We have been much interested, and, no doubt, when we read the paper we shall be able to follow it more closely and see better than now it's great value to everybody connected with matters of electrical haulage and mining operations generally, whether pumping, winding or any other of the multitudinous operations to which electricity is applied every day. We cannot be otherwise than much obliged to Mr. Pope and Mr. Cameron, and I have very great pleasure in moving a vote of thanks to them.

Mr. Alfred J. Tonge having seconded the motion, said he had the pleasure and the responsibility of having both the systems, referred to by Mr. Pope, at work, and he might say that Mr. Pope had treated the points of comparison in a very clear manner. The points he had dealt with were practical ones which every colliery manager must consider before deciding which electrical system to adopt.

The resolution was passed unanimously.

Mr. W. Saint asked if Mr. Pope could give any information as to the best method of insulating cables and of carrying or laying them in shafts and roadways, and also as to the best means of protecting them against break-down in the mine.

Mr. Pope said he had his own views on the subject mentioned by Mr. Saint. He thought that vulcanised bitumen formed the best insulator. It would stand practically any kind of water it could be brought in contact with. He had never heard of one so covered being damaged by water in a pit. He had put a good many in, and never had one break-down. As to protecting the cables that must be controlled by the local conditions. There were so many points to be considered that it was impossible to lay down a hard and fast rule. Where there was liability to falls of roof he advocated a cable armoured with a double steel tape, as it would stand a greater squeezing than any other form of cable, but in the case of a mine where there was a moving floor and the cables had to stand an end strain a double galvanised steel wire armour was much more suitable.

Mr. Tonge said that when he heard Mr. Pope's calculation of the cost of a three-phase current, taken three, four, or five thousand yards underground, it occurred to him that there were not many classes of work in a mine that one would require to use continuous-current at so great a distance in-bye. Having adopted the three-phase system he thought that managers would stick to it and not change to the other, for if there was one advantage worth considering from the manager's standpoint he thought it was this—that there was less risk of sparking in a three-phase motor. But still he thought the transmission scheme did come in when it was a case of converting the current for working compressed-air plant and so driving a coal-cutter a short distance in-bye. In regard to wiring, he thought that bitumen was not always good for the curves and the rough treatment it sometimes met with underground. Anyhow, that was his experience. They felt they could not knock it about as they could a rubber-covered cable. He quite agreed as to the propriety of a steel covering in some cases, but thought such a covering was unnecessary in others. In turning round corners and doing the usual haulage work he had found it possible for the armouring to pass through the rubber, or bitumen, and enter the copper core, and if that happened with both cables—in cases where the two cables were taken separately—then to all intents and purposes both cables were "live" cables. To guard against that danger he advocated the concentric system of wiring. By that means it happened, that if there was a fall of roof of sufficient weight to cause the armour to pass to the inner core, there was a short circuit at once established, whereas under any other system we might have a case of a fall of roof on one cable causing the armour to pierce to the inner core and become a "live" cable. Thus it only needed a fall on the other cable to cause those two to become "live" wires, and that was a danger that had not been taken sufficient note of.

Mr. POPE said he had referred more particularly to armour in connection with the three-phase cables. He would never dream of armouring a single cable, for he thought it was a most dangerous thing to do. He quite agreed with Mr. Tonge that if the armouring on a single core cable was punctured great risk ensued. He only recommended armouring with the two and three-phase systems. The closer together the three wires, for three-phase work, were run the better it would be, because if the three cores were separated any distance apart the drop in voltage due to induction was considerably greater than when the three cores were put together in the form of one cable.

Mr. Joseph Dickinson, asked if Mr. Pope v say what in his opinion would be the proper man in the street to do, supposing one of the e way wires broke.

Mr. Pope replied that it had only once bee see such a break-down as that which Mr. Dicki to. On that occasion he was not quite sure v best thing to do, but what he did was this: He which was dry, in hand and gripped the fallen it on the rail; that caused a dead short circuit out the fuzes in the power house, and speedil danger; but he thought the wisest thing was t of the wire until a competent break-down gang scene.

THE PALÆONTOLOGY OF THE LANCASHIRE COAL MEASURES.

By Mr. H. Bolton, F.R.S.E., The Museum, Bristol.

PART III.

The Upper Coal Measures.

The Upper Coal Measures of Lancashire occupy a limited surface area, to the south of the richer middle series. They occur in small patches in the Wigan area, and in the neighbourhood of Leigh, Worsley and Pendleton on the west of Manchester. The main development is, however, on the east and north of Manchester itself. The basement strata of the series in the Ardwick district contain several seams of coal which were worked over thirty years ago. It is to these productive measures of the upper series that the term "Manchester Coalfield" has been applied.

The uppermost beds of the series were very little known until the construction of the railway line from Fallowfield to Levenshulme and Longsight.

Prior to this, our knowledge of the upper beds was mainly limited to the published papers by Binney and others upon the Collyhurst section, which was opened in 1861 when the British Association visited Manchester.

The sections exposed in the railway cutting from Fallowfield to Levenshulme were worked over in the greatest detail

by Mr. Charles Roeder, and also by Messrs. Br
De Rance.*

To Mr. Roeder we are especially indebt
knowledge of the fauna of these beds.

With unwearied labour he examined and m

section inch by inch, washing the clays and
breaking up the thin limestones which occur
the section. The collection of fossils thus o
forwarded by Mr. Roeder to Messrs. Jones and
others for identification, and the complete list wa
published in the Society's Transactions.

Mr. Roeder's collections were afterwards prese
to the Manchester Museum, Owens College, whe
opportunity and pleasure of working over them.

The fauna of the lower productive measures a
chiefly known to us from the labours of Mr. I
published his results in the Transactions of t
notably in Vol. VI.

Mr. Binney's work suffers from the free use of
statements and the absence of specific determin
fossils.

The character of the Upper Coal Measure dep
in the upper portion very markedly from the
whole Coal Measure series.

The succession of sandstones, shales and coal
regard as the dominant feature of the Coal

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*"Notes on the Upper Coal Measures at Slade Lane, L
Charles Roeder. Trans. Manch. Geol. Soc., Vol. XXI., p. 1

"Further Notes on the Upper Coal Measures at Slade La
by Charles Roeder. Op. cit. p. 199.

"Notes on the Geological section exposed in the Railway
Levenshulme to Fallowfield," Part I., by William Brockbank
Rance, Mem. Proc. Lit. & Phil. Soc., Manchester, Vol. IV., Ser

Ditto. Part II. Op. cit.

"On the Entomostraca and Annelida in the Levenshulme
stones." William Brockbank, op. cit.

replaced by a succession of thin limestones, calcareous clays and shales, and red and green sandstones.

No trace of a coal seam is seen amongst these beds.

Naturally so great a lithological change is accompanied by some change in the character of the fauna.

The change is not, however, of the nature of a replacement, it is rather one of extinction. Very many of the typical examples of the Coal Measure fauna disappear and with the exception of the Ostracoda, and Anthracomya, those which do persist are few in number and difficult to find.

As the uppermost beds of the Upper Coal Measures are destitute of coal seams, only feeble traces of a coal flora are present, and we must therefore rely on the fauna to determine whether these upper beds are most closely related to the Permians above or the productive Coal Measures beneath.

Notwithstanding the sudden change in lithological character, a change which undoubtedly foreshadows the deposits of the overlying Permian, there is, nevertheless, so far as the writer knows, only the slightest approximation in the fauna of the one to that of the other. The fauna of the overlying Permians has been worked out with great thoroughness by Mr. C. Roeder, and the late Prof. Geinitz, and is published in the Society's Transactions, Vol. XX. p. 537.

The fauna of the Permians, at Newton, described and figured by Captain Brown in the first volume of the Society's Transactions shows also the same marked divergence. The fossils of the Upper Coal Measures, sparse though they be, belong undoubtedly to a Coal Measure fauna, and the only striking disparity between them and those of the Middle and Lower series is to be found in the abundance of the ostracods in the former.

Even this disparity is not so great as it appears, for ostracods are abundant over not a few of the thick coals of the Middle series. By reason of their small size they have not attracted the attention they deserve, and we are quite sure that further study in this direction will result in bringing the Middle Coal Measures more nearly into line with the Upper series.

The fauna of the Upper Coal Measures so far as we have been able to trace it, includes the following genera and species.

VERMES.

Spirorbis pusillus.

In beds Nos. 5, 12, 25a, 26 and 28 U.C.M. at Slade Lane, Longsight. (L. 1006, L. 996, and L. 1021, e. coll. Roeder, M.M.)

From U.C.M. at Ardwick, Manchester (M.M.).

As "Spirorbis carbonarius" recorded by Binney from all the limestones in the Upper Coal Measures of Ardwick, Manchester. (Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

See also Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 66.

As "Spirorbis carbonarius" recorded by Salter from thin red and black shales, and calcareous layers at Patricroft. (Salter. Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 44.)

Over the Bradford four-feet seam, in a bed of limestone one foot thick, 18 yards above the coal, and amongst plants and Anthracomya near to the seam. (Gerrard, Trans. Manch. Geol. and Min. Soc., Vol. XXVIII., p. 560.)

Spirorbis helicteres.

In beds Nos. 5 and 28, U.C.M. at Slade Lane, Longsight. (L. 992, e coll. Roeder, M.M.)

Spirorbis sp.

In beds Nos. 6, 26 and 28, U.C.M. at Slade Lane, Longsight. (L. 1012 and L. 1019, e coll. Roeder, M.M.)

Brachiopoda.

None.

Pelecypoda.

Naiadites (*olim Anthracoptera*) *Browniana.*

In limestones, shales and blackband ironstone of the Upper Coal Measures at Ardwick, Manchester. (Binney. Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

From Ardwick, Bradford, &c. (Salter. Geol. Surv. Mem.., Geology of Country around Oldham, p. 67.)

Anthracomya minima var carinata.

From the Upper Coal Measures of Ardwick, Manchester.

Anthracomya Phillipsii.

In red and black shales and calcareous layers at Patricroft. (Salter, Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 44.)

In limestones, shales and blackband ironstones in the Upper Coal Measures at Ardwick, Manchester. (Binney, Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

The blackband ironstone is found with the highest bed of coal at Ardwick, vide Binney. It also contains numerous bones, scales, teeth and rays of fishes.

The type specimen was obtained from the Spirorbis limestone shales of Pendlebury. (Dr. Hind, Pal. Soc., Monog. on Carbonicola, &c., pt. II., p. 121.)

A specimen from the Upper Coal Measures of Ardwick, Manchester, is figured by Dr. Hind, op. cit., 1895, pl. XVI., fig. 10.

See also Etheridge, Geol. Mag. (2), IV. pl. XII., figs. 6 and 7.

It is recorded from over the Yard Mine of Bradford, Manchester, by Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 67.

From over the thick limestone of the Upper Coal Measures at Clayton. (Salter, op. cit., p. 67.)

From above the Bradford four-feet coal. (Gerrard, Trans. Manch. Geol. and Min. Soc., Vol. XXVIII., p. 560).

Anthracomya lævis var Scotica.

From the Spirorbis limestone of Ardwick, Manchester. (Dr. Hind, Pal. Soc., Monog. on Carbonicola, &c., pt. 11., p. 124.)

Anatina-like shell.

From the thick limestone of the Upper Coal Measures at Clayton. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 67.)

Gervillæ and Arcae.

From beds Nos. 28 and 30 in bluish-purple and chocolate-purple calcareous clays at Slade Lane, Longsight. (Roeder, Trans. Manch. Geol. Soc., Vol. XXI., p. 114.)

GASTEROPODA.

None.

CEPHALOPODA.

None.

ARTHROPODA.

Estheria tenella.

In shales above four-feet coal at Bradford, near Manchester. (Salter, quoted by Rupert Jones, Pal. Soc., Monog. Fossil Estheriæ, p. 32.)

From fine grained red argillaceous sandstone in Mr. Jackson's pit at Astley, from 50 yards above the four-foot coal of Worsley and Pendleton. (Rupert Jones, op. cit., p. 32.) Salter also records this species from an ironstone associated with the four-foot coal.

Estheria sp.

From over the Yard Mine at Bradford, Manchester, (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 66.)

Leaia Leidyi var Williamsoniana.

In limestones, shales and blackband ironstone of U. C. M., at Ardwick, Manchester. (Binney, Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

From Ardwick limestone, U. C. M., Ardwick, Manchester. (e. coll. Williamson, M.M.)

See also Phil. Mag., New Series, Vol. IX., 1836, for description of horizon; and Rupert Jones, Pal. Soc. Monog., on Fossil Estheriæ, p. 116.

OSTRACODA.

Leperditia inflata.

In limestones, shales, and blackband ironstone in U.C.M. at Ardwick, Manchester. (Binney. Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

From the Upper Coal Measures of Ardwick, Manchester. (Salter. Geol. Surv. Mem., Geology of Country around Oldham, p. 66.)

From above the Bradford four-feet coal. (Gerrard.)

Cythere or Leperdita.

From over the Yard Mine at Bradford, Manchester. (Salter. Geol. Surv. Mem., Geology of Country around Oldham, p. 66.)

Carbonia Roederiana.

Found in Upper Coal Measures at Slade Lane, Longsight. (Roeder. Trans. Manch. Geol. Soc., Vol. XXI., p. 137.)

Carbonia Salteriana (? Candona Sa

Occurring in association with Carbonia]
10 bed, U.C.M. at Slade Lane, Longsight
cit., p. 137.)

Carbonia pungens.

Occurring in association with Carbonia S
10 bed, U.C.M. at Slade Lane, Longsight.
Roeder, M.M.) See also Roeder, op. cit., p.

Carbonia secans.

Occurring in the Upper Coal Measures a
Longsight. (Roeder, op. cit., p. 137.)

Carbonia fabulina.

Occurring in association with Carbonia bai
5 bed, U.C.M. at Slade Lane, Longsight. (L
Roeder, M.M.) See also Trans. Manch. Ge
XXI., p. 137.)

Carbonia Bairdioides.

Occurring in association with Carbonia fab
bed, U.C.M. at Slade Lane, Longsight. (L.
Roeder, M.M.) Op. cit., p. 137.

Carbonia Rankiniana.

Known to occur, but no record.

Candona (?) Salteriana.

Occurring in the shales of the four-foot coal
Pit, near Manchester. (Rupert Jones. Pal.
Fossil Estheriæ, p. 123.) From Upper Coal
Slade Lane, Longsight. (Roeder. Trans. M
Soc., Vol. XXI., p. 137.)

Bairdia mucronata.

Known to occur, but no record.

ORTHOPTERA.

"*Orthopterus insect remains*" (?.)

Found amongst plant remains in a bed of purple shale lying about 60 feet above the main limestone. (Binney. Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

See also Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 66. The specimen was in Mr. Binney's cabinet.

PISCES.

Diplodus gibbosus.

In limestones, shales, and blackband ironstone of the Upper Coal Measures at Ardwick, Manchester. (Binney. Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

As "Pleuracanthus gibbosus" recorded from over the Yard Mine of the Upper Coal Measures at Manchester by Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 17.

From Ardwick, Manchester. (Salter, op. cit., p. 67.)

From bed No. 25, in the Upper Coal Measures at Slade Lane, Longsight. (L. 1617, e coll. Roeder, M.M.)

Pleuracanthus sp.

In limestones, shales, and blackband ironstone of the Upper Coal Measures at Ardwick, Manchester. (Binney. Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

Oracanthus Milleri.

From the Upper Coal Measures of Ardwick, Manchester. (M.M.)

Oracanthus sp.

In limestones, shales, and blackband ir
Upper Coal Measures at Ardwick, Manche
Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

Ctenacanthus sp. (? *Sphenacant*

In limestones, shales and blackband iro
Upper Coal Measures of Ardwick, Manches
Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

Gyracanthus formosus.

From the Upper Coal Measures of Ardwick

Gyracanthus sp.

In limestones, shales and blackband ironston
Coal Measures at Ardwick, Manchester. (I
Manch. Geol. Soc., Vol. VI., p. 42.)

From Upper Coal Measures of Manches
Geol. Surv. Mem., Geology of Country arc
p. 67.)

Ctenodus Murchisoni

From the Upper Coal Measures of Ardwick
Specimens in the Manchester Museum.

Ctenodus sp.

In limestones, shales and blackband iron
Upper Coal Measures at Ardwick. (Binney, T
Geol. Soc., Vol. VI., p. 42.)

"*Ceratodus sp.*" (? *Ctenodus*).

In limestones, shales and blackband ironstc
Coal Measures of Ardwick, Manchester. (Bi
Manch. Geol. Soc., Vol. VI., p. 42.)

Megalichthys Hibberti.

From the Upper Coal Measures of Ardwick, Manchester. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 67.)

Megalichthys intermedius.

From the Upper Coal Measures of Ardwick, Manchester. (e. coll. Williamson, M.M.)

Megalichthys rugosus.

Above the Bradford four-feet coal. (Gerrard, Trans. Manch. Geol. and Min. Soc., Vol. XXVIII., p. 560.)

Megalichthys sp.

In limestones, shales and blackband ironstone of the Upper Coal Measures of Ardwick, Manchester. (Binney, Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

As "Rhizodus sp." from the thick limestone of the Upper Coal Measures of Ardwick, Manchester. (Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 67.)

From the Upper Coal Measures of Ardwick, Manchester, (Salter, op. cit.)

Megalichthys (?)

As "Rhizodus n. sp." In thin red and black shales and calcareous clays at Patricroft. (Salter. Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 44.)

Rhizodopsis sauroides.

In association with Elonichthys from bed No. 12 of the Upper Coal Measures at Slade Lane, Longsight. (L. 1005, e coll. Roeder, M.M.)

Also from bed No. 12a. Same locality. (L. 1010, e. coll. Roeder, M.M.)

. Above the Bradford four-feet coal. (Ge
Manch. Geol. and Min. Soc., Vol. XXVIII., p

Also from bed No. 25a. Same locality.

As "Rhizodus granulatus" from over the

Bradford, Manchester. (Salter. Geol. Surv.
of Country around Oldham, p. 67.)

Rhizodopsis sp.

In limestones, shales, and blackband iron
Upper Coal Measures at Ardwick, Manchest
Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

Coelacanthus sp.

In limestones, shales, and blackband iron
Upper Coal Measures of Ardwick, Mancheste
Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

Above the Bradford four-feet coal. (Ge
Manch. Geol. and Min. Soc., Vol. XXVIII., p.

Elonichthys Aitkeni.

From above the Bradford four-feet coal
Trans. Manch. Geol. and Min. Soc., Vol. XXV

Elonichthys Egertoni.

As "Palæoniscus Egertoni" recorded from
Measures of Ardwick, Manchester. (Salter.
Mem., Geology of Country around Oldham, p

Elonichthys sp.

In association with teeth of Rhizodopsis, fron
of the Upper Coal Measures at Slade Lane,
(L. 1005, e. coll. Roeder, M.M.)

As "Palæoniscus" recorded by Binney as
shales, limestones, and blackband ironstone o

Coal Measures at Ardwick, Manchester. (Binney. Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

As "Palæoniscus" from over the thick limestone of the Upper Coal Measures at Clayton. (Salter. Geol. Surv. Mem., Geol. of Country around Oldham, p. 67.)

"Palæoniscus scales" (Elonichthys) are also recorded from thin red and black shales and calcareous layers at Patricroft. (Salter. Geol. Surv. Mem., Geology of Country around Bolton-le-Moors, p. 44.

Amblypterus (? Elonichthys.)

From over the thick limestone of the Upper Coal Measures at Clayton. (Salter. Geol. Surv. Mem., Geol. of Country around Oldham, p. 67.)

Platysomus sp.

In limestones, shales and blackband ironstone of the Upper Coal Measures of Ardwick, Manchester. (Binney, Trans. Manch. Geol. Soc., Vol. VI., p. 42.)

See also Salter, Geol. Surv. Mem., Geology of Country around Oldham, p. 67.

Coprolites.

From the Upper Coal Measures of Ardwick, Manchester. (M.M.)

AMPHIBIA.

Labyrinthodon sp.

Recorded by Mr. Charles Roeder, from bed No. 24A, of the Upper Coal Measures of Slade Lane, Longsight. (L. 1009. e. coll. Roeder M.M.)

NOTE.—The specimen is accompanied by a note of Mr. Roeder's, in which he says that according to Dr. A. Smith Woodward, similar equally ossified slender phalanges have been found in the Coal Measures of Kilkenny.

Amphibian remains.

In limestones, shales and blackband ironstone of the Upper Coal Measures of Ardwick, Manchester. (Binney, Trans. Manch. Geol. Soc., Vol. VI., p. 42.

Range of Fossils.

The task of arranging the fossils of the Upper Coal Measures according to the beds in which they occur has already been done in a large measure in the papers by Mr. Charles Roeder and the writings of Mr. Binney.

For the purposes of the present paper, the work of these authors will serve, although in another paper which we hope to publish at some later date on the zones and faunal development of the Lancashire Coal Measures, it will be necessary to subject to a careful review, the range of dominant genera and species, both geographically and in point of time.

One feature which will at once strike the student of the Upper Coal Measures is that the fauna is by no means so scanty as once supposed. Another feature of primary importance is that the fauna is throughout an essentially Coal Measure one. If we except the reference by Mr. Roeder to the occurrence of Arcæ and Gervillæ in beds Nos. 28 and 30 at Slade Lane, Longsight, there is absolutely nothing of a Permian character in the fauna.

The Upper Coal Measure fauna is apparently an impoverished replica of that of the Middle series.

It is not our intention to deal at length with the question of subdivision of the Upper Coal Measures on the lines recently laid down by palæobotanists. This can well be left until the whole fauna is considered in its horizon and zonal aspects. One point, however, may be suggested as worthy of consideration before subdivision is attempted and this is, the question whether the flora or the fauna ought to be taken as the true index to the sequence of Coal Measure development. We are inclined to think that the fauna will furnish the most satisfactory and rational standard for several reasons. Chief of these is the fact that the faunal development is closely connected with and cannot readily be separated from the sequence of deposition. The vast bulk of deposits in the Coal Measures are of marine, lagunal or estuarine origin, the coal seams representing interludes of varying length in point of time, but being in themselves neither regular or naturally successively progressive. The fauna would we know, rapidly respond to changes of conditions, or of deposition, flourishing when conditions were favourable and migrating or being starved and attenuated when the conditions were unfavourable. In either case, the continuity of life and development would not be easily destroyed, and we should be more likely to find in the case of the fauna, and the deposits in which they occur, a well ordered continuity and developmental sequence, than in the case of the coal forests, which were intermittent in character, more inert to outside influences, and more dominated by local and special conditions.

That there was every likelihood of a progressive botanical development is very likely, but the relation of the coal plants as a whole to the Coal Measure series of deposits seems to us a minor one as contrasted to that of the fauna which was at once more sustained, more widespread and altogether more readily responsive to change.

If we briefly pass in review the fauna of the Upper Coal Measures we shall note how fully, as we have previously mentioned, it is associated with that of the Middle series.

The division Vermes is represented by one species which has come up from the Middle Coal Measures and by one species which is new.

Brachiopoda, Gasteropoda and Cephalopoda are not represented at all. In the case of the first two they are weak throughout the Coal Measures, and the Cephalopoda owe their inclusion in the Middle series entirely to their occurrence in the local and well-known "Marine Band" at Dunkinfield.

The Pelecypoda of the Middle series mainly belong to the three genera Naiadites, Carbonicola and Anthracomya, and two of these genera are represented in the Upper Coal Measures.

The Ostracoda and their allies which are so constant a feature of the uppermost beds of shale and limestone at Slade Lane, Longsight, are closely connected with the genera of Ostracods found in the Middle series, and they also occur in these beds in association with Spirorbis pusillus which is as typical of the Middle series.

Fishes which were pre-eminent during the period of the Middle Coal Measures, are represented by nine genera and ten species, seven of the latter being most typical Middle Measure forms. Most of these fish remains range on the authority of Salter and Binney into the shales and limestones which lie above the coal seams in the Upper series.

As an appendix to this paper, we have added a list of all the authentic fossils we know of found in the Lancashire Coal Measures.

Fossils of the Lower, Middle and Upper Coal Measures.	Measures. Lower.	Middle.	Upper.
Vermes.			
Serpulites wavy sp.	..	×	..
Spirorbis pusillus (*Martin*)	×	×	×
,, helicteres (*Salter*)	..	..	×
,, sp.	..	..	×
Arenicola carbonaria (*Binney*)	×	..	..
Brachiopoda.			
Lingula mytiloides (*Sow.*) or L. Credueri (*Geinitz*)	×	..	..
,, sp.	..	×	..
Discina orbicularis (*Bolton*)	×	×	..
Pelecypoda.			
"Orthonota"	..	×	..
Solenomya primæva (*Phillips*)	×	..	..
"Edmondia"	..	×	..
Tellinomya robusta (*Bolton*)	..	×	..
,, n. sp.	..	×	..
Nucula lævirostrum (*Portlock*)	..	×	..
Avicula tenua (*Brown*)	..	×	..
Monotis obtusa (*Brown*)	×	..	..
Posidoniella lævis (*Brown*)	×	..	..
,, minor (*Brown*)	×	..	..
,, subquadrata (*Hind*)	×	..	..
,, lævigata	×	..	..
Naiadites (olim Anthracoptera) modiolaris (*Sow.*)	×	×	..
,, ,, quadrata (*Sow.*)	×	×	..
,, ,, Browniana (*Salter*)	..	×	×
,, ,, triangularis (*Sow.*)	..	×	..
,, ,, carinata (*Sow.*)	..	×	..
,, ,, elongata (*Hind*)	..	×	..
,, ,, crassa (*Fleming*)	..	×	..
Carbonicola (olim Anthracosia) robusta (*Sow.*)	×	×	..
,, ,, acuta (*Sow.*)	×	×	..

Fossils of the Lower, Middle and Upper Coal Measures.	Measures. Lower.	Middle.	Upper.
Carbonicola (olim Anthracosia) acuta var ovalis (*Martin*) ..	×	×	..
„ „ acuta var rhomboidalis (*Hind*)	×	×	..
„ „ rugosa (*Brown*)	×	×	..
„ „ nucularis (*Hind*)	×	×	..
„ „ aquillina (*Sow.*)	×	×	..
„ „ obtusa (*Hind*)	..	×	..
„ „ subconstricta (*Sow.*)	×	×	..
„ „ subrotunda (*Brown*) ..	..	×	..
„ „ similis (*Brown*)	..	×	..
„ „ anguluta (*de Ryckholt*) ..	..	×	..
Anthracomya Wardi (*Salter*)	×	×	..
„ modiolaris (*Sow.*)	..	×	..
„ dolabrata (*Sow.*)	..	×	..
„ minima (*Ludwig*)	..	×	..
„ „ var carinata (*Hind*)	..	×	×
„ lævis var Scotica (*Dawson*)	..	×	×
„ Phillipsii (*Williamson*)	..	..	×
„ sp.	..	..	×
Schizodus deltoideus (*Phillips*)	×	..	..
„ sp.	..	×	..
Aviculopecten papyraceus (*Sow.*)	×	×	..
„ fibrillosus (*Salter*)	..	×	..
„ Cairnsii (*Bolton*)	..	×	..
Modiola	..	×	..
Gasteropoda.			
Raphistoma (?) ornata (*Bolton*)	×	..	..
Naticopsis globularis ((*Bolton*)	×	..	..
Turritella sp.	..	×	..
Pulmoniferons Spiroglyphus	..	×	..

Fossils of the Lower, Middle and Upper Coal Measures.	Measures. Lower.	Middle.	Upper.
Cephalopoda.			
Orthoceras teres (*Sow.*)	×	..	..
,, cinctum (*de Koninck*) or O. discrepans (deKon.)	×	..	..
,, obtusum (*Brown*)..	×	..	..
,, sp.	×	×	..
Ephippoceras costatum (*Foord*)	×	..	..
,, clitellarim (*Sow.*)..	×	..	..
Coelonautilus subsulcatus (*Phillips*)	×	..	..
,, quadratus (*Fleming*)	×	..	..
Discites rotifer (*Salter*)	..	×	..
,, sp.	..	×	..
,, sp.	..	×	..
Temnochilus concavus (*Sow*)	×	..	..
,, carbonarius (*Foord*)	×	..	..
Pleuronautilus falcatus (*Sow*)	×	..	..
Nautilus precox (*Salter*)..	..	×	..
Glyphioceras (olim Goniatites) truncatum	×	..	..
,, ,, reticulatum (*Phillips*)....	×	..	..
,, ,, diadema (*Beyrich*)	×	..	..
,, ,, paucilobum (*Phillips*)....	×	..	..
Gastrioceras (olim Goniatites) carbonarium (*Von Buch*)..	×	..	..
,, ,, Listeri (*Martin*)	×	..	..
,, ,, coronatum (*Foord & Crick*)	×	..	..
Dimorphoceras (olim Goniatites) Gilbertsoni (*Phillips*) ..	×	..	..
Goniatites sp.	×	×	..
Arthiopoda.			
Estheria tenella (*Jordan*)	..	..	×
,, striata (*Munst.*)	×	×	..
,, ,, var Beinertiana (*Jones*)..	×	×	..
Leaia Leidyi var. Williamsoni (*Jones*)	..	...	×

Fossils of the Lower, Middle and Upper Coal Measures.	Measures. Lower.	Middle.	Upper.
Ostracoda.			
Beyrichia arcuata (*Bean*)	×	×	..
,, Binneyana (*Jones*)	..	×	..
Cytheropsis	×	×	..
Leperditia inflata (*Munst*)	..	..	×
Carbonia Salteriana (? Candona Salteriana)	..	..	×
,, Rankiniana (*Jones and Kirkby*)	..	..	×
,, Bairdiodes (*Jones and Kirkby*)	..	..	×
,, secans (*Jones and Kirkby*)	..	..	×
,, pungens (*Jones and Kirkby*)	..	..	×
,, fabulina (*Jones and Kirkby*)	..	..	×
,, Roederiana (*Jones*)	..	..	×
Cypris (?)	..	×	..
Candona (?) Salteriana (*Jones*)	..	..	×
Bairdia mucronata (*Reus*)	..	..	×
Arthropoda	..	..	..
Anthrapalæmon Etheridge (*Peach*)	×	..	..
Pygocephalus Cooperi (*Huxley*)	×	×	..
Arthropleura (olim Eurypterus) mammatus (*Salter*)	..	×	..
Cyclus Johnsoni	..	×	..
,, Scotti (*Woodward*)	×	..	..
Prestwichia rotundata (*Prestwich*)	×	×	..
,, Birtwelli, *Woodward*	×	..	..
Belinurus bellulus (*Konig*) olim Limulus limuloides	..	×	..
Eoscorpius Sparthensis (*Baldwin*)	..	×	..
Eoscorpius sp.	..	..	×
Myriopoda	..	..	..
Euphoberia Browni (*Woodward*)	..	×	..
,, ferox (*Salter*)	..	×	..
Xylobius sp.	..	×	..
Orthoptera.			
"Orthopterus insect remains" (?)	..	..	×

Fossils of the Lower, Middle and Upper Coal Measures.	Measures.		
	Lower.	Middle.	Upper.
Insecta.			
Neuropteris	..	×	..
Etoblattina	..	×	..
Pisces.			
Diplodus gibbosus (*Binney*)	..	×	×
,, tenuis (*A. S. Woodward*)	..	×	..
Pleuracanthus lævissimus, *Agassiz*	..	×	..
,, alatus, *Davis*	..	×	..
,, cylindricus, *Davis*	..	×	..
,, undulatus (*Davis*)	..	×	..
,, erectus (*Davis*)	..	×	..
,, serratus (*Davis*)	..	×	..
,, denticulatus (*Davis*)	..	×	..
,, sp.	..	..	×
Oracanthus Milleri, *Agassiz*	..	..	×
,, sp.	..	..	×
Ctenoptychius apicalis, *Agassiz*	..	×	..
Callopristodus pectinatus (*Agassiz*)	..	×	..
Helodus simplex (*Agassiz*)	..	×	..
Pleuroplax (olim Pleurodus) Rankinei (*Hancock & Atthey*)	×	×	..
,, ,, Attheyi (*Barkas*)	..	×	..
Psephodus magnus (*McCoy*)	..	×	..
Hybodopsis Wardi (*Barkas*)	×	..	..
Sphenacanthus hybodoides (*Egerton*)	×	×	..
Stemmatodus	..	×	..
Acanthodes Wardi (*Egerton*)	×	×	..
Hoplonchus elegans (*Davis*)	..	×	..
Lepracanthus Colei (*Egerton*)	×	×	..
Gyracanthus formosus (*Agassiz*)	×	×	×
Listracanthus spinatus (*Bolton*)	×	..	..
,, n. sp.	..	×	..

Fossils of the Lower, Middle and Upper Coal Measures.	Measures. Lower.	Middle.	Upper.
Euctenuis unilateralis (*Barkas*)	..	×	..
Ctenodus cristatus (*Agassiz*)	..	×	..
,, Murchisoni (*Agassiz*)	..	..	×
Sagenodus inæqualis (*Owen*)	..	×	..
Megalichthys Hibberti (*Agassiz*)	×	×	×
,, intermedius (*A. S. Woodward*)	..	×	×
,, pygmæus (*Traquair*)	×	×	..
,, rugosus (*Young*)	..	..	×
Strepsodus sauroides (*Williamson*)	×	×	×
,, sulcidens (*Hancock and Atthey*)	..	×	..
Rhizodopsis sauroides (*Williamson*)	×	×	×
Coelacanthus elegans (*Newberry*)	×	×	×
Rhadinichthys Wardi (*Traquair*)	..	×	..
,, Planti (*Traquair*)	×	×	..
,, monensis (*Egerton*)	×	..	..
Elonichthys Aitkeni (*Traquair*)	×	×	×
,, Egertoni (*Agassiz*)	×	×	..
,, striolatus (*Agassiz*)	..	×	..
,, semistriatus (*Traquair*)	×	..	..
Elonichthys sp.	..	..	×
Acrolepis (?)	..	×	..
Mesolepsis scalaris (*Young*)	..	×	..
Cheirodus granulosus (*Traquair*)	..	×	..
Platysomus parvulus (*Agassiz*)	..	×	×
Coprolites	×	×	×
Amphibia.			
Archegosaurus	..	×	..
Labyrinthodon (?)	..	..	×
Reptilian remains	..	..	×
Hylonomus Wildii (*Smith Woodward*)	×	..	..

This concluded the business of the Ordinary Meeting.

SPECIAL MEETING.

NEW RULES AND BYE-LAWS.

A Special Meeting was then held, in accordance with the notice issued on 15th July, for the purpose of voting on the proposed New Rules and Bye-laws to be submitted for adoption in place of the regulations hitherto in force.

The President said the rules had been very carefully considered. A large amount of time and discussion had been spent upon them, and since the copies had been sent out to the members one or two amendments had been suggested to the Council and approved by them.

The proposed rules were read by Mr. W. Saint as follows:—

MANCHESTER GEOLOGICAL & MINING SOCIETY.

Established 15th October, 1838.

OBJECTS.

The objects of the Manchester Geological and Mining Society *are the collection and diffusion of Practical and Theoretical Knowledge respecting Geology and Mining. In furtherance of such objects original Papers on Geology and Mining subjects, including Engineering generally—either written by the members of the Society, or communicated to the Society through a member, on behalf of the authors—shall be read and discussed at its meetings, and if judged to be of sufficient interest, shall be printed at the expense of the Society, in its Transactions.*

RULES.

I.—The membership of the Society shall consist of Members, Associate Members, Honorary Members, Associates and Students.

The following shall be entitled to federate with
tion of Mining Engineers:—

(*a*.) Each Member shall be more than twent
of age, have been regularly educated
metallurgical, or mechanical engineer, or
branch of engineering according to the
of pupilage, and have had subsequent em
at least two years in some responsible sit
engineer; or if he has not undergo
routine of pupilage he must have been
have practised as an engineer for at le

(*b*.) Each Associate Member shall be a pers
with or interested in mining, metallurgy
ing, and not practising as a mining,
or mechanical engineer, or some othe
engineering.

(*c*.) Each Honorary Member shall be a per
distinguished himself by his literary
attainments, or who may have made im
munications to any of the Federated Insti

(*d*.) Each Associate shall be a person acting
viewer, undermanager, or in other subord
in a mine or a metallurgical works, or en
analogous position in some other branch of

(*e*.) Each Student shall be a person who
himself for the profession of mining, met
mechanical engineering, or other branch of
and such person may continue a Stud
attains the age of twenty-five years.

II.—Every candidate for admission into the Soc
proposed by two or more members, one of whom
personal knowledge, who must sign a certificate
mendation form A in the Appendix, setting fort
description, qualifications, and address of the cand

III.—The certificate, when duly filled up, and after at least three days previous notice to the members, shall be read aloud at the next ordinary meeting of the Society; and the election of the candidate shall forthwith be decided by a majority of votes.

IV.—The Secretary shall address to every person elected a Member, Associate Member, Associate, or Student, within one week after his election, a notification of such election, with a copy of the printed Rules and Bye-laws of the Society. The notice of election shall be sent on Provisional Election form B, enclosing at the same time Declaration form C, which shall be returned by the Member, Associate Member, Associate, or Student, signed and accompanied with the amount of the first subscription, within two months of the date of such election, which otherwise shall become void.

V.—Every Member or Associate Member having signed a declaration according to Form C. in the Appendix, and having likewise made the proper payment, shall receive a diploma of his election, according to Form F. in the Appendix.

VI.—The annual subscriptions, to be paid by Members, Associate Members, Associates, and Students shall be as follows, viz.:—

	£	s.	d.
Members (non-federated)	1	0	0
Do. Federated..	2	2	0
Associate Members do...	2	2	0
Associates do...	1	5	0
Students do...	1	5	0

and shall be due on election, and afterwards on each successive first day of October, and payable in advance for the current year, and shall be a debt due to and recoverable as such by the Treasurer for the time being.

VII.—Owners of Collieries, Lessors, Engineers, Manufacturers, Railway Companies, Employers of labour and Subscribers generally, may subscribe annually to the funds of the Society, and each such subscriber of £2 2s. annually shall be entitled to tickets to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible; and each such subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Transactions of the Society sent to him.

VIII.—Any Member or Associate Member may, at his election or any future period, become a life member by compounding for future annual subscriptions, including that of the current year, by the payment of twenty-five pounds. If he has already paid the subscription for the current year, or any part of it, such payment shall be allowed as part of his composition.

IX.—No person elected a member shall be entitled to exercise any privilege as such until he shall have paid his annual subscription, or the composition in lieu thereof.

X.—The payment by a member or associate member, associate, or student of the subscription, or the composition in lieu thereof, shall imply the acquiescence of such member in the Rules and Regulations of the Society, and shall entitle him (so long as no subscriptions remain unpaid) to admission to the meetings of the Society, the use of the Rooms and Library, and to one copy of each of the Transactions, and of any other publications the Society may print.

XI.—Any person whose subscription is two years in arrear, that is to say, whose arrears and current subscriptions shall not have been paid on or before the 1st of October shall be reported to the Council, who shall direct application to be made for it according to Notice form D; and in the event of it continuing one month in arrear after such application, the Council may direct his name to be posted up in the Society's Rooms as a defaulter, and shall have power, after suitable remonstrance by letter in the form so provided (Forfeit form E), of erasing the name of the defaulter from the register of the Society.

XII.—The Transactions of the Society shall not be forwarded to those whose subscriptions are in arrear on the first of January in each year.

XIII.—Any member may withdraw from the Society by signifying his wish to do so, by letter under his hand, to the Secretary, at the rooms of the Society; provided always, that such member shall be liable for the subsciiption for the whole year wherein he signifies his wish to withdraw; and shall continue liable to future annual subscriptions until he has discharged all sums due from him to the Society, and returned all books and other property, if any, in his custody, belonging to the Society; or shall have made full compensation for the same if lost or not forthcoming after two months' notice from the Secretary.

XIV.—Individuals distinguished for their Geological or Mining attainments, or for their communications to this or other Societies, may, on the recommendation of the Council, and after at least one month's notice has been given be elected honorary members of this Society at any ordinary or general meeting. But such honorary members shall have no vote in the affairs of the Society.

XV.—An annual meeting of the Society shall be held in the month of October, for the purpose of receiving the Annual Report of the Council, together with an Audited Statement of the Receipts and Expenditure of the last year, and electing the officers for the current year, and also transacting the general affairs of the Society. At this meeting any member may question the Council upon any matter contained in such report, and comment thereon, and on any other matter of which notice in writing has been previously given to the Council, relating to the affairs of the Society, as to him may appear proper.

XVI.—A President, four Vice-Presidents, a Secretary, and a Treasurer, shall be elected at each annual meeting; and the foregoing, together with twelve members, or associate members, to be elected at the same time, shall form the Council of the

Society, and shall have the management of its affairs, except as is otherwise provided by these Rules; and at the same meeting two Auditors shall be elected for the year ensuing. These elections shall be by ballot, or, when so decided by the meeting, by show of hands. In addition to the four Vice-Presidents annually elected, the Ex-Presidents, so long as they retain their memberships, shall be *ex post officio*, Vice-Presidents of the Society and members of the Council.

XVII.—The President shall not be eligible for that office for more than two years in succession; and the two Vice-Presidents, and the four members of the Council who shall have attended the meetings of the Council the least number of times, shall be ineligible to the same office for the ensuing year.

XVIII.—Any member or associate member who has been for six months a member of the Society, and whose subscription is not in arrear, shall be eligible to be elected an officer or member of the Council.

XIX.—In the event of any vacancy occurring during the year in the Officers or Council, the same may be filled up by the Council.

XX.—Ordinary meetings of the Society shall be held once, at least, in every month, from October to June inclusive, at such time as the Council shall appoint. An attendance book shall be kept in which members may enter their names, and in which the numbers attending the meetings shall be recorded. Each member shall have the power to introduce visitors to the meetings, on their names being entered in the attendance book.

XXI.—Ordinary meetings may be held in other localities than Manchester, at such times and places as may be determined by the Council.

XXII.—Special General meetings may be summoned by the Council, or by the Secretary, on the requisition, in writing, of any six members of the Society, by notice delivered free, or sent by post, pre-paid, to all the members whose addresses are known not less than one week, nor more than a fortnight, before any such meetings. Such notice shall state the time and place of holding the meeting, and the specific purposes for which it is convened; and the business of such meeting shall be restricted to such purposes.

XXIII.—Circulars announcing meetings of the Society, or of the Council, shall be sent, free of postage, to the members concerned, at least three days before such meeting.

XXIV.—At the hour appointed for a meeting of the Society or Council, the chair shall be taken by the President, or, in his absence, the senior Vice-President present, and in their absence the meeting shall, previous to entering upon any other business, elect some member present to be Chairman.

XXV.—All questions discussed at any such meeting, except as otherwise provided, shall be decided by a majority of votes; and if upon any question the votes shall be equal, the Chairman of the meeting shall have a second vote as a casting vote.

XXVI.—No business shall be done at any such ordinary or special meeting unless when five members at least are present, except that any number of members who may be present, not being less than two, may adjourn the meeting to a future day, such adjourned meeting to be summoned in the same manner as the original meeting.

XXVII.—The Council shall meet once at least in every month, from October to June inclusive, and upon such other occasions as they may deem expedient. Special meetings of the Council may be called by the President, the Secretary, or on the requisition of any three members of the Council, of which number the officer convening such meeting may be one. Any three members of the Council present at a Council meeting shall be sufficient to constitute a quorum.

XXVIII.—The Council shall have power to make Bye-laws and Regulations, in accordance with the general Rules of the Society; to appoint, suspend, or dismiss salaried agents, clerks, or servants; to purchase and collect books, maps, models, specimens, and other objects; to provide rooms for the meetings of the Society, and pay rent for the same; and to purchase furniture or other articles that they deem necessary for the use of the Society.

XXIX.—A minute of the proceedings of all Council meetings shall be entered by the Secretary in a book to be kept for that purpose.

XXX.—The Council shall decide whether a paper shall be printed in the Transactions or not, and if they do not unanimously agree to print it, or reject it, they may refer it to one or more members of the Society, to report upon its merits, and, in exceptional cases refer it to competent persons who are not members. After having received such report, the Council shall decide without delay whether or not the paper is to be printed. The Transactions shall be edited by the Secretary.

XXXI.—The copyright of all papers accepted for printing by the Council shall become vested in the Society, and such communications shall not be published for sale or otherwise without the written permission of the Council.

XXXII.—Twenty copies of each paper and the accompanying discussion shall be presented to the writer free of cost. Subject to the permission of the Council, he may also obtain additional copies, upon payment of the cost to the Secretary, by an application attached to his paper.

XXXIII.—All moneys, the Library, and all chattels of the Society, shall be held by the President and Treasurer for the time being, as legal owners thereof, but in trust for the Society and under the direction of the Council. All investments shall be made in the names of such members, not being less than two, as the Society may from time to time appoint as Trustees.

XXXIV.—All the funds and moneys of the Society shall be applied by or under the Direction of the Council, in paying the debts and demands for the time being owing by the Society, and carrying out the purposes thereof as defined in the preceding Rules; and no dividend, gift, division, or bonus in money, shall at any time, or under any circumstances, be made unto or between the members of the Society, or any of them.

XXXV.—No additional rule, nor any alteration or repeal of any existing or future rule or rules of the Society shall be made, unless with the consent of three-fourths in number of such of the members and associate members as may be present at any annual or special meeting; and the proposed change must be announced by circular to the members whose addresses are known, at least three weeks before such meeting.

XXXVI.—The Society shall not be dissolved, nor shall the Library or other property be disposed of, unless with the consent, in writing, of three-fourths of such of the members and associate members as may be present at each of two successive special general meetings, duly convened by public advertisement in two of the Manchester daily newspapers, and by notice sent by post at least one calendar month before each meeting, to all members whose addresses are known; such meetings to be held at an interval of not less than two, nor more than four, calendar months.

APPENDIX.

Form A.

Name in full, Mr.

Description and Qualification

Address

being desirous of admission into the Manchester Geological and Mining Society, we, the undersigned, propose and recommend that he shall become a thereof.

Proposed by .... } Signatures of two Members.

From personal knowledge

....

Dated 19 .

Form B.

Sir,—I beg to inform you that on the day of you were elected a of the Manchester Geological and Mining Society, and to enclose a copy of the Rules and Form C. Subscriptions are payable in advance, therefore, if it be your pleasure to confirm the election, please sign the form, and return it, with the amount of your first annual subscription, namely, £

If the signed form and the first subscription are not received within two months from the present date the election will become void under Rule IV.

I am, Sir,

Yours faithfully,

Secretary.

Dated 19 .

Form C.

I, the undersigned, being elected a   of the Manchester Geological and Mining Society, do hereby agree that I will be governed by the Rules of the said Society; that I will advance the objects of the Society; and will not aid in any unauthorised publication of the proceedings; and I will pay all subscriptions due from me, provided that whenever I signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) be free from this obligation.

Witness my hand this   day of   19

Form D.

Sir,—I am directed by the Council of the Manchester Geological and Mining Society to draw your attention to Rule XI., and to remind you that the sum of £   of your annual subscription to the funds of the Society remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Rule above referred to.

I am, Sir,

Yours faithfully,

Secretary.

Dated   19 .

Form E.

Sir,—I am directed by the Council of the Manchester Geological and Mining Society to inform you that in consequence of non-payment of your arrears of subscription, and in pursuance of Rule XI., the Council have declared, by Special Vote on the   day of   19   , that you have forfeited your claim to belong to the Society, and your name will be in consequence expunged from the Register unless payment is made previous to

But notwithstanding such forfeiture I am directed to call upon you for payment of your arrears, amounting to £

I am, sir,

Yours faithfully,

Secretary.

Dated   19 .

Form F.

The Manchester Geological and Mining Society.

Established 1838.

Elected ....

A Member* on the   day of

19   in testimony whereof this Diploma is signed by

.... Chairman.

....
....
....
.... } Members of the Council.

.... Secretary.

* Or "An Associate Member."

BYE-LAWS

FOR

REGULATION OF THE LIBRARY.

I.—New Books, Maps and Documents shall lie one month on the table before being issued. No Book, Map, or document shall be taken from the Library without the same being first entered in a Register, in such manner as the Council shall from time to time direct.

II.—The time allowed for retaining a Book, &c., shall not exceed one calendar month.

III.—No member shall be allowed to renew a Volume, Map, &c., in case any other member shall have entered his name as being desirous of taking out the same on its return. Such Volume, Map, &c., shall, on its return from the person holding the same, be entered as taken out by the member so applying, and shall not be taken away by any member, save him in whose name it is entered, till the expiration of the period for which the member in whose name it is entered would have been entitled to hold the same. At which period the said Book, &c. (in case the same shall not have been taken out by the party in whose name it is entered on the Register), shall be entered in the Register as returned.

IV.—The time allowed for holding shall, in every case, be computed from the date of the entry in the Register.

V.—Every member shall return the Books, Maps, and documents belonging to the Society in as good a condition as when they were delivered into his possession, and shall be answerable for the same till their return from him, to the Society, is correctly entered in the Register.

By Order of the Council.

After a short discussion the new rules were adopted unanimously, on the motion of Mr. J. Dickinson, F.G.S., seconded by Mr. W. Pickstone.

LIST OF MEMBERS,

SEPTEMBER, 1904.

The names of Honorary Members are printed in *Italics*.

* Members who have compounded for the Annual Subscription.

Year of Election.	Names and Addresses.
1874	*Agassiz, Alexander*, Cambridge, Massachussetts, U.S.A.
1897	Allen, Edward, M.E., Willow Bank, Hale, Bowdon, Cheshire.
1898	Allen, Robert, 28, Irwell Street, Lower Broughton, Man- Manchester.
1903	Aroksamy, M. R., 175, Oxford Street, Secundarabad (Deccan), India.
1893	Ashworth, John, C.E., 8, King Street, Manchester, *Vice-President.*
1878	Ashworth, Thomas, 42, Deansgate, Manchester.
1877	Atherton, James, 13, Mawdsley Street, Bolton.
1895	Atherton, H. Stanley, 13, Mawdsley Street, Bolton. *Member of Council.*
1897	Baker, Godfrey, Pendlebury, Manchester.
1901	Baldwin, Walter, F.G.S., 218, Yorkshire Street, Rochdale.
1900	Banks, Thomas, 60, King Street, Manchester.
1895	Barnes, J., F.G.S., South Cliff House, 301, Great Clowes Street, Higher Broughton. *Past-President. Hon. Auditor.*
1875	Barrett, W. S., J.P., 64, The Albany, Old Hall Street, Liverpool. *Past-President.*
1891	*Bell, Thomas*, J.P., 15, The Valley, Scarborough.
1903	Bentley, George, Bradford Colliery, Bradford, Manchester.
1881	Black, W. G., F.R.C.S.Ed., F.G.S., 2, George's Square, Edinburgh.
1898	Boden, Peter, Butterworth Hall Collieries, Milnrow, Rochdale.

Year of Election.	Names and Addresses.
1889	Bolton, Edgar O., Burnley Colleries, Burnley. *Member of the Council.*
1867	Bolton, H. H., Newchurch, near Manchester.
1880	Bolton, H. H., jun., The Collieries, Accrington.
1902	Bouchier, C. F., Strangeways House, Platt Bridge, near Wigan.
1904	Bradshaw, Hubert, Yew Tree House, Stoneclough, Manchester.
1886	Bramall, Henry, M.Inst C.E., Pendlebury Collieries, Pendlebury, Manchester.
1900	Brancker, Richard, 11, Old Hall Street, Liverpool.
1902	Brewerton, Joseph, Civil and Mining Engineer, 97, Bridge Street, Manchester.
1877	*Broeck, Ernest Van den*, 32, Place de l'Industrie, Brussels.
1904	Buckley, C. A., The Thorns, Prestwich Park, near Manchester.
1900	Burke, Harry.
1878	Burrows, John S., F.G.S., Green Hall, Atherton, Manchester. *Past-President.*
1903	Bury, A., 187, Margaret Street, Ashton-under-Lyne.
1903	Campbell, H. H., 444, Produce Exchange Buildings, Manchester.
1887	Campbell, W. M., Sutton Heath Colleries, St. Helens, Lancashire.
1901	Chapman, C. H., 293, Liverpool Road, Salford.
1898	Clark, Robert F., Bickershaw Collieries, Leigh, Lancashire.
1903	Clark, William, Garswood Coal and Iron Co., Park Lane, Wigan.
1894	Clarke, Robert, 42, Deansgate, Manchester.
1894	Cole, Robert H., Endon, Stoke-on-Trent.
1901	Coleman, W. H., 299, North Road, Clayton, Manchester.
1904	Collier, Rev. E. C., M.A., The Vicarage, Dinting, near Glossop.

Year of Election.	Names and Addresses.
1904	Constantine, E. G., M.Inst.Mech.E., 17, St. Ann's Square, Manchester.
1901	Cotterill, H. W. B., Hazlehead, near Sheffield.
1878	Cowburn, Henry, 253, Westleigh Lane, Westleigh, near Manchester.
1883	Crankshaw, Joseph, F.G.S., 11, Ironmonger Lane, London.
1879	Crawford and Balcarres, the Right Hon. the Earl of, Haigh Hall, Wigan. *Past-President.*
1900	Davidson, Robert, 2, Park Lane West, Pendlebury, Manchester.
1904	Davies, G. M., 28, New Road, Ynysybwl, Pontypridd.
1869	Dawkins, Professor W. Boyd, M.A., D.Sc., F.R.S., F.G.S., F.S.A., A.M.I.C.E., The Owens College, Manchester. *Past-President.*
1900	Deane, Adam, Stopes Colliery, Little Lever, Bolton.
1877	*De Rance, C. E.*, F.G.S., 32, Carshalton Road, Blackpool.
1898	Dickinson, Archibald, 199, Brunshaw Road, Burnley.
1856	Dickinson, Joseph, F.G.S., Hon.M.I.M.E., South Bank, Sandy Lane, Pendleton. *Past-President. Trustee.*
1904	Dickson, James, Westhoughton Colliery, Westhoughton, Bolton.
1904	Dixon, Walter, Eccleston Hall Colliery, Prescot, Lancashire.
1904	Dixon, William B., Birkacre Colliery, near Chorley.
1889	Dobbs, Joseph, Coolbawn House, Castlecomer, Co. Kilkenny.
1898	Douglas, Ernest, Pemberton Collieries, Wigan.
1898	*Eagle, George, 37, Brown Street, Manchester.
1903	Edmondson, J. H., Garswood Hall Colliery, Wigan.
1903	Edmondson, R. H., Garswood Hall Colliery, Wigan.
1878	Ellesmere, the Right Hon. the Earl of, Worsley.
1895	Ellis, Thomas Ratcliffe, King Street, Wigan.

Year of Election.	Names and Addresses.
1897	Ellis, W. T. Wood, M.Inst.M.E., M.S.A., 34, Strand, London, W.C.
1900	Elce, Abraham, jun., Colliery Manager, Highfield Terrace, Hooley Hill, Manchester.
1884	Elce, George, Altham Colliery, Whalley Road, Accrington.
1895	Evans, Robert, Mining Engineer, Olive Bank, Royton, Oldham.
1897	Evans, Walter, J.P., M.E., Royton, Oldham.
1880	Fairclough, William, Leigh, near Manchester.
1891	Finch, John, 4, Wellington Terrace, Lichfield Road, Sutton Coldfield.
1901	Flatters, A., F.R.M.S., 16, Church Road, Longsight.
1891	Fletcher, Arthur, 8, St. Andrews, Ainsworth Road, Radcliffe.
1896	Fletcher, Leonard R., Atherton Collieries, Atherton, Manchester.
1868	Fletcher, Thomas, Wheatfield, Bolton.
1873	Garforth, W. E., F.G.S., Snydale Hall, near Pontefract.
1893	Garside, Edward, B.Sc., Assoc.M.Inst.C.E., Town Hall Chambers, Ashton-under-Lyne.
1902	Garton, Walter, Brookside, Bickershaw, Wigan.
1874	*Geikie, Sir Archibald*, D.Sc., LL.D., F.R.S., 10, Chester's Terrace, Regent's Park, London, W.
1892	Gerrard, John, H.M. Inspector of Mines, Worsley, Manchester. *Member of the Council.*
1903	Gillott, J. W., Lancaster Works, Barnsley.
1904	Glover, R. B., Manager, The St. Helens Cable Co., Ltd., St. Helens.
1898	Glover, J. W., M.E., 41A, Victoria Buildings, Manchester.
1882	Greenhalgh, Robert, Engineer, Atherton, near Manchester.
1874	Greenwell, G. C., M.Inst.C.E., F.G.S., Beechfield, Poynton, Cheshire. *Past-President.*

Year of Election.	Names and Addresses.
1879	Greenwood, John, c/o The Globe Spinn Marsden Street, Manchester.
1892	Gregson, G. Ernest, 11, Chapel Street, Pı
1877	Grundy, H. T., Colliery Surveyor, Radcli
1888	Grundy, James, F.G.S., H.M. Inspector o Middle Road, Calcutta, India.
1881	Hall, Henry, I.S.O., H.M. Inspector of Prescot, Lancashire. *Past-President.*
1898	*Hall, Levi J., Morland House, Birch Val (Furness Vale Collieries, Stockport).
1877	Harris, George E., M.E., Assam Railway Limited, Margerita, Assam, India.
1894	Harrison, George B., H.M. Inspector Worsley Road, Swinton, Manchester.
1904	Hatton, G. P., Civil Engineer and Surve Co. Tyrone.
1892	*Haworth, Denis, Oswaldwistle Collieries,
1897	Heather, Frank, 47, Mosley Street, Manch
1900	Henshaw, A. M., Talk-o'th'-Hill Collieries
1902	Hewitt, J., 114, Bell Green Lane, Ince, W
1889	Higson, Charles H., 106, Eccles Old R Manchester.
1876	Higson, John, F.G.S., 18, Booth Street, M
1904	Higson, Peter, 18, Booth Street, Manchest
1900	Hinnell, Leonard H., Civil Engineer, Street, Manchester.
1897	Hobson, Bernard, M.Sc., F.G.S., The Manchester.
1877	Holding, William, Cossall Colliery, near N
1878	Hollingworth, Col. George H., F.G.S., 3 Manchester. *President. Hon. Treasurer*
1899	Hollingworth, David, Chemist, Gas W Manchester.

Year of Election.	Names and Addresses.
1904	Hollingworth, Henry, Manager, Ellerbeck Collieries, Coppull, near Chorley.
1897	Howsin, Evelin G., Huntroyd Estate Office, Padiham.
1894	Hughes, Owen, Rose Hill House, Hindley, near Wigan. *Member of the Council.*
1874	*Hull, Professor Edward,* M.A., F.R.S., 20, Arundel Gardens, Notting Hill, London, W.
1903	Humphries, Henry, Blaenau Festiniog.
1895	Hutchinson, John William, The Lewis Merthyr Consolidated Collieries, Ltd., Hafod, near Pontypridd.
1878	Jackson, Charles G., Rookwood, near Chorley.
1902	Jobes, R. A., 13, Douglas Terrace, Carley Road, Southwick-on-Wear.
1883	Jobling, Albert, 91, Rectory Road, Burnley.
1883	Jobling, Henry, 91, Rectory Road, Burnley.
1884	Jobling, John, Manager, Cliviger Collieries, Burnley.
1882	Johnson, William, Abram Colliery, Wigan.
1903	Johnson, William Henry, B.Sc., 24, Lever Street, Manchester.
1903	Jones, O. R., H.M. Inspector of Mines, 5, Spring Gardens, Chester.
1897	Keen, James, Hindley Green, Wigan.
1893	Kenrick, James P., 8, St. James's Square, Manchester.
1879	*Kinahan, G. H.,* M.R.I.A., Woodlands, Fairview, Co. Dublin.
1901	Knight, Henry, Manager, Rose Bridge and Ince Hall Collieries, Wigan.
1889	Knowles, John, Brynn Mount, Westwood, Lower Ince, Wigan.
1887	*Knowles, Lt.-Col. Sir Lees, Bart., M.A., LL.D., F.G.S., M.P., Westwood, Pendlebury. *Trustee.*

Year of Election.	Names and Addresses.
1898	Krauss, John Samuel, B.A., Stonycroft, Wilmslow, Cheshire.
1898	Landless, Richard, Bank Hall Colliery, I
1902	Latham, Daniel, Surveyor, Rose Bridg Collieries, Wigan.
1890	Law, J. Illingworth, Waterfoot, Manches
1884	Leech, A. H., Brinsop Hall Colliery, Wig
1897	Lees, Frederick, The Rookery, Ashford, I
1899	Leigh, Oswald B., The Towers, Didsbury
1898	Livesey, John, Rose Hill Colliery, Bolton
1887	Lord, James, Hill House, Rochdale.
1898	Lowe, Henry, Chisnall Hall Colliery, Copp
1904	Macalpine, George L., B.Sc., Altham and Collieries, Accrington.
1881	Macalpine, G. W., Parkside, Accrington.
1902	Machin, Thomas H., Hyde Lane Colliery,
1901	McKay, William, Carlton Villa, Park Road,
1897	Makepeace, H. R., H.M. Inspector of Min Road, Wolverhampton.
1903	Marshall, Eustace, The Larches, Wigan.
1892	Mathews, D. H. F., H.M. Inspector of Chester. *Member of Council.*
1893	Matthews, E. L., Belvedere Street, Witl Pendleton, Manchester.
1896	Matthews, Thomas, Imperial Iron Works, B Withington Street, Pendleton, Mancheste
1873	*Martin, Joseph S.*, H.M. Inspector of Mine 16, Durdham Park, Clifton, Bristol.
1892	Miller, Arthur, Broad Oak, Hurst, Ashton-u
1892	Millington, W. W., Hardman House, Hollin *Member of Council.*

Year of Election.	Names and Addresses.
1892	Mills, David, Bradford Street, Farnworth.
1895	Mitton, A. Dury, Assoc.M.Inst.C.E., 50, Victoria Buildings, Manchester. *Vice-President.*
1895	Mort, Arthur, B.Sc., Sharigh, Baluchistan.
1904	Munroe, Martin, Shakerley Collieries, Tyldesley.
1878	Nall, Simon, Firgrove, near Rochdale.
1898	Naylor, Alfred, Shirebrook Colliery, Mansfield.
1904	Nicholson, James J., Mining Engineer, Bank House, Deansgate, Bolton.
1897	Noar, T. Lamb, Rossendale, Fairhaven, Lytham.
1900	Ollerenshaw, W., Manager, Denton Colliery, Denton, Manchester. *Member of Council.*
1904	Ormond, Percy, Earlestown, Lancashire.
1903	Orrell, G. Harold, M.E., Swallowfield, Horwich.
1903	Owen, Richard, Messrs. Pearson & Knowles' Collieries, Wigan.
1876	Peace, George, Monton Grange, Eccles.
1883	Peace, George Henry, M.Inst.C.E., Monton Grange, Eccles. *Vice-President.*
1897	*Pickup, P. W. D., Rishton Colliery, Rishton, near Blackburn.
1900	Pickstone, William, 8, St. Paul's Road, Kersal, Manchester. *Member of Council.*
1879	Pilkington, Charles, The Headlands, Prestwich, Manchester.
1873	Pilkington, Edward, J.P., Clifton Collieries, near Manchester. *Past-President.*
1899	Pilkington, Lawrence, South Garth, Eccles Old Road, Pendleton.
1903	Pilkington, Lionel, Haydock Collieries, St. Helens, Lancashire.

Year of Election.	Names and Addresses.
1877	Place, W. H., Hoddleston Collieries, Da
1887	Platt, Samuel Sydney, M.Inst.C.E., F. King's Road, Rochdale.
1904	Pope, Philip Crosby, Electrical Engine Road, Birkdale.
1891	Prestwich, Joseph, Elm Bank, 72,] Pendleton, Manchester.
1903	Ramsbottom, James, Church Road, New
1897	Reid, Alexander, Pekin Syndicate Limitec
1897	Richardson, Isaiah, Blainscough Collier Chorley.
1860	Ridyard, John, F.G.S., Hilton Bank, Litt *Past-President.*
1900	Ridyard, George, M.E., Shakerley Collie
1893	Rigby, John, Highfield, Winsford, Chesh
1903	Ritson, Thomas F., Manager, Bamfurlon Wigan.
1897	Ritson, W. A., 44, Woodlands Street, chester.
1889	Robinson, John, Haydock Collieries, St. H
1904	Robinson, Fred, Haydock, St. Helens.
1903	Rogers, W., 311, Wigan Road, Bolton.
1892	Roscoe, George, Peel Hall Collieries, Little
1898	Roscoe, Thomas, Peel Hall Collieries, Littl
1895	Rothwell, Samuel, 21, Chorley New Road,
1903	Rushton, A., Moss Hall Collieries, near W
1895	Ryans, Joseph, Colliery Manager, Arigna on-Shannon.
1887	Saint, William, H.M. Inspector of Mines, Ker Broughton, Manchester. *Past-President.*
1902	Salisbury, S., 62, Ayres Road, Brooks' Bar,

Year of Election.	Names and Addresses.
1888	Scarborough, George Edward, Colliery Manager, Newton and Meadows Collieries, Wigan.
1889	Scott, William B., Eversley Cottage, Middleton.
1891	Scowcroft, Thomas, J.P., Redthorpe, Bromley Cross, near Bolton.
1899	Selby, John B., Atherton House, Leigh, Lancashire.
1882	Settle, Joel, The Hill, Alsagar, Stoke-on-Trent.
1899	Shaw, Alfred, Bersham Colliery, Wrexham.
1887	Shuttleworth, The Right Hon. Lord, of Gawthorpe, Burnley.
1884	*Simpson, W. W., Winkley, near Whalley, Blackburn.
1864	*Smethurst, William, F.G.S., Brynmair, Dolgelly, North Wales.
1881	Smith, John, Bickershaw Collieries, Westleigh, near Manchester.
1873	*Smith, R. Clifford, F.G.S., Ashford Hall, Bakewell. *Past-President.*
1888	Smith, Sydney A., Assoc.M.Inst.C.E., 1, Princess Street, Albert Square, Manchester. *Member of the Council.*
1903	Spackman, Charles, Rosehaugh, Clitheroe.
1886	Speakman, Harry, Bedford Collieries, Leigh, Lancashire.
1881	Squire, J. B., Assoc.Inst.C.E., F.G.S., M.I.M.E., 20, Victoria Street, Westminster Street, London, S.W.
1880	Stirrup, Mark, F.G.S., High Thorn, Stamford Road, Bowdon, Cheshire. *Past-President.*
1902	Stocks, F. W., F.S.I., The Hermitage, Middlewich.
1882	Stopford, T. R., Woodley, Radcliffe, near Manchester.
1891	Sutcliffe, Richard, Horbury, near Wakefield.
1903	Sutcliffe, W. H., F.G.S., Shore Cottage, Littleborough.
1899	Tansley, A. E., Springfield House, Coppull, Chorley.
1899	Tatham, Roger.
1901	Taylor, John, 51, Park Road, Darwen.
1889	Taylor, William, 51, Park Road, Darwen.

Year of Election.	Names and Addresses.
1892	Thompson, James, 248, Chorley Road, Westhoughton, Bolton.
1897	Tickle, James, Bamfurlong Collieries, Bamfurlong, Wigan.
1893	Timmins, Arthur, A.M.I.C.E., F.G.S., Argyll Lodge, Higher Runcorn.
1891	Tonge, Alfred J., Hulton Colliery, near Bolton. *Member of Council.*
1898	Tonge, James, F.G.S., Westhoughton, near Bolton. *Hon. Secretary.*
1886	*Trafford, Sir Humphrey Francis de, Bart., F.G.S., 18, Arlington Street, London, W.
1895	Travers, T. W., Mining Engineer, Spring Bank, Broad Oak Park, Worsley.
1904	Turner, Charles, Irlam, near Manchester.
1896	Turner, Robert, Jesmond House, St. Helens.
1876	Unsworth, John, Scot Lane Collieries, Wigan.
1887	Walkden, Richard, Colliery Manager, 26, Watery Lane Terrace, Springvale, Darwen.
1882	Walker, T. A., Pagefield Iron Works, Wigan.
1882	Wall, Henry, Rowbottom Square, Wallgate, Wigan.
1893	Wallwork, Jesse, Bridgewater Collieries, Walkden, near Bolton.
1888	*Walmesley, Oswald, 2, Stone Buildings, Lincoln's Inn, London, W.C.
1897	Walton, Thomas, Exors. of Col. Hargreaves, Colliery Offices, Bank Parade, Burnley.
1892	Ward, Alexander Haustonne, Raneegunge, Bengal, India.
1903	Wasley, John C., M.E., 184, Saltwell Road, Gateshead.
1880	Watts, William, F.G.S., Underbank Hall, Deepcar, near Sheffield. *Past-President.*

Year of Election.	Names and Addresses.
1897	Wells, Lionel B., M.Inst.C.E., 5, John Dalton Street, Manchester. *Member of the Council.*
1890	*Whitaker, William*, B.A., F.R.S., F.G.S., Freda, Campden Road, Croydon.
1891	Whitehead, J. J., P.O. Box 6407, Johannesburg, S. Africa.
1898	Widdowson, J. H., 19, Brazennose Street, Manchester.
1880	Williams, Sir E. Leader, M.Inst.C.E., Manchester Ship Canal Company, Spring Gardens, Manchester.
1897	Winstanley, George H., F.G.S., 42, Deansgate, Manchester. *Hon. Auditor.*
1876	Winstanley, Robert, C.E., 42, Deansgate, Manchester. *Past-President.*
1886	*Wood, Guy.
1897	Wood, John, M.E., Barley Brook Foundry, Wigan.
1897	Wood, Percy Lee, Clifton and Kersley Coal Co., Ltd., Clifton, Manchester. *Member of the Council.*
1895	Wordsworth, T. H., New Moss Colliery, Audenshaw, near Manchester.

SUBSCRIBERS.

Stechert & Co,, 2, Star Yard, Carey Street, London, W.C.

Cornish Brothers, Ltd., 87, New Street, Birmingham.

Members are requested to communicate to the Hon. Secretary all changes of address, also any omissions, or corrections required in the list.

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