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CIRCUMSPICE
DEPARTMENT
OF
ENGINEERING

TRANSACTIONS

OF THE

NORTH-EAST COAST INSTITUTION

OF

ENGINEERS AND SHIPBUILDERS.

EDITED BY THE SECRETARY OF THE INSTITUTION.

VOLUME XXIV.

TWENTY-FOURTH SESSION, 1907-1908.

NEWCASTLE-UPON-TYNE AND LONDON:
ANDREW REID & COMPANY, Limited, PRINTERS AND PUBLISHERS.

1908.

ADVERTISEMENT.

"The Institution merely places on record, and is not, as a body, responsible for the statements or opinions advanced in the Papers read, or the Discussions thereon, which occur at the Meetings during the Session."

CONTENTS OF VOLUME XXIV.

TWENTY-FOURTH SESSION, 1907-1908.

PAPERS READ DURING THE SESSION.

LIST OF PLATES.

ERRATA.

Page 198, line 31, for "rational" read "rotational."
Page 186, line 37, for "stem" read "stern."

ALPHABETICAL LIST OF WRITERS OF PAPERS AND SPEAKERS.

ELECTED.

Bainbridge, T. L., Messrs. Swan, Hunter & Wigham Richardson, Ltd., Wallsend-on-Tyne ... ... (S) { Graduate Dec. 1903; Member Oct. 1906 }

Baines, Geo. Henry, c/o Messrs. W. Gray & Co., Central Marine Engine Works, West Hartlepool ... ... (E) Oct. 1888

Baker, E. F., Eng.-Lieut., R.N., H.M.S. "Argyle," First Cruiser Squadron, Greenock ... ... (E) { Graduate, Nov. 1892; Member, Feb. 1898 }

Ball, Ralph H. C., Eng.-Com. R.N., c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Openshaw, Manchester ... ... (E) Nov. 1905

Barber, Wm. Daglish, 46, Riverside Road, Norwich ... ... (S) Oct. 1902

Barrett, A., Highfield, Hutton Avenue, West Hartlepool ... (E) May 1896

Bartram, W. N., South Dock, Sunderland ... ... (S) Mar. 1907

Bateman, John, South Vane Terrace, Darlington ... ... (E) Mar. 1901

Batey, John Thomas, 52, Queen's Road, Jesmond, Newcastle-upon-Tyne ... ... (S) Nov. 1885

Batliboi, Jehangir Framji, 49, Forbes Street Fort, Bombay ... (E) Dec. 1888

Baxter, J., 26, Simonside Terrace, Heaton, Newcastle-upon-Tyne (E) Nov. 1884

Bayliss, Wilfrid, 110, Rye Hill, Newcastle-upon-Tyne ... ... (E) Feb. 1908

Beckett, Eng.-Com. W. H., H.M.S. "London," Home Fleet ... (E) Dec. 1903

Bedlington, A. S., 15, Stanhope Road, South Shields (S) { Graduate, Nov. 1904; Member, Nov. 1907 }

Belford, David, 15, Eldon Place, Newcastle-upon-Tyne ... ... (E) Nov. 1905

Bell, Joshua Robson, 40, Hill Street, Jarrow-on-Tyne ... ... (S) Mar. 1899

Bell, Robert T., 17, Kingsley Terrace, Newcastle-upon-Tyne ... (S) Jan. 1907

Bell, William, Messrs. Cleland's Graving Dock and Slipway Co., Willington Quay-on-Tyne ... ... (E) Nov. 1888

Bench, George E., Eng.-Com., R.N., 1, The Ferns, Addington Grove, Sydenham, London, S.E. ... ... (E) Mar. 1907

Bennett, Percy M., Calle de San Juan de Letran Num 5½ Mexico (E E) Dec. 1899

Berkley, A. B., 8, Camden Terrace, Clifton Vale, Bristol ... ... (E) Mar. 1887

Bigge, D. L. Selby, 27, Mosley Street, Newcastle-upon-Tyne ... (E E) Nov. 1894

Billetop, Torben Christian, Springfield, Lesbury Road, Heaton, Newcastle-upon-Tyne ... ... (E) Nov. 1896

Bindesböll, S. C. W., Aktieselskabet Helsingors Jernskibs- og Maskinbyggeri, Helsingor, Denmark ... ... (S) Nov. 1884

Binns, Aubrey B., 33, Lovaine Place, Newcastle-upon-Tyne ... ... (E) { Graduate, Oct. 1894; Member, Dec. 1899 }

Black Charles, c/o Messrs. Vacuum Oil Co., Ltd., D, Milburn House, Newcastle-upon-Tyne ... ... (E) Oct. 1902

Blackett, Walter, c/o Messrs. Hawthorn, Leslie & Co., St. Peter's Works, Newcastle-upon-Tyne ... (E) { Graduate, Nov. 1886; Member, Nov. 1892 }

Blackie, Thomas Reid, Lloyd's Register of Shipping, 71, Fenchurch Street, London ... ... (SUR) Nov. 1890

Blackwood, M., Messrs. Lloyd's Register of Shipping, Maritime Buildings, Dundee ... ...(SUR) Nov. 1907

Blake, James, 3, West Park, Woodlands Road, Darlington ... (E) Nov. 1899

Blaylock, Robert, 10, Greenbank Crescent, Darlington ... ...(F M) Dec. 1900

Blenkinsop, John N., Marine Supt. Engineer, Great-Eastern Railway, Parkeston Quay ... ... (E) Oct. 1885

Blow, Charles, Beech Grove, Benton, Newcastle-upon-Tyne ... (E) Nov. 1898

Blumer, Wm., Ashbrooke Tower, Sunderland ... ... (S) Dec. 1886

Böcler, Harry, 19, Azalea Terrace South, Sunderland (S) { Graduate, Mar. 1898; Member, Dec. 1901 }

ELECTED.

Bone, W. J., 61, Linskill Terrace, North Shields ... ... (S) Dec. 1884
Bonnyman, James Smith, 64, Plasturton Avenue, Cardiff... ... (E) Nov. 1889
Booth, Edward Spence, Box 5124, Boston, U.S. America ...(M S & N A) Oct. 1889
Borrowman, William Cameron, Wh.Sch. ... ... (E) Oct. 1898
Bosi. Giuseppe, Via xx. Settembre 36-17, Genoa, Italy ... (E & NA) Jan. 1894
Battlinala, Cawasji H., The Assur Virjee Mills, Parel, Bombay, British India ... ... (E) May 1907
Box, Edward, c/o Messrs. Smith's Dock Co., Ltd., North Shields... (C E) Dec. 1906
Bowerbank, Albert W., 42, Marine Avenue, Monkseaton, Northumberland ... ... (E) { Graduate, Nov. 1900 / Member, Dec. 1902 }
Bowmer, Matthew Noel, 8, Tankerville Terrace, Newcastle-upon-Tyne ... ... (E) { Graduate, Dec. 1900 / Member, May 1906 }
Boyd, Arthur, c/o "Post Office," St. Johns, Newfoundland (E SUR) May 1895
Boyd, Wm., Prestwick Lodge, Ponteland, nr. Newcastle-upon-Tyne (E) Nov. 1884
Boyd, William, 25, Woodbine Avenue, Gosforth, Newcastle-upon-Tyne ... ... (E) Nov. 1904
Boyt, John T., 432, Bourse Buildings, Philadelphia, Pa., U.S.A. ... (E) Nov. 1893
Bradney, Walter, Billiter Buildings, Billiter Street, London, E.C. (E) Nov. 1905
Broadbent, Frank, 4, Queen Street Place, London, E.C. ... ... (E E) Nov. 1893
Brookfield, J. W., c/o Messrs. Halifax Graving Dock Co., Halifax, Nova Scotia ... ... (N A) Nov. 1903
Brotherston, James, 23, Nelson Street, Sunderland ... ... (E) Oct. 1895
Brown, E. Eugene, 20, Victoria Terrace, Whitley Bay, Northumberland ... ... (E E) Feb. 1886
Brown, Geo. Matthew, c/o Messrs. The British Thomson-Houston Co., Rugby ... ... (E) { Graduate, April 1895 / Member, Nov. 1897 }
Brown, James, c/o Messrs. Scott & Co., Greenock ... ... (E) Mar. 1891
Brown Joseph, c/o Mr. J. Reed, 23, Albany Park Road, Tynemouth (E) May 1904
Brown, Percy J., 3, Douro Terrace, Sunderland ... ... (E) May 1899
Brown, Robson, 32, Salmon Street, South Shields ... ... (E) Nov. 1889
Brown, William, c/o Messrs. Siemens Brothers & Co., Woolwich... (E) April 1887
Browne, Benjamin C., jun., 8, Lambton Road, Newcastle-upon-Tyne ... ... (E) { Graduate, Oct. 1898 / Member, Dec. 1901 }
Browne, Sir B. C., Westacres, Benwell, Newcastle-upon-Tyne (C E) Jan. 1885
Bryers, Charles, 10, The Avenue, Sunderland ... ... (E) Nov. 1902
Buchanan, John H., Oswald Chambers, 5, Oswald Street, Glasgow (SUR) Oct. 1888
Buckland, H. B., Baltic Chambers, Quayside, Newcastle-upon-Tyne (E) Nov. 1885
Buckwell, George William, Board of Trade Surveyor's Offices, Government Buildings, Barrow-in-Furness ... ...(SUR) Oct. 1896
Bull, John Catharinus, Yoker, near Glasgow ... ... (E) Oct. 1892
Bulmer, A. E., Spring Garden Engineering Works, Pitt St., Newcastle-upon-Tyne ... ... (E) { Graduate, Nov. 1895 / Member, Nov. 1901 }
Bulmer, Frederick Charles, 29, Benwell Grove, Benwell, Newcastle-upon-Tyne ... ... (E) { Graduate, May 1894 / Member, Oct. 1895 }
Bulmer, John George, 34, Brighton Grove, Newcastle-upon-Tyne (E) May 1894
Bulmer, Septimus, Ashlyn, Moorside, Fenham, Newcastle-upon-Tyne ... ... (E) { Graduate, May 1894 / Member, Dec. 1899 }
Burge, C. R. W., 33, Sandringham Gardens, North Shields ... (E) April 1907
Burgess, N. H., 210, Trewhitt Road, Heaton, Newcastle-upon-Tyne ... ... (S) { Graduate, Dec. 1901 / Member, Dec. 1902 }
Burley, M. F., 14, Croft Terrace, Jarrow-on-Tyne ... ... (F) Nov. 1899

Ordinary Members of Council.

JAMES M. ALLAN, Belle Vue House, Low Fell, Gateshead-on-Tyne.
GEORGE J. CARTER, c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Elswick Shipyard, Newcastle-upon-Tyne.
E. C. CHAMPNESS, Lloyd's Register of Shipping, Collingwood Buildings, Newcastle-upon-Tyne.
ALFRED HARRISON, Scotia Engine Works, Sunderland.
ROBERT HINCHLIFFE, 29, Lish Avenue, Whitley Bay, Northumberland.
DAVID R. MACDONALD, c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Walker Shipyard, Newcastle-upon-Tyne.
GEORGE MOFFITT, c/o Messrs. The Blyth Shipbuilding Co., Ltd., Blyth.
D. MYLES, c/o Messrs. North-Eastern Marine Engineering Co., Ltd., Northumberland Engine Works, Wallsend-on-Tyne.
NATHANIEL E. ROBSON, c/o Messrs. North-Eastern Marine Engineering Co., Ltd., Northumberland Engine Works, Wallsend-on-Tyne.
ROBERT TRAILL, 6, Windsor Crescent, Whitley Bay, Northumberland.
J. L. TWADDELL, Green Bank, Jarrow-on-Tyne.
H. WALKER, 9, Gladstone Terrace, Gateshead-on-Tyne.
ROBERT WALLIS, c/o Messrs. Wallsend Slipway & Engineering Co., Ltd., Wallsend-on-Tyne.
GEORGE D. WEIR, c/o Messrs. North-Eastern Marine Engineering Co., Sunderland Engine Works, Sunderland.
R. SAXTON WHITE, c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Walker Shipyard, Newcastle-upon-Tyne.

Hon. Treasurer.

GEORGE E. MACARTHY, 54, Pilgrim Street, Newcastle-upon-Tyne.

Secretary and Treasurer.

JOHN DUCKITT, 4, St. Nicholas' Buildings West, Newcastle-upon-Tyne.

GRADUATE SECTION.

Chairman.

HUGH CAMPBELL, c/o Messrs. The North-Eastern Marine Engineering Co., Northumberland Works, Wallsend-on-Tyne.

Hon. Secretary.

W. J. SEDCOLE, 17, Westoe Lane, South Shields.

Committee.

OSWELL B. BINNS, 76, Holly Avenue, Jesmond, Newcastle-upon-Tyne.
GEORGE M. BROWN, c/o Messrs. Scott, Mountain & Co., Close Works, Gateshead-on-Tyne.
F. W. GREEN, Rutherford College, Newcastle-upon-Tyne.
. W. HOBSON, 53, Bishop's Road, Benwell, Newcastle-upon-Tyne.
AMES F. MALLET, Ivy Road, Gosforth, Newcastle-upon-Tyne.
[redacted]

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

COMMITTEES.

TWENTY-FOURTH SESSION, 1907-1908.

The President is *ex officio* a Member of all Committees.

Finance Committee:

WILLIAM BOYD (Chairman).

G. J. CARTER.
W. H. DUGDALE.
J. R. FOTHERGILL.
JAMES MARR.
H. B. ROWELL.
SUMMERS HUNTER.
GEORGE E. MACARTHY (Hon. Treasurer).

Reading Committee:

D. R. MACDONALD.
ROBERT TRAILL.
J. L. TWADDELL.
R. WALLIS.
G. D. WEIR.
R. SAXTON WHITE.

Library Committee:

J. H. HECK (Chairman).

H. CAMPBELL.
E. C. CHAMPNESS.
R. HINCHLIFFE.
R. L. WEIGHTON, M.A.

Graduates' Award Committee:

J. H. HECK.
M. C. JAMES.
W. G. SPENCE.
HENRY WALKER.
R. L. WEIGHTON, M.A.

Educational and Scholarship Award Committee:

W. H. DUGDALE (Chairman).

Trustees :—WILLIAM BOYD, SIR W. THEODORE DOXFORD, HENRY WITHY.

Tyne and Blyth :—G. J. CARTER, SUMMERS HUNTER, H. B. ROWELL, W. G. SPENCE, R. L. WEIGHTON, R. SAXTON WHITE.

Wear :—HENRY CLARK, F. DICKINSON, HUGH LAING, JAMES MARR.

Tees and Hartlepools :—D. B. MORISON.

Measured Mile-Posts' Committee:

C. A. BUSHELL.
W. H. DUGDALE.
JAMES MARR.
W. G. SPENCE.
JOHN DUCKITT.

Representative on Inst. of Civil Engineers Educational Committee:

R. L. WEIGHTON, M.A.

Representatives on Lloyd's Sub-Committee:

W. H. DUGDALE.
SUMMERS HUNTER.
ANDREW LAING.
HENRY WITHY.

Representatives on the Consultative Committee to the Board of Trade:

W. H. DUGDALE.
J. H. IRWIN.
GEORGE JONES.
D. B. MORISON.

Representative on Council of Armstrong College:

W. H. DUGDALE.

Representatives on Committees on Standard Sections:

HENRY WITHY. | SUMMERS HUNTER. | ANDREW LAING.

Representative on Governing Body of Marine School, South Shields.

HARRY ELTRINGHAM.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

List of Members, August, 1907.

EXPLANATION.

(A.)	Agent and Accountant.	**(I. & S. M.)**	Iron and Steel Merchants and Manufacturers.
(B. B.)	Boiler Builder.	**(M.)**	Merchant.
(C. E.)	Civil and Consulting Engineer.	**(M. S.)**	Marine Superintendent.
(E.)	Engineer and Boilermaker.	**(N. A.)**	Naval Architect.
(E. A.)	Engineering Agent.	**(R. M.)**	Rope Manufacturer.
(E. E.)	Electrical Engineer.	**(S.)**	Shipbuilder.
(F. M.)	Forge Master.	**(S. O.)**	Ship Owner.
(F.)	Iron and Brass Founder.	**(SUR.)**	Engineer & Ship Surveyor
(D.)	Draughtsman.	**(P)**	Pupil.

HONORARY MEMBERS.

			ELECTED.
Sir W. H. White, K.C.B., LL.D., F.R.S., D.Sc., Cedarcroft, Putney Heath, London, S.W.	**(N A)**		Nov. 1884
The President of the Institution of Naval Architects (The Right Honourable the Earl of Glasgow, G.C.M.G., LL.D., Fairlie Craig, Fairlie, Ayrshire)			April 1902
The Right Honourable Lord Armstrong, M.A., D.C.L., D.L., J.P., Cragside, Rothbury			Feb. 1904
Sir Andrew Noble, Bart., K.C.B., F.R.S., Jesmond Dene House, Newcastle-upon-Tyne			Mar. 1904
The Principal of Armstrong College, Newcastle-upon-Tyne (Sir Isambard Owen, D.C.L., M.D.)			Nov. 1906
Sir Philip Watts, K.C.B., F.R.S., LL.D., D.Sc., The Admiralty, Whitehall, London	**(N A)**	Member Hon. Mem.	Nov. 1885 May 1907

MEMBERS.

A.

Adams, Cecil T., c/o Messrs. The N.E. Marine Engineering Co., Sunderland Works, Sunderland	**(E)**	Graduate, Member,	Oct. 1891 Nov. 1897
Adamson, Chas. P., c/o Mrs. Burt, 207, Kent Road, Glasgow	**(E)**	Graduate, Member.	Nov. 1897 April 1901
Adamson, Daniel, c/o Messrs. Joseph Adamson & Co., Hyde,		Graduate,	Feb. 1888

[redacted]

		Elected.
Agnew, T., Eng.-Capt., R.N., 7, Paddock Ter., New Road, Chatham	(E)	Nov. 1903
Ainsworth, G., The Hall, Consett, Co. Durham	(I & S M)	Jan. 1908
Aisbitt, Matthew Wheldon, 47, Mount Stuart Square, Cardiff ...	(N A)	Oct. 1895
Aitkenhead, Thomas, E. Eng.-Lieut. R.N., H.M.S. "Grafton," Portsmouth...	(E)	May 1908
Alder, Sydney, 34, King Street, South Shields	(C E & N A)	Nov. 1893
Alexander, Francis H., Armstrong College, Barras Bridge, Newcastle-upon-Tyne	(NA)	Dec. 1902
Allan, Jas. McNeal, Belle Vue House, Low Fell, Gateshead-on-Tyne	(E)	Dec. 1886
Allan, Percy F., c/o Messrs. Yarrow & Co., Scotstoun, Glasgow	(E E)	Graduate, Nov. 1901; Member, Nov. 1905
Allan, John, Lloyd's Register of Shipping, 55, Fawcett Street, Sunderland	(S)	Jan. 1900
Allardes, Wm., Ashburn, Strandtown, Belfast	(E)	Nov. 1884
Anderson, Joseph, 5, Westfield Terrace, Wallsend-on-Tyne ...	(E)	Nov. 1884
Anderson, T. C., Bigges Main House, near Wallsend-on-Tyne	(E)	Graduate Mar. 190; Member Oct. 1906
Anderson, Thos. James, Cotton Exchange Building, Galveston, Texas, United States of America	(E SUR)	Mar. 1898
Andrew, D., 33, Osborne Road, Jesmond, Newcastle-upon-Tyne ...	(SUR)	Jan. 1885
Andrew, David, jun.	(E)	Graduate, Jan. 1898; Member, Dec. 1903
Andrew, John Davies, 33, Osborne Road, Newcastle-upon-Tyne	(E)	Graduate, Jan. 1898; Member, Jan. 1906
Andrews, Jas., The Lea, Myrtle Avenue, Lenzie, nr. Glasgow ...	(E)	Nov. 1884
Andrews, R. B., Eng.-Lieut., R.N., 53, Clarendon Road, Lewisham, London	(E)	Dec. 1906
Angus, W. J., Messrs. Vickers, Sons & Maxim, Naval Construction Works, Barrow-in-Furness	(E)	Oct. 1892
Arkins, Walter, 12, Laverton Street, Williamstown, Victoria, Australia	(M E)	Nov. 1905
Armstrong, Adam Latimer, 42, Percy Park, Tynemouth	(S)	April 1901
Armstrong, Joseph, 50, High Southwick, Sunderland	(S)	Nov. 1892
Arnesen, Olaf, York Chambers, Sunderland	(SUR)	May 1908
Ascroft, Frederick W., 3, Bridge Place, Chester	(E)	May 1900
Atkinson, Alfred, c/o Messrs. Clarke, Chapman & Co., Victoria Works, Gateshead-on-Tyne	(E)	May 1901
Atkinson, George H., Westoe House, Grange Road, West Hartlepool	(E)	Nov. 1898
Atkinson, John H., 65, Grove Street, Newcastle-upon-Tyne ...	(S)	Jan. 1907
Atkinson, John Joseph, 7, Swiss Road, Elm Park, Fairfield, Liverpool	(E)	Mar. 1891
Avery, Thomas, R.I.M. Dockyard, Kidderpore, Calcutta	(NA)	Nov. 1903

B.

Baggallay, Robert, Messrs. Flannery, Baggallay & Johnson, 9, Fenchurch Street, London, E.C.	(C E)	May 1902
Bagnall, Richard S., The Groves, Winlaton, Co. Durham	(E)	Mar. 1908
Bailey, James, 3, South Avenue, Ryton-on-Tyne	(E)	Nov. 1884
Bailey, James T., c/o Messrs. Swan Hunter & Wigham Richardson, Ltd., Neptune Works, Low Walker	(E)	Feb. 1899

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Bone, W. J., 61, Linskill Terrace, North Shields ... ... (S) Dec. 1884
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Boyd, Arthur, c/o "Post Office," St. Johns, Newfoundland (E SUR) May 1895
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Boyd, William, 25, Woodbine Avenue, Gosforth, Newcastle-upon-Tyne ... ... (E) Nov. 1904
Boyt, John T., 432, Bourse Buildings, Philadelphia, Pa., U.S.A. ... (E) Nov. 1893
Bradney, Walter, Billiter Buildings, Billiter Street, London, E.C. (E) Nov. 1905
Broadbent, Frank, 4, Queen Street Place, London, E.C. ... ... (E E) Nov. 1893
Brookfield, J. W., c/o Messrs. Halifax Graving Dock Co., Halifax, Nova Scotia ... ... (N A) Nov. 1903
Brotherston, James, 23, Nelson Street, Sunderland ... ... (E) Oct. 1895
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Brown, James, c/o Messrs. Scott & Co., Greenock ... ... (E) Mar. 1891
Brown Joseph, c/o Mr. J. Reed, 23, Albany Park Road, Tynemouth (E) May 1904
Brown, Percy J., 3, Douro Terrace, Sunderland ... ... (E) May 1899
Brown, Robson, 32, Salmon Street, South Shields ... ... (E) Nov. 1889
Brown, William, c/o Messrs. Siemens Brothers & Co., Woolwich... (E) April 1887
Browne, Benjamin C., jun., 8, Lambton Road, Newcastle-upon-Tyne ... ... (E) { Graduate, Oct. 1898 / Member, Dec. 1901 }
Browne, Sir B. C., Westacres, Benwell, Newcastle-upon-Tyne (C E) Jan. 1885
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Buchanan, John H., Oswald Chambers, 5, Oswald Street, Glasgow (SUR) Oct. 1888
Buckland, H. B., Baltic Chambers, Quayside, Newcastle-upon-Tyne (E) Nov. 1885
Buckwell, George William, Board of Trade Surveyor's Offices, Government Buildings, Barrow-in-Furness ... ...(SUR) Oct. 1896
Bull, John Catharinus, Yoker, near Glasgow ... ... (E) Oct. 1892
Bulmer, A. E., Spring Garden Engineering Works, Pitt St., Newcastle-upon-Tyne ... ... (E) { Graduate, Nov. 1895 / Member, Nov. 1901 }
Bulmer, Frederick Charles, 29, Benwell Grove, Benwell, Newcastle-upon-Tyne ... ... (E) { Graduate, May 1894 / Member, Oct. 1895 }
Bulmer, John George, 34, Brighton Grove, Newcastle-upon-Tyne (E) May 1894
Bulmer, Septimus, Ashlyn, Moorside, Fenham, Newcastle-upon-Tyne ... ... (E) { Graduate, May 1894 / Member, Dec. 1899 }
Burge, C. R. W., 33, Sandringham Gardens, North Shields ... (E) April 1907
Burgess, N. H., 210, Trewhitt Road, Heaton, Newcastle-upon-Tyne ... ... (S) { Graduate, Dec. 1901 / Member, Dec. 1902 }
Burley, M. F., 14, Croft Terrace, Jarrow-on-Tyne ... ... (F) Nov. 1899

ELECTED.

Burnott, J. E., c/o Messrs. H. Watson & Sons, High Bridge Works, Walker Gate ... ... (E) Nov. 1907
Burnett, Norman, B, Milburn House, Newcastle-upon-Tyne ... (E) Oct. 1891
Bushell, Chas. A., 1, Benton Terrace, Newcastle-upon-Tyne (N A & SUR) Nov. 1893
Butterfield, George, 3, Kayll Road. Sunderland ... ... (S) Nov. 1884
Butterworth, George Herbert, The Stanfield, 134, Liverpool Road, Great Crosby, nr. Liverpool ... ... (E) Nov. 1899

C.

Cadle, T. O. M., 11, Saville Row, Newcastle-upon-Tyne ... ... (E) Nov. 1904
Cairns, C. W., M.Sc., 22, Otterburn Avenue, Gosforth, Newcastle-upon-Tyne ... ... (E) { Graduate, Nov. 1894; Member, Dec. 1897 }
Carr, Ralph, jun., Thornleigh, Clayton Road, Newcastle-upon-Tyne ... ... (E) { Graduate, Jan. 1894; Member, Nov. 1901 }
Cama, Nusserwanji Bomanji, Sleater Road, Tardeo, Bombay, British India ... ... (E) Dec. 1888
Cameron, Angus, 27, Rosslyn Terrace, Sunderland ... ... (S) Nov. 1892
Cameron, Hugh Robert, Tweed House, York Terrace, North Shields (E) Feb. 1903
Carstens, Samuel, Messrs. Burmeister & Wains, Maskin- og Skibsbyggeri, Copenhagen, Denmark... ... ... (S) Dec. 1887
Carter, Geo. J., c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Elswick Shipyard, Newcastle-upon-Tyne ... ... (N A) Dec. 1897
Ceuvel, John L., 763, Gulgenstug, Naarden, Holland ... ... (E) Mar. 1886
Chaldecott, H. R., 17, Kenilworth Road, Newcastle-upon-Tyne ... (E) Jan. 1907
Champness, K. Coulter, Lloyd's Register of Shipping, Collingwood Buildings, Newcastle-upon-Tyne ... ... (SUR) Dec. 1904
Chapman, Harry Reynolds, Messrs. Clarke, Chapman & Co., Gateshead-on-Tyne .. .. (E) Mar. 1893
Chapman, John Abel, c/o Messrs. Clarke, Chapman & Co., Victoria Works, Gateshead ... ... (E) Mar. 1906
Charlton, F. J. L., Eng.-Lieut., R.N., 2, Brunswick Place, Southampton ... ... (E) Dec. 1906
Charlton, T., 23, Lincoln Street, Gateshead-on-Tyne ... ... (E) Nov. 1884
Chasen, Edward Catmore, 36, St. George's Terrace, Newcastle-upon-Tyne . ... (E) Oct. 1894
Chilton, John W., Vane Terrace, Seaham Harbour, Durham .. (M S) Dec. 1906
Chilton, Joseph, Laxey House, Polemarse Street, Blaydon-on-Tyne (E) Dec. 1899
Chisholm, Alexander, c/o Messrs. The Sunderland Shipbuilding Co., Sunderland ... ... (S) Mar. 1893
[illegible], J. D., 12, Northumberland Terrace, Tynemouth . (S) Nov. 1884
Clark, George, Southwick Engine Works, Sunderland (E) Feb. 1886
Clark, Henry, Southwick Engine Works, Sunderland . (E) Oct. 1887
Clark, John Harwood, Messrs. Sir James Laing & Sons, Deptford Yard, Sunderland . .. (E) Nov. [illegible]
Clarke, Harry, Lloyd's Register of Shipping, Bank Chambers, Newport, M[illegible] . (E) Mar. 189[illegible]
Clarke, [illegible] (S) Mar. 1892
Clegg, William George, [illegible] Terrace, [illegible], Newcastle (E) [illegible]
Clugston, Alexander, [illegible] (E) [illegible]

[redacted]

ELECTED.

Coller, F. E. W., Elswick Works, Newcastle-upon-Tyne ... ... (S) Jan. 1907
Collins, Edward D., 5, Albert Terrace, Whitley Bay, Northumberland ... ... (E) Feb. 1903
Conradi, Carl, Prinsens Gade 2b, Christiania, Norway ... ... (E) Nov. 1884
Cookson, John A., 2, St. Edmund's Road, Gateshead-on-Tyne ... ... (E) { Graduate, Dec. 1895; Member, Nov. 1897 }
Cookson, William D., 6, Primrose Hill, Low Fell, Gateshead-on-Tyne ... ... (E) Nov. 1901
Cooper, Shapoojee P., c/o Messrs. The Lakhshmi Cotton Manufacturing Co., Ld., Luxmi Mills, Sholapur, British India ... (E) Apl. 1903
Cormack, Charles, 7, John's Place, Leith, N.B. ... ... (SUP E) May 1908
Cornish, H. P., Lloyd's Register of Shipping, 28, Kattendyk, Ouest Quai, Antwerp ... ... (E) Oct. 1888
Couche, Henry Drew, 24, Derwent Road, Oxton, Birkenhead ... (S) Oct. 1891
Coull, Alex. B., Baltic Chambers, Newcastle-upon-Tyne ... ... (C E) Jan. 1898
Coull, Thomson B., c/o Red Star Line of Steamers, Department Technique, Antwerp ... ... (E) { Graduate Dec. 1906; Member Dec. 1906 }
Cowan, R., Grosvenor Road, Westoe, South Shields ... ... (E) Dec. 1896
Cowan, William W., 216, Alexander Road, Gateshead-on-Tyne ... (E D) Nov. 1905
Craggs, Ernest H., Messrs. R. Craggs & Sons, Tees Dockyard, Middlesbrough ... ... (S) Oct. 1888
Craggs, Robert Henry, Teeside Dockyard, Middlesbrough... ... (S) May 1908
Craig, Robert, Pageland House, Grange Road, West Hartlepool ... (E) Nov. 1892
Crammond, A., Tyne Dock Entrance, Corstorphine Town, South Shields ... ... (E) Nov. 1903
Crawford, T. W., 10, Haldane Terrace, Newcastle-upon-Tyne ... ... (E) { Graduate Nov. 1903; Member Oct. 1906 }
Crighton, A. T., Messrs. Egyptian Mail Steamship Co., Ltd., 18, Rue de la Republique, Marseilles ... ... (E) April 1903
Crookston, John, 72, Mark Lane, London, S.E. ... ... (E) Mar. 1896
Crouch, Herbert, c/o Messrs. The Thames Ironworks and S. B. Co., Tidal Basin, London, E. ... ... (S) May 1905
Crozier, Thomas W., c/o Messrs. Blyth Shipbuilding Co.. Blyth ... (S) Dec. 1902
Cruddas, W. D., Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Elswick, Newcastle-upon-Tyne ... ... (E) Dec. 1884
Cruickshank, Alexander, 34, Landford Road, Putney, London, S.W.... ... ... (SUR) Mar. 1892
Cruikshank, A., 34, Landford Road, Putney, London, S.W. ... ... (E) { Graduate Nov. 1899; Member Oct. 1906 }
Cummins, William, 30, Ewesley Road, Sunderland... ... ... (E) Mar. 1896
Curgenven, L. W., Eng.-Lieut., c/o The Admiralty, Whitehall, London ... ... (E) Nov. 1903
Currie, H. B., 48, Jesmond Road, Newcastle-upon-Tyne (C E) { Graduate, Nov. 1897; Member, Oct. 1904 }

D.

Dalrymple, Wm., Myrtle Cottage, nr. Cleadon, Sunderland ... (E) Dec. 1886
Dalrymple, William, Jun., c/o Messrs. Ruston Proctor & Co., Sheaf Ironworks, Lincoln ... ... (E) Dec. 1895
Daniels, A. F. G., 2, Woodlands Terrace, South Shields .. (SUP E) Jan. 1907
Danielsen, John William, Highfield, Farquhar Road, Birmingham... ... ... (E) { Graduate, Mar. 1899; Member, Mar. 1902 }

ELECTED.

Douglas, John F., c/o Messrs. Day Summers & Co., Northam Iron-works, Southampton ... ... (E) Jan. 1888

Dove, Herbert J., 14, Lyndhurst Avenue, Jesmond, Newcastle-upon-Tyne ... ... (E) Nov. 1896

Downing, Nicholas, Glenbrooke, Victoria Avenue, Norton Road, Stockton-on-Tees ... ... (I F) Oct. 1894

Dowsen, Chas., 21, Croft Terrace, Jarrow-on-Tyne... ... ... (E) Dec. 1885

Dowsen, Charles, jun., 21, Croft Terrace, Jarrow-on-Tyne (S) { Graduate, Feb. 1901; Member, Oct. 1904 }

Dowsen, Jas. Wm., Gillett House, 53, Frobisher Street, Hebburn-on-Tyne ... ... (E) May 1903

Doxford, Albert Ernest, M.A., Cleadon Meadows, Sunderland... ... ... (E) { Graduate, Oct. 1890; Member, Nov. 1893 }

Doxford, Charles D., Pallion Shipyard, Sunderland ... ... (S) Nov. 1884

Doxford, Robt., jun., Silksworth Hall, Sunderland (S) { Graduate, Feb. 1897; Member, Dec. 1901 }

Doxford, Robert P., Pallion Engine Works, Sunderland ... ... (E) Nov. 1884

Doxford, Sir W. Theodore, M.P., Pallion Shipyard, Sunderland ... (S) Nov. 1884

Doxford, William, M.Sc., c/o Messrs. W. Doxford & Sons, Pallion Shipyard, Sunderland ... ... (S) May 1908

Dressler, Gustav, c/o Messrs. Blohm & Voss, Shipbuilders, Hamburg (E) Jan. 1900

Duckitt, Jno., "Wimborne," Holywell Avenue, Monkseaton, Northumberland ... ... (E) Nov. 1884

Duckitt, John Brentnall, "Leazes," Arnold Hill, Hyde, Cheshire ... ... (E E) { Graduate, Oct. 1888; Member, April 1895 }

Duckitt, Talbot, "Grasmere," 14, Hillaries Road, Gravelly Hill, Birmingham ... ... (E E) { Graduate, Oct. 1891; Member, Oct. 1898 }

Dugdale, William H., Wear Dock Yard, Sunderland ... (C E, S) Mar. 1894

Duguid, Robert, c/o Messrs. Thomas Wilson & Sons, Naval Architects' Department, Hull ... ... (S) Oct. 1892

Dykes, John, Lloyd's Register of Shipping, 3, Oriental Place, Southampton ... ...(SUR) Oct. 1889

E.

Eason, Thos., 30, Rothwell Road, Gosforth, Newcastle-upon-Tyne (E) April 1899

Easthope, James, Messrs. Lloyds Register of Shipping, Ramsden Square, Barrow-in-Furness ... ... (SUR) Dec. 1903

Eden, Edgar Mark, 25, Coquet Terrace, Heaton, Newcastle-on-Tyne... ... . (E) April 1908

Edmiston, A. R., 7, Lovaine Avenue, North Shields (E) { Graduate, Jan. 1898; Member, Oct. 1904 }

Edwards, Robert Wm., Eng. Captain, R.N., H.M.S. "Agamemnon," Nore Division, Home Fleet ... ... (R N E) Feb. 1902

Elder, Edward, c/o Messrs. Frew, Elder, & Co., 9, Queen Street, Newcastle-upon-Tyne ... ... (S) { Graduate, Nov. 1890; Member, Oct. 1892 }

Elliott, Andrew, 28, Barkeley Drive, Seaforth, near Liverpool ... (E) May 1903

Elliott, E. E., 31, Via S. Spirits, Florence, Italy ... . (CE) Nov. 1907

Elliott, Richard G., 184, Chillingham Road, Heaton, Newcastle-upon-Tyne ... ... (S) May 1905

Elliott, William D., Hessle, Hull ... ... (E) Nov. 1894

Eltringham, Harry, Messrs. J. T. Eltringham & Co., Stone Quay, South Shields ... ... (S) Feb. 1901

ELECTED.

English, George W., Ash Lea House, South Hylton, near Sunderland ... ... (M E) Nov. 1905
Eshelby, William, 13, Brankingham Terrace, Norton Road, Stockton-on-Tees ... ... (E) Feb. 1888
Eyres, Reginald J., 4, Cedars Crescent, Sunderland ... (C E) Feb. 1900

F.

Fairbairn, Archbold, Violet Street, South Hylton, Sunderland ... (E) Mar. 1902
Fairburn, William Armstrong, P.O. Box, 183, Quinay, Mass., U.S.A. (*Life Member*) ... ... (N A) (E) Nov. 1902
Fairweather, C. W., C. Milburn House, Newcastle-upon-Tyne ... (E) Oct. 1902
Farina, A. J., 63, Quayside, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Farquharson, Geo. James, Claudiusstr 31, Wandsbek Bei, Hamburg (E) April 1899
Fawcus, Walter, "Halcyon," 15, Marina, Western Shore, Southampton ... ... (E) Nov. 1907
Fenwick, James, B.Sc., C.E., 19, Bridge Street, Sydney, New South Wales ... ... (E) Oct. 1892
Ferguson, Wm. Deeble, 3, Mount Delphi, Antrim Road, Belfast ... (CE) Feb. 1901
Ferry, S. O., 10, Malvern St., Newcastle-upon-Tyne ... ... (E) Oct. 1902
Field, Arthur M. C., 30, St. Cuthbert's Terrace, Blackhill, Co. Durham ... ... (E E) Jan. 1898
Field, Thomas, 23, Lansdowne Terrace, Gosforth, Newcastle-upon-Tyne ... ... (E SUR) April 1907
Figari, Emanuel D., c/o Messrs. Odero & Co., Shipbuilding Yard, Foce, Genoa, Italy ... ... (S) Dec. 1900
Findlay, John Taylor, 6, Earls Dene, Low Fell, Gateshead (S SUR) Mar. 1902
Fish, Thomas Wilson, Lloyd's Register of Shipping, 2 Hare Street, Calcutta, British India ... ...(SUR) May 1892
Fisher-Christensen, J. A. L., 318, North 4th Street, Camden, New Jersey, U.S.A. ... ... (E D) Nov. 1905
Fitzgerald, Arthur F., 39, Horsley Road, South Shields (E) { Graduate, Feb. 1901; Member, Oct. 1902 }
Fitzgerald, Durham W., Messrs. J. T. Eltringham & Co., Stone Quay, South Shields ... . (S) Dec. 1900
Flood, George H., 442, Westgate Road, Newcastle-upon-Tyne ... (S) Jan. 1907
Foggan, John, 26, Curtis Road, Newcastle-upon-Tyne ... ... (E S) Oct. 1904
Ford, John McLaren, 70, Mount Pleasant, Barrow-in-Furness ... (S) Nov. 1896
Forster, William James, 92, Granville Road, Middlesbrough ... (NA) Dec. 1903
Fortune, Tom Cameron, 76, Falmouth Road, Heaton, Newcastle-upon-Tyne ... ... (E) { Graduate, Jan. 1902; Member, April 1905 }
Foster, Henry, Greenhill House, Griffithstown, near Newport, Mon. (E) April 1885
Foster, Herbert Symes ... ... (E E) Dec. 1904
Foster, Martin, Claremont, Norton, Stockton-on-Tees ... ... (F M) Nov. 1900
Fothergill, J. R., 1, Bathgate Terrace, West Hartlepool ... ... (C E) Mar. 1886
Fowler, Jas. Speir, 5, Stanley Terrace, Fishergate Hill, Preston, Lancashire ... ... (E) Nov. 1901
Fox, Carter, 32, Lish Avenue, Whitley Bay ... ... (E) { Graduate, Feb. 1898; Member, Dec. 1899 }
Fox, William, 56, Talbot Road, Old Trafford, Manchester ... (E) April 1895
France, Alfred Brown, "Normandale," Linden Grove, West Hartlepool ... ... (E) Feb. 1900

ELECTED.

Franki, J. P., c/o Messrs. Morts Dry Dock and Engineering Co., Sydney, N.S.W., Australia ... ... (E) Jan. 1886
Friederichs, Herbert F., West Hartlepool Electricity Works, Burn Road, West Hartlepool ... ... (E E) Mar. 1901
Fuller, Philip S., 229, Cardigan Terrace, Gateshead-on-Tyne ... (E) Nov. 1899
Furness, Stephen Wilson, Messrs. Furness, Withy & Co., West Hartlepool ... ... (S) May 1904

G.

Gaisford, Harold, Eng. Com. R.N., 78, Dorchester Road, Weymouth (E C)
Gannaway, H. G., Palazzina Faggiani, via Colombara, Cornigliano-Ligure, Italy ... ... (S) Nov 1884
Garmey, John, Prince Line, Ltd., Produce Exchange, New York... (E) Dec. 1898
Garson, Stanley T., 5, Rome Terrace, Borough Road, Middlesbrough ... ... (I M) Nov. 1902
Garthwaite, John R., c/o Messrs. R. Ropner & Sons, Stockton-on-Tees (S) May 1889
Garwood, Harry Tom, Eng. Commander R.N., H.M.S. "Exmouth," Atlantic Fleet ... ... (R N E) May 1903
Gates, W., 2, Morpeth Avenue, South Shields ... ... (SUP E) Jan. 1907
Gayner, Robt. H., Jun., West Bank, Sunderland ... (E) Graduate, Mar. 1886; Member, Oct. 1888
Geddes, Christopher, 2A, Drury Lane, Water Street, Liverpool ... (E) Oct. 1888
Gibb, Maurice S., Central Marine Engine Work, West Hartlepool... (E) Mar. 1908
Gibbs, Alfred P., 83, Goldhurst Terrace, South Hampstead, London ... ... (E) Graduate, Nov. 1901; Member, Nov. 1905
Gibson, H., 1, Park Parade, Roker, Sunderland ... ... (S) Nov. 1884
Gibson, J. Hamilton, c/o Messrs. Cammel, Laird & Co., Birkenhead Iron Works, Birkenhead ... ... (E) Graduate, April 1891; Member. Oct. 1894
Gibbeson, John W., Wansbeck Villa, Choppington, Morpeth ... (E) Jan. 1907
Golledge, William, c/o Messrs. Tutbury Engineering Co., Ltd., Tutbury, Burton-on-Trent ... ... (E E) Graduate, Nov. 1891; Member, Nov. 1896
Good, Farrant, The Croft, Beer, R.S.O., Devon ... ... (E) Mar. 1896
Gordon, William James, c/o Messrs. Vickers, Sons & Maxim, Naval Construction Works, Barrow-in-Furness ... ... (E) Oct. 1887
Gordon, William Leslie, Invermark, Broughty Ferry, N.B. ... (E) April 1893
Graham, James Thos., 252, Westmorland Road, Newcastle-upon-Tyne ... ... (E) Nov. 1897
Graham, Joseph S., Morro House, Syon Street, Tynemouth ... (S) Feb. 1903
Graham, William, West House, Tynemouth ... ... (S) Oct. 1891
Graham, William, 30, Hill Street, Jarrow-on-Tyne... ... ... (S) April 1893
Graham, William, Rockcliffe, Redbrink Crescent, Barry Island, South Wales ... ... (E) Nov. 1894
Gravell, John, Bureau Veritas Register of Shipping, 155, Fenchurch Street, London, E.C. ... ... (N A SUR) Nov. 1884
Gray, Tom Leonard, 18, Grainger Street West, Newcastle-upon-Tyne ... ... (E E) Feb. 1906
Green, W. G., Churchill Street, Willington Quay-on-Tyne ... (E) Nov. 1884
Grimes, Thomas Benjamin, 39, Vespasian Avenue, South Shields... (E) Mar. 1890
Gulston, A., Clayton Park Lodge, Jesmond, Newcastle-upon-Tyne (E) Dec. 1888

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

List of Members, August, 1907.

EXPLANATION.

(A.)	Agent and Accountant.	(I. & S. M.)	Iron and Steel Merchants and Manufacturers.
(B. B.)	Boiler Builder.	(M.)	Merchant.
(C. E.)	Civil and Consulting Engineer.	(M. S.)	Marine Superintendent.
(E)	Engineer and Boilermaker.	(N. A.)	Naval Architect.
(E. A.)	Engineering Agent.	(R. M.)	Rope Manufacturer.
(E. E.)	Electrical Engineer.	(S.)	Shipbuilder.
(F. M.)	Forge Master.	(S. O.)	Ship Owner.
(F.)	Iron and Brass Founder.	(SUR.)	Engineer & Ship Surveyor
(D.)	Draughtsman.	(P)	Pupil.

HONORARY MEMBERS.

		ELECTED.
Sir W. H. White, K.C.B., LL.D., F.R.S., D.Sc., Cedarcroft, Putney Heath, London, S.W.	(N A)	Nov. 1884
The President of the Institution of Naval Architects (The Right Honourable the Earl of Glasgow, G.C.M.G., LL.D., Fairlie Craig, Fairlie, Ayrshire)		April 1902
The Right Honourable Lord Armstrong, M.A., D.C.L., D.L., J.P., Cragside, Rothbury		Feb. 1904
Sir Andrew Noble, Bart., K.C.B., F.R.S., Jesmond Dene House, Newcastle-upon-Tyne		Mar. 1904
The Principal of Armstrong College, Newcastle-upon-Tyne (Sir Isambard Owen, D.C.L., M.D.)		Nov. 1906
Sir Philip Watts, K.C.B., F.R.S., LL.D., D.Sc., The Admiralty, Whitehall, London	(N A) Member Hon. Mem.	Nov. 1885 May 1907

MEMBERS.

A.

Adams, Cecil T., c/o Messrs. The N.E. Marine Engineering Co., Sunderland Works, Sunderland	(E) Graduate, Member,	Oct. 1891 Nov. 1897
Adamson, Chas. P., c/o Mrs. Burt, 207, Kent Road, Glasgow	(E) Graduate, Member,	Nov. 1897 April 1901
Adamson, Daniel, c/o Messrs. Joseph Adamson & Co., Hyde. Cheshire	(E) Graduate, Member,	Feb. 1888 Oct. 1894
Adamson, David, "Balmereco," Lenchars, Fife, N.B.	(E D)	Nov. 1905
Adamson, Henry, Supt. Eng., Adelaide S.S. Co., 6, Bridge Street, Sydney, N.S.W.	(E)	Oct. 1902

ELECTED.

Henderson, Alex., 11, Rua Nova do Almada 1°, Lisbon ... ... (E) April 1893
Henderson, A. M., Bennochy, Elm Grove, West Hartlepool ... (E) Nov. 1890
Henderson, John, c/o Messrs. A. Henderson & Co., Mount Stuart Square, Cardiff ... ... (E) June 1896
Henry, William P., Cragside, St. Aidan's Road, South Shields ... (E) April 1897
Henshall, Samuel, c/o Messrs. Sir Raylton Dixon & Co., Cleveland Dockyard, Middlesbrough ... ... (S) { Graduate, May 1885; Member, Jan. 1894 }
Hepburn, Alfred, c/o Messrs. N.E. Marine Engineering Co., Northumberland Forge, Wallsend-on-Tyne ... ... (F M) Dec. 1890
Hepburn, James M., 17, Grosvenor Place, Newcastle-upon-Tyne ... ... (E) { Graduate, Nov. 1895; Member, Dec. 1901 }
Heslop, Thomas, 6, Eldon Place, Newcastle-upon-Tyne ... ... (E) Dec. 1900
Hewison, Herbert, 31, Ferndale Avenue, Wallsend-on-Tyne ... (S) Dec. 1900
Higginbotham, George Emerton, c/o Messrs. John H. Holmes & Co., Portland Road, Newcastle-upon-Tyne ... ... (E) Nov. 1900
Hildrey, A. J., 11, Newcastle Road, Sunderland ... ... (S) Nov. 1884
Hinchliffe, Robert, 29, Lish Avenue, Whitley Bay, Northumberland ... ... (S) { Graduate, Nov. 1893; Member, Oct. 1898 }
Hobson, J. W., 53, Bishop's Road, Benwell, Newcastle-on-Tyne ... ... (E) { Graduate, Nov. 1903; Member, Nov. 1907 }
Hodge, Rowland F. W., c/o Messrs. The Northumberland Shipbuilding Co., Limited, Northumberland Shipyard, Howdon-on-Tyne ... ... (S) Dec. 1890
Hogarth, G. V. ... ... (S) May 1900
Hogg, Archibald, 80, Welbeck Road, Walker-on-Tyne ... ... (S) Jan. 1897
Hök, Wilhelm, 10, Karlaplan, Stockholm, Sweden ... ... (S) Oct. 1886
Hollis, Henry E., 87, Union Street, Glasgow ... ... (I & S M) Feb. 1858
Holmes, John H., Wellburn, Jesmond Dene Road, Newcastle-upon-Tyne ... ... (E E) Jan. 1888
Holmes, Stephen, 15, Park Road, Jarrow-on-Tyne ... (E) { Graduate, Dec. 1901; Member, Oct. 1905 }
Houston, John, 7 Thornhill Crescent, Sunderland ... ... (E) Nov. 1894
Howie, Robert, Messrs. Lloyd's Register of Shipping, 28, Ouest Quai, Kattendyk, Antwerp .. .. (SS) Oct. 1904
Hughes, Thos. Charles, 8, Oxnam Crescent, Spital Tongues, Newcastle-upon-Tyne ... ... (E) { Graduate, Nov. 1893; Member, Nov. 1897 }
Humphreys, George, Ashfield, Northumberland Avenue, Forest Hall, Northumberland ... ... (E) Jan. 1902
Hunt, Allen E., 8, Dockwray Square, North Shields ... (SUR) Feb. 1901
Hunter, George B., D.Sc., Messrs. Swan, Hunter & Wigham Richardson, Ltd., Wallsend-on-Tyne ... ... (S) Nov. 1884
Hunter, George Ernest, c/o Messrs. Swan, Hunter & Wigham Richardson, Ltd., Wallsend-on-Tyne ... ... (S) { Graduate, Feb. 1898; Member, Nov. 1899 }
Hunter, Joseph Gilbert, Lloyds Register of Shipping, Bute Docks, Cardiff ... ... (SUR) Feb. 1900
Hunter, J. W., 22, Argyle Square, Sunderland ... ... (E) May 1885
Hunter, Summers, c/o Messrs. N.E. Marine Engineering Co., Northumberland Engine Works, Wallsend-on-Tyne ... ... (E) Nov. 1885
Hutchinson, C. W., 214, Westmoreland Road, Newcastle-on-Tyne (E) Nov. 1884
Hutchison, J., Board of Trade Offices, North Shields ... ...(SUR) Dec. 1891
Hyslop, Alfred M., c/o Messrs. Boothroyd, Hyslop & Co., Akenside Street, Bootle, Liverpool ... ... (E) Mar. 1900

I.

		ELECTED.
Inglis, John, c/o Messrs. Hawthorn & Co., Leith	(S)	April 1887
Inglis, John, LL.D., Pointhouse Shipyard, Glasgow ...	(E & S)	Oct. 1886
Ingram, Herbert P.	(NA)	Dec. 1906
Ireland, J. H. H., Eng. Com. R.N., H. M. Yacht, "Alexandra," Portsmouth	(E)	Dec. 1906
Irvin, Matthew B., Jesmond Cottage, Mustapha Pasha Ramleh, Alexandria, Egypt	(E)	Oct. 1900
Irwin, J. H., The Gables, Ashbrook Range, Sunderland	(E)	Nov. 1884
Isherwood, Joseph William, Roman Road, Linthorpe, Middlesbrough	(S)	May 1908
Ito, Kumezo, Mitsu Bishi Dockyard and Engine Works, Nagasaki, Japan	(E)	Dec. 1900

J.

Jack, Joseph, 14, Coquet Terrace, Heaton, Newcastle-upon-Tyne	(SUP E)	Dec. 1906
Jack, William C., Victoria Buildings, 5, Queen's Road Central, Hongkong, China	(E)	Nov. 1894
Jackson, William S., Messrs. Gourlay Bros. & Co., Camperdown Shipyard, Dundee, N.B.	(S)	April 1891
James, M. C., 39, Beverley Terrace, Cullercoats, Northumberland	(S)	Nov. 1884
James, Matthew C., Jun., 62, Blagdon Avenue, Westoe, South Shields	(E E)	Graduate, May 1899; Member, Mar. 1906
Jarvis, Harry Robert, 12, Burnfoot Terrace, Whitley Bay, Northumberland	(S)	Feb. 1901
Jarvis, Horace William, West Dyke, Coatham, Redcar	(E)	May 1902
Job, Norris H., 79, Station Road, Norton, Stockton-on-Tees ...	(C E)	Nov. 1905
Jobling, W. J., 1, Akenside Hill, Newcastle-upon-Tyne ...	(E & S O)	Nov. 1884
Johnson, Alexander A., 5, Quayside, Newcastle-upon-Tyne ...	(E)	Feb. 1893
Johnson, Alfred, Victoria Buildings, Stockton-on-Tees	(C E)	Nov. 1907
Johnson, Charles, 118, Biddlestone Road, Heaton, Newcastle-upon-Tyne	(E)	Nov. 1907
Johnson, Johan, 16, Magasinsgatan, Gothenburg, Sweden ...	(S)	May 1885
Johnson, Joseph, Messrs. Cammell, Laird & Co., Ltd., 28a & 29, Collingwood Buildings, Newcastle-upon-Tyne	(E)	May 1901
Johnson, T. Allan, Clive Hall, Canton, Cardiff	(S)	Nov. 1884
Johnston, J. M'Fetridge	(S)	Graduate, Nov. 1903; Member, Oct. 1904
Jones, Arthur P., Lloyd's Register of Shipping, 16, Rue Beauvau, Marseilles	(E)	April 1903
Jones, Edmund V., 139, Normount Road, Benwell Grove, Newcastle-on-Tyne	(S)	Jan. 1907
Jones, George, c/o Messrs. Sir W. Gray & Co., Shipyard, West Hartlepool	(S)	Oct. 1888

K.

Kapadia, Framjee Dorabjee, Khetmadi 10th Lane, Arab Motimwalla's Bungalow, Girgaunr-post, Bombay, British India	(E)	Feb. 1903
Kemp, Herbert J., 1, Theobald Road, Cardiff	(E)	Nov. 1904

ELECTED.

Kendall, Stonard O., Lloyd's Register of Shipping, 97 and 98, Scottish Provident Institution Buildings, Donegal Square West, Belfast ... ...(SUR) Mar. 1891
Kennedy, Robert Sinclair, Glengall Ironworks Millwall, London, E. ... ... (E) Dec. 1905
Kennedy, William, 14, Gladstone Street, Hartlepool ... ... (E) April 1900
Kerfoot, James, Messrs. The Antwerp Engineering Co., Rue des Indes, Antwerp ... ... (E) Oct. 1892
Kerr, Robert, Bank Chambers, Mosley Street, Newcastle-upon-Tyne ... ... (E) Oct. 1902
King, John, Surveyor's Office, Board of Trade, Liverpool ... ... (S) { Graduate, Dec. 1890 / Member. Oct. 1892 }
Kirkaldy, John, 21, Ground Floor, Leadenhall House, 101, Leadenhall Street, London, E.C. ... ... (E) Nov. 1885
Kitching, J. F., 36, Lime Street, London, E.C. ... ... (E) Nov. 1890
Knight, R. C., 19, Highbury, West Jesmond, Newcastle-on-Tyne ... ... (S) { Graduate, Nov. 1901 / Member Nov. 1907 }
Knox, Robert, 14, West Avenue, Gosforth, Newcastle-upon-Tyne (NA) Dec. 1903
Kyle, Norman M. W., Norwood, West Avenue, Gosforth, Newcastle-upon-Tyne ... ... (E) Nov. 1898

L.

Laing, Andrew, c/o Messrs. Wallsend Slipway and Engineering Co., Wallsend-on-Tyne ... ... (E) Oct. 1892
Laing, Hugh, Deptford Shipyard, Sunderland ... ... (N A) April 1897
Landreth, Cowen, Northumberland Avenue, Forest Hall, Northumberland ... ... (E) Mar. 1896
Latta, James G., 77, Billiter Buildings, Billiter Street, London, E.C. ... ... (C E) Mar. 1902
Laws, B. C., Messrs. Lloyd's Register of Shipping, Collingwood Buildings, Newcastle-upon-Tyne ... ... (NA) Nov. 1903
Lax, George A., 141, High Park Road, Newcastle-upon-Tyne ... (S) Jan. 1907
Leitch, John S., c/o Messrs. Workman, Clarke & Co., Ltd., Belfast Shipyard, Belfast ... ... (S D) { Graduate, Mar. 1903 / Member, Jan. 1906 }
Levick. Charles E., Clarence Street Works, Sheffield ... ... (S M) April 1907
Lewins, Frank, Rosehill, Willington-on-Tyne ... ... (E) Dec. 1895
Lindfors, Hugo, Surveyor to Lloyd's Register of Shipping, 16 Alexandersgatan, Helsingfors, Finland ... ... (SUR) May 1889
Lineham, Wilfrid J., Jesmond, 21, Newstead Road, Lee, London, S.E. ... ... (E) Oct. 1890
Lishman, John J., Jun., Moult Tors, Salcombe, S. Devon { Graduate, Dec. 1892 / Member, May 1900. }
Littleboy, Chas. Wm., South Stockton Iron Shipyard, Stockton-on-Tees ... ... Oct. 1887
Littledale, John W. E., c/o Great Western Railway, Park Generating Station. Park Royal, Willesden, London.
Livingston, Thos. L., Bowerhope, Hill Street, Jarrow-
Lohmeyer, H. G. C., 53, Crown Street, Newcastle-
Long, A. E., Ierne, Bede Burn Road, Jarrow-on-T
Lonnon, W., Eng.-Com., R.N., 93, London Road,
Lopez, Jose S., 71, Osborne Avenue, Jesmond, Tyne ... ...

		ELECTED.
Loveridge, Wm. Henry, 8, Grantully Terrace, West Hartlepool ...	(E)	Feb. 1901
Lowes, J. Alfred, 35, West Sunniside, Sunderland	(E)	Dec. 1903
Luhrs, H., 29, Ferndale Avenue, Wallsend-on-Tyne	(E)	Graduate, Nov. 1899 Member. Oct. 1904
Ludgate, William G., Eng.-Com., R.N., 49, Holly Avenue, Newcastle-upon-Tyne	(E)	Jan. 1907
Lumley, Gascoigne, "Lagos," Southern Nigeria	(E)	Nov. 1901
Lund, Pearson, Messrs. Noble & Lund, Northern Machine Tool Works, Felling-on-Tyne	(E)	Nov. 1900
Lyon, William J., 10, Lynnewood Place, Maryfield, Dundee, N.B.	(E)	Nov. 1905

M.

MacColl, Hector, Kirkliston Drive, Bloomfield, Belfast	(E)	Dec. 1890
MacColl, Hugo, Wreath Quay Engineering Works, Sunderland (*Life Member*)	(E)	Nov. 1896
Macdonald, Charles, 4, St. Nicholas' Buildings, Newcastle-upon-Tyne	(SUR)	Feb. 1898
MacDonald, David R., c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Walker Shipyard, Newcastle-upon-Tyne	(S)	Nov. 1891
Mace, W., 2, Kew Gardens, Monkseaton, Northumberland ...	(E)	Jan. 1886
Macdonald, J. F., 5, Park Avenue, Roker, Sunderland	(SUR)	Jan. 1907
Macdonald, Thomas, 5, York Street, Glasgow	(E)	Jan. 1906
Macfarlane, Archibald P., 25, Kells Gardens, Low Fell, Gateshead-upon-Tyne	(E)	Mar. 1902
MacHaffie, John, 635, Terrace Place, Schenectady, New York, U.S.A. (*Life Member*)	(E)	Dec. 1885
Mackay, William, 15, Haldane Street, Whiteinch, near Glasgow	(S)	Mar. 1892
Mackley, Edward N., 55, Wingrove Road, Newcastle-upon-Tyne	(E)	April 1901
Mackley, J. R., 55, Wingrove Road, Newcastle-upon-Tyne	(E)	Graduate. Dec. 1902 Member. Oct. 1904
Macleod, M., Messrs. Lloyd's Register of Shipping, Collingwood Buildings, Newcastle-upon-Tyne	(S SUR)	Mar. 1907
Maillard, James, 307, Beaconsfield Street, Newcastle-upon-Tyne	(E D)	Nov. 1905
Male, Francis John, B.Sc., 9, Abbey Terrace, Gateshead-on-Tyne	(E)	Nov. 1902
Manaira, Giuseppe, c/o Messrs. The Cantiere Navale di Muggiano, Spezia, Italy	(E & N A)	Nov. 1893
Marr, James, c/o Messrs. J. L. Thompson & Sons, North Sands Shipyard, Sunderland	(S)	Nov. 1884
Marr, J. Lynn, Parkside, Roker, Sunderland	(E E)	Jan. 1908
Marshall, R. J., 53, Larkspur Terrace, Jesmond, Newcastle-upon-Tyne...	(E)	Mar. 1887
Marshall, Robert, Board of Trade Surveyor's Office, West Hartlepool	(SUR)	Mar. 1901
Mason, George F., Lloyds' Bank Buildings, Mount Stuart Square, Cardiff	(E)	Oct. 1895
Massey, L. F., M.I.M.E., Messrs. B. & S. Massey, Openshaw, Manchester	(E)	Mar. 1907
Mather, Charles, 60, St. George's Terrace, Newcastle-upon-Tyne	(SUR)	Oct. 1888
Mather, Thomas Brewer, Denholme, Osborne Gardens, Monkseaton, Northumberland	(C E)	Nov. 1898

ELECTED.

Matheson, William, c/o Messrs. R. & W. Hawthorn, Leslie & Co., Hebburn-on-Tyne... ... ... (S) Dec. 1889
Mathieson, Donald, 28, Belle Vue Park, Sunderland ... ... (E) Nov. 1898
Matthews, Jas., c/o Messrs. R. & W. Hawthorn, Leslie & Co., Forth Banks, Newcastle-upon-Tyne ... ... (E) Oct. 1886
Maxwell, William Ward, B.Sc., Messrs. H. Charlton & Co., Engineers, Gateshead-on-Tyne ... ... (E) Dec. 1896
McArthur, Duncan, Maritime Buildings, St. Thomas Street, Sunderland ... ... (E SUR) Dec. 1906
McBride, William, Hartburn, Cleveland Road, Hartlepool ... (E) Dec. 1894
McClintock, E. E., 73, Cleveland Road, North Shields ... ... (E) Nov. 1903
McCoull, Cecil, 4, Leazes Park Road, Newcastle-upon-Tyne ... ... (EE) { Graduate, Oct. 1895 / Member, Dec. 1901 }
McCullock, T. M., c/o Mrs. Kelly, 146, Hendon Road, Sunderland (S) Feb. 1905
McFarlane, John T., Craigmore, Cargil Terrace, Trinity, Leith, N.B.... ... ... (S) Nov. 1905
McGlashan, Arch., Beechcroft, Clifton Avenue, West Hartlepool (S) Nov. 1885
McIlvenna, J. G., West Chirton Hall, North Shields ... ... (S) Nov. 1884
McKechnie, James, Messrs. Vickers, Sons & Maxim, Naval Construction Works, Barrow-in-Furness ... ... (E) April 1896
McKenna, Francis, c/o Messrs. E. F. Wailes & Co., 4, St. Nicholas' Buildings, Newcastle-upon-Tyne ... (E) { Graduate, Dec. 1890 / Member, Dec. 1896 }
McKenzie, James, 11, Holmwood Grove, West Jesmond, Newcastle-upon-Tyne ... ... (E) Nov. 1907
McLaren, Robert M., Lloyd's Register of Shipping, 342, Argyle Street, Glasgow ... ... (S) Nov. 1893
McLean, John H. K., Abey House, Plotina Terrace, South Shields (S) Mar. 1897
McLellan, William, c/o Messrs. Merz & McLellan, Collingwood Buildings, Newcastle-upon-Tyne ... ... (CE) Feb. 1903
McNab, Andrew P. W., Lloyd's Register of Shipping, 71, Fenchurch Street, London, E.C. ... ... (SUR) May 1903
McNeil, Thomas Young, Ship Drawing Office, Messrs. John Brown & Co., Clydebank, Glasgow ... ... (S) Oct. 1895
McRae, Alex., 91, Rothbury Terrace, Heaton, Newcastle-upon-Tyne ... ... (S) { Graduate, Mar. 1903 / Member, Oct. 1906 }
Meagher, H. L., 86, Park Road, Newcastle-upon-Tyne ... ... (E) Dec. 1896
Mechan, Henry, Scotstoun Ironworks, Scotstoun, Glasgow ... (E) May 1898
Meikle, A. F. T., 5, Caledonian Mansions, Glasgow ... ... (E) Oct. 1904
Meldrum, Harrison, 84, Aldborough Road, Seven Kings, Essex (SUP E) Oct. 1906
Meldrum, Michael, 2, Ashbrook Crescent, Sunderland ... ... (E) Dec. 1893
Mellanby, Alex. Lawson, D.Sc., The Glasgow and West of Scotland Technical College, Glasgow ... (E) { Graduate, Dec. 1894 / Member, Oct. 1896 }
Melville, James, Messrs. The Jute Factory Co., Ltd., Samnuggur, Calcutta ... ... { Graduate, Feb. 1900 / Member, Jan. 1902 }
Melvin, Robert, 17, Roker Baths Road, Sunderland .. ... (E) April 1908
Merz, Charles H., Messrs. Merz & McLellan, 28, Victoria Street, Westminster, London, S.W. ... ... (CE) Feb. 1903
Metcalf, Thos., 18, John Street, Sunderland ... (S) { Graduate, May 1885 / Member, Nov. 1893 }
Metcalfe, C. S., 3, Argyle Street, Sunderland ... ... (E) Nov. 1884
Meuwissen, J., Engineer, Chargé de Cours à l'Université de Gand, 29, Rue des foulons, Ghent, Belgium ... ... (E) Nov. 1899

ELECTED.

Middlemass, Thomas, Inglefield, Eaglescliffe, R.S.O. ... ... (S) Oct. 1889
Middleton, H., 20, Lynnwood Avenue, Newcastle-upon-Tyne (I & S M) Jan. 1893
Middleton, R A., 20, The Grove, Benton, near Newcastle-upon-Tyne ... ... (N A) Oct. 1892
Millar, Thos., 81, St. Vincent Street, Glasgow ... ... (S) Nov. 1884
Mills, Giles, Salisbury Chambers, Fish Docks, Grimsby ... ... (E) Mar. 1906
Milne, Geo. M., 9, James Place, Broughty Ferry, Scotland (S) { Graduate, Feb. 1898; Member, Nov. 1903 }
Milne, J. J., Anthracit Werke, Gusta Schulze, Gm. C. H. Steinwarder, Hamburg ... ... (SUP E) Jan. 1908
Milne, W. J., 18, Kirton Park Terrace, North Shields ... (SUP E) Nov. 1907
Mills, William, Northwood, Roker, Sunderland ... ... (E) Dec. 1906
Milne, James, Messrs. Hawthorn, Leslie & Co., Hebburn-on-Tyne (E) Nov. 1904
Milton, James Edward, Messrs. Lloyd's Register of Shipping, 71, Fenchurch Street, London, E.C. ... ...(SUR) Nov. 1900
Milton, J. T., Lloyd's Register of Shipping, 71, Fenchurch Street, London, E.C. ... ... (E SUR) Nov. 1886
Mitchell, Ewen H., Elswick Shipyard, Newcastle-upon-Tyne ... (S) Jan. 1907
Mitchell, Wm., 61, Nelson Street, Willington Quay-on-Tyne (S) { Graduate, Jan. 1898; Member, Feb. 1901 }
Moffatt, William Graham, 6, Northland Drive, Scotstoun, Glasgow (E) Mar. 1899
Moffitt, George, c/o Messrs. The Blyth Shipbuilding Co., Blyth ... (S) Oct. 1888
Moncrieff, John M., Consett Chambers, Pilgrim Street, Newcastle-upon-Tyne ... ... (C E) Dec. 1899
Moody, Thomas V., c/o Messrs. Scott Bros., 46, Sandhill, Newcastle-upon-Tyne ... ... (E) Dec. 1887
Morgan, John Osborn, Bank Chambers, Sandhill, Newcastle-upon-Tyne... ... ... (CE) Feb. 1901
Morgan, W. H., 8, Hawthorn Grove, Wallsend-on-Tyne ... ... (E) Nov. 1884
Morison, D. B., Hartlepool Engine Works, Hartlepool ... ... (E) Feb. 1885
Mörk, Peter, Osterbrogade 56D, Copenhagen ... ... (E) Nov. 1884
Morley, John W., Consett Chambers, Pilgrim Street, Newcastle-upon-Tyne ... ... (E) Jan. 1907
Moroney, E. F., Board of Trade, Surveyor's Office, Liverpool ... ... (E) { Graduate, Feb. 1892; Member, Nov. 1899 }
Morris, Arthur, Elswick Shipyard, Newcastle-upon-Tyne ... ... (NA) Jan. 1907
Morrison, William, Lloyd's Register of Shipping, Maritime Buildings, Dundee ... ... (E SUR) Oct. 1890
Morrow, John, Armstrong College, Newcastle-upon-Tyne ... (E) April 1908
Morton, John, 13, Hillside, Tunstall Road, Sunderland ... ... (E) Nov. 1902
Morton, Richard Fraser, Lloyd's Register of Shipping, Orchard Chambers, Church Street, Sheffield ... ... (E SUR) Oct. 1890
Morvig, Georg B., 34, Azalea Terrace South, Sunderland ... (SUR) May 1908
Moss, William, 14, Leazes Terrace, Newcastle-upon-Tyne ... ... (E) { Graduate, Jan. 1898; Member, Dec. 1901 }
Mould, Francis H., 34, St Alban's Road, Swansea (E) { Graduate, Feb. 1892; Member, Jan. 1897 }
Mountain, William Chas., The Hermitage, Gateshead-on-Tyne (E E) Feb. 1889
Mudd, Percival Arthur, c/o Messrs. P. A. Mudd & Co., Engineers, 55, Church Street, West Hartlepool (E) { Graduate, Oct. 1900; Member Oct. 1902 }
Muir, Alfred Edward, Messrs. J. L. Thompson & Sons, North Sands Shipyard, Sunderland ... ... (S) Mar. 1893

ELECTED.

Muir, John, 7, Ilford Road, High West Jesmond, Newcastle-upon-Tyne ... ... (E) May, 1906
Muir, Robert, 11, Clarence Crescent, Whitley Bay, Northumberland ... ...(SUR) Oct. 1886
Muir, Robert Home, 41, Percy Park, Tynemouth ... ... (S) Oct. 1892
Mulherion, G. F., Collingwood House, Tynemouth ... ... (S) Nov. 1884
Munck, Ove. Holger, c/o Messrs. Burmeister & Wain, Shipbuilders, Copenhagen, Denmark ... ... (S) Feb. 1899
Murdock, Thomas Plunkett, 2, Park Avenue, Dunoon, N.B. ... (E) Jan. 1904
Murray, Athole J., Hussendean, Holywell Avenue, Monkseaton, Northumberland ... ... (S D) Nov. 1905
Murray, Charles W., c/o Messrs. Babcock & Wilcox, Ltd., Oriel House, 30, Farringdon Street, London, E.C. ... ... (E) May 1901
Murray, David, 59, Warkworth Avenue, Whitley Bay, Northumberland ... ... (E) Nov. 1903
Murray, George Harper, 47, Murray Terrace, Aberdeen ... ... (S D) May, 1906
Murray, William I., Eng. Lieut., R.N., H.M.S. "Ure," Second Destroyer Flotilla, Aberdeen ... ... (E) Jan. 1905
Myles, David, c/o Messrs. N.E. Marine Engineering Co., Northumberland Engine Works, Wallsend-on-Tyne ... ... (E) Nov. 1884

N.

Nastoupil, John, Chief Engineer, Austro-Hungarian Navy, Marine Casino, Pola, Austria ... ... (E) Nov. 1890
Neill, William Reid, 5, Azalea Avenue, Sunderland ... ... (E) Dec. 1897
Nelson, George, 13, Mosley Street, Newcastle-upon-Tyne (E) { Graduate, Jan. 1900 / Member, Dec. 1901 }
Nevins, William, Hazel Brae, 18, Bradford Road, Shipley, Yorkshire (E) Mar. 1894
Nevison, Thomas C., 18 Milton Road, West Hartlepool ... ... (E) April 1900
Nichols, G. H., 30, Denmark Street, Gateshead-on-Tyne (E) { Graduate, Oct. 1900 / Member, Oct. 1906 }
Nicholls, H. E., 25, Churchill Street, Sunderland ... ... (E) Nov. 1893
Nichols, Walter W., 19, Telford Street, Gateshead ... ... (E) May 1895
Nicholson, John S., North View, Mowbray Road, Westoe, South Shields ... ... (E) Nov. 1893
Nicholson, P. F., ... (S) Feb. 1901
Nicol, John M., 15, Linskill Terrace, North Shields ... ... (E) Nov. 1884
Nicolson, G. C., 8, York Terrace, Gillingham, Kent (E) { Graduate, Oct. 1885 / Member, Oct. 1888 }
Nixon, John R., c/o Messrs. Blyth Shipbuilding Co., Ltd., Blyth ... ... (S) { Graduate, Feb. 1898 / Member, Oct. 1902 }
Noble, Harry, Northern Machine Tool Works, Brewery Lane, Felling-on-Tyne .. .. (E) Nov. 1888
Norman, W. S., White House, Whitby, near Chester ... ... (E) Nov. 1884
Norton, Harold P., Bureau of Steam Engineering, Navy Department, Washington, U.S.A. ... ... (E) Oct. 1890
Noton, F. B., Lloyd's Register of Shipping, 55, Fawcett Street, Sunderland... ... ... (S) Nov. 1884
Nunes, Enrique E., 4451 Calle Charcas, Buenos Ayres ... ... (E) April 1891
Nylen, Otto, Repslagaregatan, 9[II], Stockholm, Sweden ... ... (E S) Oct. 1904

ELECTED.

O.

Ogilvie, William, c/o Newcastle Corporation Tramways, Newcastle-upon-Tyne	(E E)	Graduate, Oct. 1902 Member, Nov. 1905
Olsen, Hans B., jun., Victoria Road, West Hartlepool	(E)	Graduate, Feb. 1895 Member, Feb. 1902
O'Neill, J. J., 2, Erith Terrace, Sunderland	(E)	Nov. 1884
Ord, Godfrey C., The Esplanade, Sunderland	(E E)	Jan. 1897
Orde, E. L., c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Walker Shipyard, Newcastle-upon-Tyne	(E)	Oct. 1887
Orlando, Chev. Giuseppe, Cantiere Navale, Fratelli Orlando, Leghorn	(N A)	Jan. 1893
Ormonde, John Grey, 35, Percy Gardens, Tynemouth	(E)	Nov. 1897
Oxley, G., 51, Norman Terrace, Howdon-on-Tyne	(S)	Nov. 1884
Oxton, Walter, Red House, Wivenhoe Cross, Colchester	(E)	Graduate, Dec. 1890 Member, May 1894

P.

Page, F. J., Eng.-Lieut., R.N., Water Works, Gateshead	(E)	Dec. 1903
Parker, James H., 1, Cliff Gardens, Frodingham, near Doncaster	(E)	April 1900
Parsons, The Hon. Charles A., C.B., M.A., F.R.S., Turbinia Works, Wallsend-on-Tyne	(E E)	Dec. 1887
Patterson, Jas., c/o Messrs. Caldwell & Co., Limited, Elliot Street, Glasgow	(E)	Nov. 1884
Patterson, Robert O., Thorneyholme House, Wylam-on-Tyne	(E)	Graduate, Jan. 1895 Member, Dec, 1901
Pattison, Jos., Bute Docks, Cardiff	(E)	Nov. 1884
Paulin, William J., 27, Cheltenham Terrace, Heaton, Newcastle-upon-Tyne	(E)	April 1897
Paxton, John F., 52, Walker Terrace North, Gateshead	(E)	May, 1899
Pease, J. C. S., Board of Trade Offices, Falmouth	(E S)	Oct. 1904
Penney, R. H., Board of Trade Offices, 79, Mark Lane, London, E.C.	(S SUR)	Nov. 1884
Pepper, W., Sunnyside, Stockton-on-Tees	(E)	Nov. 1888
Perrett, Jos. Richard, c/o Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Elswick Shipyard, Newcastle-upon-Tyne ...	(N A)	Nov. 1896
Pescod, Joseph Hind, 18, Bede Burn Road, Jarrow-on-Tyne	(S)	Graduate, Feb. 1898 Member, Jan. 1900
Petree, James, Lloyd's Register of Shipping, 12, Oriel Chambers, Water Street, Liverpool	(N A SUR)	Oct. 1885
Petterson, Carl Edwin, 16, Magasinsgatan, Gothenburg, Sweden	(E)	Oct. 1891
Phillips, Alex., 15, Park Avenue, Wallsend-on-Tyne...	(S)	Graduate, Dec. 1902 Member, Dec. 1906
Phillips, Joseph, 15, Park Avenue, Wallsend-on-Tyne	(S)	Dec. 1902
Phorson, P., Glen Lea, Roker, Sunderland	(S)	Nov. 1884
Pierce, Robert Cecil, Creetleet, Cumberland Gate, Kew, Surrey	(E E)	Graduate Dec. 1898 Member Dec. 1899
Pilling, Joseph H., 31, Roker Park Road, Roker, Sunderland ...	(E D)	Nov. 1905
Pinkney, Edmund W. R., 65, Fern Avenue, Newcastle-upon-Tyne	(E)	Dec. 1904

Pitt, Frederick William, 51, Seymour Grove, Old Trafford, Man-

[redacted]

ELECTED.

Posgate, James S., Super. Engineer, Messrs. Texas Portland Cement Co., Dallas, Texas, U.S.A. ... .. (E) { Graduate, Nov. 1895 / Member, Dec. 1901

Powell, James Richard, Royal Stuart Buildings, Cardiff ... ... (C E) May 1894

Prest, G. S., 29, Eldon Street, Newcastle-upon-Tyne ... ... (E) Nov. 1907

Pringle, Alfred, 10, Airey Terrace, Walker-on-Tyne (S) { Graduate, Dec. 1891 / Member, Jan. 1894

Pringle, James G., 10, Airey Terrace, Walker-on-Tyne ... ... (S) Oct. 1892

Pringle, Robert A., 16, Second Avenue, Heaton, Newcastle-upon-Tyne ... ... (EE) { Graduate, Nov. 1901 / Member, Dec. 1906

Purdon, Andrew S., Messrs. Irvine's Shipbuilding and Dry Docks Co., Limited, West Hartlepool ... ... (S) Oct. 1892

Purvis, Fred. W., c/o Messrs. Sir W. Gray & Co., Central Shipyard, West Hartlepool ... ... (S) April 1893

Putnam, T., Darlington Forge, Darlington ... ... (FM) Nov. 1884

Q.

Quicke, Herbert John, c/o Messrs. Harfield & Co., Blaydon Ironworks, Blaydon-on-Tyne ... ... (E) Feb. 1891

R.

Ramage, J. T., St. Aubyn's, Kinneir Road, Inverleith, Edinburgh (E) April 1887

Ramage, John Anderson, Getsdale, Harton, South Shields ... (S) Oct. 1892

Ranken, David, 8, Brookside Terrace, Sunderland ... ... (E) Nov. 1900

Rappaport, Fred. G., The Baku Russian Petroleum Co., Ltd., Balakhani, South Russia ... ... (E) { Graduate, Mar. 1894 / Member, Jan. 1902

Rea, Harry Ernest, "Gowanbrae," Windsor Crescent, Whitley Bay, Northumberland ... . (S) Dec. 1904

Readhead, Jas., Westoe Hall, South Shields ... ... (S) Nov. 1884

Readhead, John, Rockcliffe, Westoe, South Shields ... ... (E) Mar. 1886

Readhead, R., South Garth, Westoe Village, South Shields ... (E) Nov. 1884

Readhead, Stanley, 5, Logan Terrace, South Shields (S) { Graduate, Dec. 1902 / Member, Mar. 1906

Readhead, W. B., Beach View, South Shields .. .. (S) Nov. 1886

Redpath, David, 59, Claremont Road, Seaforth, Liverpool ... (E) Nov. 1901

Reed, J. W., c/o Messrs. Palmer's Shipbuilding and Iron Co., Limited, Engine Works Department, Jarrow-on-Tyne ... (E) Nov. 1884

Reilly, Myles O'Hara, c/o Messrs. Antwerp Shipbuilding Co., Ltd., Hoboken-lez-Anvers, Belgium ... ... (S) Oct. 1902

Rennoldson, Jos. M., Fairfield, Westoe, South Shields ... ... (S) Feb. 1886

Renton, James, Engineer's Department, Trinity House, Tower Hill, London, E.C.... ... ... (E) Jan. 1904

Reynolds, Charles H., 155, Fenchurch Street, London, E.C. ... (S) Mar. 1889

Richardson, Jas. Wm., "Beaufront," Brough, E. Yorks. ... (E & S) Nov. 1903

Richardson, John Lyth, The Avenue, Bishop Lane, Hull ... ... (E) Nov. 1901

Riley, J. H., Messrs. Riley Bros., Stockton-on-Tees ... ... (B B) May 1893

Riley, John, Grangefield House, Oxbridge Lane, Stockton-on-Tees (B M) Oct. 1902

Riseley, Harry Lorimer, Western Villa, Wallsend-on-Tyne ... (E) Nov. 1900

Ritson, Cuthbert, 5, Middleton Street East, Waterloo, Blyth ... (S) Nov. 1907

Ritson, Maurice, Lloyd's Register of Shipping, Piazza S. Giorgio, 32, Genoa ... ... (E SUR) Nov. 1884

Ritson, S. M., 2, Rectory Terrace, Sunderland ... (E) { Graduate, Nov. 1887 / Member, Nov. 1893

ELECTED.

Skentelbery, Joseph W., "Southend," Riftswood Mill Road, Saltburn by the Sea ... ... (E) Dec. 1900
Skentelbery, G. Arthur, 19, Sandringham Terrace, Benton, Newcastle-upon-Tyne ... ... (S) Oct. 1902
Skinner, Leslie, Westoe, South Shields ... ... (S) { Graduate, Dec. 1886 / Member, Oct. 1891 }
Slee, Herbert T., "Underwood," Beaconsfield Road, Gosforth, Newcastle-upon-Tyne ... ... (E) { Graduate, Jan. 1903 / Member, Nov. 1907 }
Smith, C. E., Cowesby, Clifton Avenue, West Hartlepool ... (E) Nov. 1888
Smith, Chas. R., c/o Messrs. Barclay, Curle & Co., Ltd., Glasgow (E) Nov. 1903
Smith, E. J., Brandon House, Haughton-le-Skerne, Darlington ... (E) Dec. 1900
Smith, L. Eustace, Roseworth Cottage, Moor Road, Gosforth, Newcastle-upon-Tyne ... ... (E) { Graduate, Oct. 1889 / Member, Oct. 1892 }
Smith, J. E., 15, Eslington Terrace, Newcastle-upon-Tyne (E) { Graduate, Nov. 1897 / Member, Oct. 1906 }
Smith, Thomas, Steam Crane Works, Old Foundry, Rodley, near Leeds (E) Oct. 1888
Smith, Thomas Edward, Messrs. John Smith & Sons, Newgate Street, Newcastle-upon-Tyne ... ... (E) April 1885
Smith, Wm., 152, Roker Avenue, Sunderland, M. ... ... (E) Nov. 1884
Smith, Wm. Stawart, West Villa, The Green, Wallsend-on-Tyne ... ... (S) { Graduate, Nov. 1893 / Member, Dec. 1897 }
Snell, John F. C., M.I.C.E., Caxton House, Westminster, London, S.W.... ... ... (E E) Mar. 1902
Soliani, Nabor, Col., Messrs. G. Ansaldo, Armstring & Co., Sestri-Ponente, Italy ... ... (S) Jan. 1885
Spence, W. G., c/o Messrs. Swan, Hunter & Wigham Richardson, Ltd., Neptune Works, Walker-on-Tyne (*Life Member*) ... (E) Nov. 1884
Spencer, J. W., Newburn Steel Works, Newburn-on-Tyne ... (E) Feb. 1885
Squire, Charles E., c/o Messrs. Underground Electric Railway Co. of London, Ld., Earls Court Station, London, S.W. (E E) { Graduate, Nov. 1893 / Member, Oct. 1898 }
Staig, William Andrew, 296, Condercum Road, Benwell, Newcastle upon-Tyne ... ... (E) Feb. 1897
Stanger-Leathes, C. F., 49, Heaton Road, Newcastle-upon-Tyne ... ... (S) { Graduate, Oct. 1903 / Member, Dec. 1906 }
Stanley, John T., 6, Belmont Gardens, West Hartlepool ... ... (E) Oct. 1898
Stephen, A. E., Linthouse, Govan, Glasgow ... ... (E & S) June, 1896
Stephens, H. C. J., 3, Lodge Place, St. John's Wood, London, N.W. ... ... (E) { Graduate, Oct. 1890 / Member, Nov. 1897 }
Sterry, Frank W. ... ... (E) Jan. 1907
Stevenson, Wm., 10, Neville Street, Newcastle-upon-Tyne ... (E) Nov. 1884
Stewart, James, Proctor House, Newcastle-upon-Tyne ... ... (E) Oct. 1890
Sterling, J. F. ... ... (F M) Oct. 1902
Stoddart, A. Lane, York House, Pelaw-on-Tyne ... . (S) Nov. 1898
Stoddart, J. E., Lloyd's Register of Shipping, 71, Fenchurch Street, London, E.C. ... ... (E SUR) Oct. 1888
Stokoe, M. B., 12, The Oaks, Sunderland ... ... (S) { Graduate, Oct. 1904 / Member, Oct. 1906 }
Stoney, Gerald, c/o Messrs. C. A. Parsons & Co., Turbinia Works, Heaton, Newcastle-upon-Tyne ... ... (E) May 1902
Stuart, John, 135, Heaton Park Road, Newcastle-upon-Tyne (E) { Graduate, Dec. 1895 / Member, Nov. 1901 }

ELECTED.

S.

Sandeman, John Watt, 1, St. Nicholas' Buildings, Newcastle-upon-Tyne... ... ... (E) Oct. 1891
Sawyer, John, c/o Messrs. Thos. Wilson, Sons, & Co., Hull ... (E) Oct. 1886
Sayer, Henry, Montrose Avenue, Toronto, Canada ... ... (F M) Feb. 1906
Schofield, Charles, A, Milburn House, Newcastle-upon-Tyne ...
Scope, Robert, 48, Bewick Road, Gateshead-on-Tyne ... ... (E) Oct. 1904
Scott, Ernest, Sun Buildings, Collingwood Street, Newcastle-upon-Tyne ... ... (E E) Nov. 1884
Scott, George, Drawing Office, Messrs. Denny & Co., Dumbarton ... ... (E) { Graduate, Jan. 1900; Member, May 1901 }
Scott, Henry G. ... ... (E) Jan. 1907
Scott, James, Selby Lodge, Consett, Co. Durham ... ... (E) Oct. 1892
Scott, Joseph, 49, Leazes Terrace, Newcastle-upon-Tyne (E) { Graduate, Dec. 1891; Member, Oct. 1898 }
Scott, Joseph R., E, Milburn House, Newcastle-upon-Tyne ... (E) Oct. 1887
Scott, Walter, Ivydene, Ailesbury Park, Merrion, co. Dublin ... (NA) Mar. 1897
Scott, William, 18, Worcester Road, Bootle, near Liverpool ... (E) Nov. 1884
Scott, William, "Marsden," Ninian Road, Roath Park, Cardiff ... (E) June 1896
Seabury, Edward, Station Road, Broxbourne, Herts ... ... (E) Mar. 1886
Seaman, C. J., Newton Heath Iron Works, Manchester ... ... (E) Jan. 1889
Seaton, Albert Edward, Lawn Park, Boxmoor, Herts. ... ... (E) Jan. 1891
Sedcole, James, 21, Springbank Terrace, Aberdeen ... ... (E D) Jan. 1906
See, Horace, 1, Broadway, New York City, U.S.A.... ... ... (E) May 1896
Selby, Christopher H., 26, Cobbam Road, Westcliff-on-Sea, Essex (E) Feb. 1908
Sellex, James E., Lloyd's Register of Shipping, Collingwood Buildings, Newcastle-upon-Tyne ... ... (E SUR) Dec. 1906
Sergent, William John, 12, College Avenue, Crosby, near Liverpool ... ... (E) Oct. 1898
Sharp, A. E., c/o Messrs. The Peninsular and Oriental Steam Navigation Co., 122, Leadenhall Street, London, E.C. ... (E) Nov. 1884
Sharp, Mark, 144, Albert Road, Jarrow-on-Tyne ... ... (E) Dec. 1889
Shaw, Thomas, Messrs. Lloyd's Register of Shipping, Collingwood Buildings, Newcastle-upon-Tyne ... ... (SUR) Nov. 1900
Short, John Gill, East Side, Tyne Dock, South Shields ... ... (N A) Feb. 1899
Short, Jos., 13, John Street, Sunderland ... ... (S) Nov. 1884
Short, Thomas S., c/o Messrs. Short Brothers, Pallion, Sunderland ... ... (S { Graduate, Oct. 1892; Member, May 1899 }
Shute, A. E., 12, Clyde View, Partick, Glasgow ... ... (E) Dec. 1892
Simpson, James M., Eng.-Lieut., R.N., H.M.S. "Thetis," Chatham (E) Nov. 1901
Sinclair, Charles E., 18, James Street, Liverpool ... ... (C E) Jan. 1902
Sinclair, W. Rendall, 14, Roxburgh Place, Heaton, Newcastle-upon-Tyne ... ... (E) { Graduate, Nov. 1901; Member, Dec. 1903 }
Singleton, Thomas, 46, Drury Buildings, Water Street, Liverpool (F) Apr. 1903
Sinton, John K., 15, Beech Gardens, Low Fell, Gateshead ... (E) Nov. 1885
Sisson, Wm.. "Hucclecote," near Gloucester ... ... (E & N A) Oct. 1888
Sivewright, G. W., 5, Radcliffe Terrace, Hartlepool ... ... (S) Nov. 1886
Sivewright, R. W., 6, Ashfield Terrace East, Newcastle-upon-Tyne (S) Jan. 1907
Skentelbery, Charles, c/o Messrs. Massachusetts Steamship Co., 512, Shawmut Bank Buildings, Boston, Mass., U.S.A. ... (E) Oct. 1900

ELECTED

Tierney, John W., c/o Messrs. The Globe Pneumatic Engineering Co., Ltd., 150, Queen Victoria Street, London, E.C. ... . (E) Nov. 1905

Tinn, Fred. D., North View, Mowbray Road, South Shields ... (S) Nov. 1891

Tinn, George, 215, Cardigan Terrace, Gateshead-on-Tyne ... ... (E) Dec. 1897

Tocher, J. W., c/o Messrs. Wallsend Slipway and Engineering Co., Wallsend-on-Tyne ... ... (S) Mar. 1898

Todd, George William, 114, Bede Burn Road, Jarrow (S) { Graduate, Jan. 1898; Member, Dec. 1899 }

Todd, John P., 21, Steven Street, Edge Lane, Stretford, near Manchester ... ... (E) Dec. 1897

Todd, W. Surtees, Coronation Buildings, 65, Quayside, Newcastle-upon-Tyne ... ... (N A) Nov. 1901

Toomer, C. R., Ravensworth, Westoe, South Shields ... ... (E) Jan. 1899

Toovey, Alfred F., 28, Burdon Terrace, Newcastle-upon-Tyne ... (E) Dec. 1894

Tose, Thomas, Ravenhill, Grange Road, West Hartlepool ... (E) Mar. 1901

Towers, Edward, Jun., 7 Collingwood Street, Newcastle-upon-Tyne ... ... (E) { Graduate, Nov. 1886; Member, Oct. 1888 }

Trail, John, 21, Grosvenor Place, Jesmond, Newcastle-upon-Tyne ... ... (M S) Oct. 1892

Traill, Robert, 6, Windsor Crescent, Whitley Bay, Northumberland (E) Oct. 1896

Trewent, F. J., 43, Billiter Buildings, Billiter Street, London, E.C. ... ... (S) Dec. 1884

Tsimenis, Andreas, 65, Shortridge Terrace, Jesmond, New-castle-upon-Tyne .. .. (N A) { Graduate, Oct. 1900; Member, Jan. 1902 }

Tulip, Wilfred, Messrs. Hong Kong and Whampoa Dock Co., Hong Kong, China ... ... (E) { Graduate, Mar. 1902; Member, April 1905 }

Turnbull, John, 258, Chillingham Road, Heaton, Newcastle-upon-Tyne ... ... (E) Nov. 1898

Turner, S. J., 71, Warwick Street, Heaton, Newcastle-upon-Tyne (E) Mar. 1887

Tuxen, Holger, Bureau Veritas Register of Shipping, Heibersgade, 14, Copenhagen, K. ... ... (S) Nov. 1896

Twaddell, James L., Green Bank, Jarrow-on-Tyne... ... ... (S) Oct. 1891

Tweedy, G. F., The Noak, Jesmond Park East, Newcastle-upon-Tyne... ... ... (E) May 1899

Tweedy, John, Kelso House, Fernwood Road, Jesmond, Newcastle-upon-Tyne ... ... (E) Nov. 1884

U.

Urquhart, Douglas M., c/o Messrs. Menzies & Co., Ltd., Old Dock, Leith, N.B. ... ... (S) May 1899

V.

Vardy, George, c/o Messrs. Swan, Hunter & Wigham Richardson, Ltd., Wallsend Shipyard, Wallsend-on-Tyne (E) { Graduate, Oct. 1894; Member, 1898 }

Varty, Bartholomew Snowball, Messrs. Bureau Veritas Register of Shipping, 8, Place de la Bourse, Paris (S) { Graduate Oct. 1895; Member May 1901 }

Vianson, N. E., Via, Corsica 20/5, Genoa, Italy ... ... (E) Dec. 1885

Vick, R. W., Messrs. Furness, Withy & Co., Middleton Shipyard, West Hartlepool ... ... (S) Nov. 1888

Vowell, Josias, East Devon County School, Sampford Leverell, Tiverton ... ... (E) Feb. 1901

		ELECTED.
Stupersky, Antony, 8, Percy Avenue, Monkseaton, Northumberland		
Summers, James, 4, Vicarage Terrace, Newtown, Stockton-on-Tees	(E)	Mar. 1889
Sutherland, Donald, c/o Messrs. Hawthorn & Co., Ltd., Leith, N.B.	(E)	Jan. 1905
Swinburne, M. W., The Cottage, Jesmond Park East, Newcastle-upon-Tyne	(E)	Nov. 1884
Swinburne, T. M., 18, Bewick Road, Gateshead-on-Tyne	(E)	Jan. 1885
Swinney, W., 10, Wentworth Terrace, Westoe Lane, South Shields	(E)	Dec. 1888
Syme, James, Fairfield Works, Govan, Glasgow	(E)	Oct. 1892

T.

Tait, Peter W., The Leith, Hull, and Hamburg Steam Packet Co., Ltd., 16, Bernard Street, Leith, N.B.	(MS)	Jan. 1905
Tait, Robert, 23, Ardgowan Street, Greenock, N.B....	(S D)	Graduate, Dec. 1903 Member, Mar. 1906
Tate, Chas. H., 7, Side, Newcastle-upon-Tyne	(N A)	Nov. 1884
Taylor, J. T. Lloyd, Dock Engineer's Office, Middleton Road. West Hartlepool	(CE)	Graduate, Oct. 1900 Member, May 1903
Taylor, John, ...	(E)	Dec. 1894
Taylor, Martin B., Pitlochie, Annfield Terrace E., Partickhill, Glasgow	(S)	Jan. 1903
Taylor, Matthew M., c/o Messrs. Crossley Bros, Ltd., 11, Saville Row, Newcastle-upon-Tyne	(E)	Dec. 1906
Taylor, Sydney T., 15, Windsor Terrace, Newcastle-upon-Tyne ...	(SD)	Nov. 1905
Teed, Henry R., Eng. Com., R.N., H.M.S. "Cochrane," 5th Cruiser Squadron, Chatham	(E)	Dec. 1906
Teesdale, John, 7, Portland Terrace, Jesmond, Newcastle-upon-Tyne...	(E)	Mar. 1898
Terry, F. Herbert	(M)	Feb. 1901
Thackrah, John, 8, Mentone Place, Little Woodhouse Street, Leeds	(E)	Nov. 1901
Thew, Charlton, 20, West Avenue, Gosforth, Newcastle-upon-Tyne	(E)	Graduate, Dec. 1899 Member, Nov. 1902
Thomas, Benjamin, 8, Balmoral Terrace, Heaton, Newcastle-upon-Tyne	(E)	Feb. 1899
Thomas, Harold, 43, University Street, Belfast	(S)	Apr. 1903
Thomas, Thomas Roberts, 2, Queen's Gardens, Sunderland	(E SUR)	May 1908
Thomas, William, 41, Glenmore Road, Hampstead, London, N.W.	(E)	Graduate, Oct. 1895 Member, Nov. 1899
Thompson, C. E., The Poplars, Sunderland	(S)	Nov. 1884
Thompson, Jas., Farringford, Roker, Sunderland	(E)	Dec. 1886
Thompson, Joseph Andrew, North Sands Shipyard, Sunderland ...	(S)	Nov. 1901
Thomson, Alex. T. G., Elswick Shipyard, Newcastle-upon-Tyne ..	(S)	Jan. 1907
Thomson, Harold, 37, Larkspur Terrace, Newcastle-upon-Tyne ...	(E)	Nov. 1905
Thomson, James, M.A., 22, Wentworth Place, Newcastle-upon-Tyne...	(E & N A)	Nov. 1890
Thorn. W. H., 5, Waterville Terrace, North Shields	(E)	Nov. 1884
Thyne, John Sinclair, 32, Azalea Terrace N., Sunderland	(S)	Dec. 1899

ELECTED

White, R. Saxton, Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Walker Shipyard, Walker-on-Tyne ... ... (S) Nov. 1884
Whitfield, Eli, Atlas Villa, Dunston-on-Tyne ... ... (E) Oct. 1906
Whitfield, George, Whickham View, Dunston-on-Tyne ... ... (E) Oct. 1906
Widdas, T. D., 56, Plasturton Avenue, Cardiff ... ... (SUR) April 1885
Wildridge, Richard, 90, Berry Street N., Sydney, N.S.W. ... ... (E) { Graduate, Oct. 1895 / Member, Oct. 1898 }
Wilkie, John, 8, North View, Wallsend-on-Tyne ... ... (E) Dec. 1906
Wilkie, W., 5, Northumberland Gardens, Jesmond, Newcastle-upon-Tyne ... ... (S) Jan. 1907
Wilkinson, Thomas, 67, Laburnum Avenue, Wallsend-on-Tyne ... (S) Nov. 1899
Willcox, F. A., B.Sc., 18, Holinlands, Park, Sunderland ... ... (C E) Nov. 1903
Willcox, Henry Walker, 14, Norfolk Street, Sunderland ... ... (C E) Nov. 1897
Willcox, Percy F. C., 14, Norfolk Street, Sunderland ... ... (C E) Nov. 1897
Willcox, R. J. N., c/o Thames Conservancy, Port of London Wharf, London ... ... (E) { Graduate, Mar. 1892 / Member, Dec. 1897 }
Williams, Thomas, Messrs. South Durham Steel & Iron Co., West Hartlepool ... ... (I & S M) Dec. 1900
Williams, Thomas R., "Holmside," Bede Burn Road, Jarrow-on-Tyne ... ... (S) Oct. 1895
Williamson, Alex., B.Sc., c/o Messrs. Cammell, Laird & Co., Sheffield ... ... (E) Jan. 1907
Wilson, Alfred Allan, 6, Percy Terrace, Newcastle-upon-Tyne ... ... (S) { Graduate, Nov. 1904 / Member, May 1906 }
Wilson, Edmund, 8, Clifton Terrace, Forest Hall, near Newcastle-upon-Tyne ... ... (E) Nov. 1901
Wilson, Henry J. H., "Lancefield," Kellfield Avenue, Low Fell, Gateshead-on-Tyne ... ... (E) Nov. 1895
Wilson, Henry Maxson, 65, Quayside, Newcastle-upon-Tyne ... (E) May 1902
Wilson, John Reginald, The Willows, Gosforth, Newcastle-upon-Tyne ... ... (E E) { Graduate, Mar. 1894 / Member, Dec. 1899 }
Wilson, W. J., Messrs. William Crighton & Co., Engineers and Shipbuilders, Abo, Finland ... ... (S) Nov. 1907
Wimble, Arthur, 10, Ventnor Gardens, Monkseaton ... ... (E) Dec. 1893
Winstanley, P. D., Bureau Veritas Register of Shipping, 155, Fenchurch Street, London, E.C. ... ... (S) Nov. 1884
Withy, Ernest, Brantford House, West Hartlepool ... ... (S) Oct. 1906
Withy, Henry, Middleton Shipyard, West Hartlepool ... ... (S) Nov. 1884
Wood, Henry Alfred, Sunnyside, Marton, R.S.O., Yorks ... ... (S) Dec. 1893
Wood, Lionel, 20, Edward's Road, Whitley Bay, Northumberland ... ... (E E) { Graduate, Nov. 1897 / Member, Jan. 1903 }
Wood, William, Ruthven, Adderstone Crescent, Jesmond, Newcastle-upon-Tyne ... ... (S) Nov. 1897
Woodeson, Wm. A., 14, Bewick Road, Gateshead-on-Tyne ... (E) Nov. 1901
Wortley, Henry B., Kent House, Egerton Park, Rock Ferry, Birkenhead... ... ... (S) { Graduate, Jan. 1886 / Member, Nov. 1892 }
Wray, Thomas W., Board of Trade Offices, Sunderland ... ...(SUR) Jan. 1895
Wright, George H., 33, Albury Park Road, Tynemouth (EE) { Graduate, Feb. 1896 / Member, Dec. 1901 }
Wright, Joseph, jun., 7, St. Mary's Place, Newcastle-upon-Tyne ... (F M) Feb. 1906
Wright, R., 5, Hawthorn Terrace, Newcastle-upon-Tyne ... ... (E) Nov. 1884
Wynd, William Adam, 8, Dilston Terrace, Gosforth, Newcastle-upon-Tyne ... ... (N A) Feb. 1902

Y.

ELECTED.

Young, Andrew, Bureau Veritas Register of Shipping, 155, Fenchurch Street, London, E.C. ... ... (S) { Graduate, Feb. 1892 / Member, May 1893
Young, J. Denholm, 7, Commercial Court, 17, Water Street, Liverpool ... ... (E) Oct. 1888

Z.

Zeeman, J. H., 147, Bankastraat den Haag ... ... (S) Oct. 1889

ASSOCIATES.

A.

Allan, A. S., 27, Hotspur Street, Tynemouth ... ... (M) Dec. 1903
Anderson, Daniel G., c/o Messrs. W. Angus & Co., Grainger Street West, Newcastle-upon-Tyne ... ... (A) Nov. 1893

B.

Barklam, George, Braemar, Dudley Port, Staffordshire ... ... (A) April 1888
Barnes, Henry, Highcliffe, Roker, Sunderland ... ... (A) Nov. 1901
Barrie, C. C., 49, Meadowside, Dundee ... ... (S O) Oct. 1904
Barrie, J. J., 49, Meadowside, Dundee, N.B. ... ... (S O) Aug. 1908
Beynon, Thomas, Hamburg Chambers, Quayside, Newcastle-upon-Tyne ... ... (E A) Oct. 1891
Bigge, C. W., Northern Counties Club, Newcastle-upon-Tyne ... (A) Dec. 1889
Bingham, Sir J. E., Bart., West Lea, Ranmoor, Sheffield ... ... (M) Mar. 1895
Bird, William, 22, Percy Gardens, Tynemouth ... ... (A) May 1896
Borrie, Walter, Messrs. Blair & Co., Ltd., Stockton-on-Tees ... (A) Jan. 1899
Bowmer, John J., 8, Tankerville Terrace, Newcastle-upon-Tyne... (S O) Nov. 1901
Brims, D. N., 5, St. Nicholas' Buildings, Newcastle-upon-Tyne ... (C) Nov. 1893
Brown, Charles Ernest, Fairfield, South Boldon, R.S.O., near Sunderland ... ... (A) Oct. 1900
Brown, Percy Ledger, 66, Saville Street, North Shields ... ... (E A) Oct. 1896
Bullen, Tempest C., Derwentwater Chambers, 33, Sandhill, Newcastle-upon-Tyne ... ... (S O) Nov. 1891

C.

Carr, Ralph, Thornleigh, Clayton Road, Newcastle-upon-Tyne (A & S O) Nov. 1886
Cohan, Edward Asher, c/o Messrs. H. E. Moss & Co., Chapel Street, Liverpool ... ... (S O) Nov. 1889
Cory, John, Mount Stuart House, Cardiff ... ... (S O) June 1896
Coull, John, Baltic Chambers, Quayside, Newcastle-upon-Tyne ... (S O) Oct. 1886
Crawford, Thomas, 10, Haldane Terrace, West Jesmond, Newcastle-upon-Tyne ... ... (A) Oct. 1896
Crosier, Edward James, East Boldon, via Newcastle-upon-Tyne ... (A) Oct. 1889

D.

Darling, Henry, Secretary, Messrs. Smith's Dock Co., Ltd., High Docks, South Shields ... ... Nov. 1904
Dingle, Charles ... ... (M S) Nov. 1905
Dixon, Thomas, c/o Messrs. Sir Raylton Dixon & Co., Ltd., Shipbuilders, Middlesbrough ... ... (A) May 1902

S.

		ELECTED.
Scholefield, A., 17, Sandhill, Newcastle-upon-Tyne	(S O)	Nov. 1884
Simm, William, c/o Messrs. John Taylor & Co., 12, Dean Street, Newcastle-upon-Tyne	(M)	Nov. 1905
Snowdon, W. F., 32, Side, Newcastle-upon-Tyne	(E A)	Dec. 1886
Stallybrass, William S., 30, Dean Street, Newcastle-upon-Tyne ...	(M)	Mar. 1901
Stephenson, George R., c/o Messrs. N. E. Marine Engineering Co., Northumberland Engine Works, Wallsend	(A)	Nov. 1899
Storey, Christopher, 13, Sunbury Avenue, Jesmond, Newcastle-upon-Tyne	(A)	April 1896
Sutherland, Arthur M., Eastcliffe, Elmfield Road, Gosforth, Newcastle-upon-Tyne	(S O)	Nov. 1897
Swinney, Robert Nesbit, Ashleigh, Morpeth	(A)	Nov. 1901

T.

Temple, George T., 20, Beach Avenue, Whitley Bay, Northumberland	(A)	Jan. 1899
Thompson, Wm. H., 3, East Parade, Newcastle-upon-Tyne ...	(A)	Nov. 1899
Thorpe, Samuel, Market Place Chambers, 74, High Street, Sheffield	(I & S M)	Feb. 1901
Todd, John Stanley, Maritime Buildings, Newcastle-upon-Tyne	(U)	Nov. 1895
Towers, Edward, 27, Brandling Park, Newcastle-upon-Tyne ...	(A)	Oct. 1888
Towers, Michael G., Clementhorpe, North Shields	(A A)	Dec. 1899
Trechmann, Otto K., Church Street, West Hartlepool	(S O)	Oct. 1896
Tully, Robert, 9, The Lawe, South Shields	(M S)	May 1900

W.

Wainford, Edgar H., 3, Woodbine Road, Gosforth, Newcastle-upon-Tyne	(A)	Nov. 1899
Ward, Heber, Messrs. Walker & Hall, Sheffield	(A)	Feb. 1901
Watson, Thomas W., Gisburn House, Hartlepool	(M S)	Nov. 1890
Weatheral, Henry, 27, Alderson Street, West Hartlepool	(A)	Feb. 1893
Weiss, T. L., Marine Superintendent, 5, Quayside, Newcastle-upon-Tyne	(M S)	Nov. 1903
Willis, John B., 2, Belgrave Crescent, Blyth...	(A)	Jan. 1907
Winstanley, Robt. Hope, 26, Rectory Terrace, Gosforth, Newcastle-upon-Tyne	(A)	Nov. 1897
Wisnom, Edward, "Glenford," 63, Penylan Road, Roath Park, Cardiff	(M S)	May 1906

Y.

Yeoman, F., Ship and Steamship Broker, West Hartlepool ...	(S O)	Nov. 1888
Young, Charles E., Murton Chambers, Grainger Street, Newcastle-upon-Tyne	(M)	Nov. 1905
Young, John Barrow, Optician, 46, Dean Street, Newcastle-upon-Tyne		Nov. 1901
Younger, Robert Laurie, Messrs. Greenock Steamship Co., Limited, Greenock	(A)	Feb. 1889

L.

ELECTED.

Levin, Otto, c/o Messrs. Holzapfel's Compositions Co., D, Milburn House, Newcastle-upon-Tyne ... ... (A) Nov. 1902
Lodwidge, Philip, Baltic Chambers, Sunderland ... ... (A) June 1896
Lucock, George, c/o Messrs. W. Lucock & Son, Hudson Street, Tyne Dock ... ... (M) Oct. 1900

M.

Macarthy, George E., 54, Pilgrim Street, Newcastle-upon-Tyne ...(S O) Oct. 1887
Maughan, William, 13, Mosley Street, Newcastle-upon-Tyne ... (A) Feb. 1887
McBeath, Harry C., 87, Jesmond Road, Newcastle-upon-Tyne ... (A) Dec. 1900
Miller, T. R., 9, Great St. Helen's, London, E.C. ... ... (A & S O) Nov. 1884
Moss, J. Frank. Jr., 24, Riverdale Road, Sheffield ... ... (S M) Nov. 1901
Muller. J. C. F.. 79, Rue Harringrode, Antwerp ... ...(SUR) Feb. 1890
Murray, Henry H., Hastings Lodge, Hartlepool ... ... (A) Dec. 1901
Murray, Matthew, The Green, Wallsend-on-Tyne ... ... (A) Nov. 1893
Murray, David, 13, Argyle Square, Sunderland ... ... (A) May 1908

N.

Naismith, John. Neptune Works, Newcastle-upon-Tyne ... ... (A) Nov. 1901
Nettleship, G., 39, Trent Street, Norton Road, Stockton-on-Tees .. (A) Nov. 1907
Nielsen, Hans Christian, 12, Cliff Terrace, Hartlepool ... ... (S O) Feb. 1898

O.

Olsen, Hans Benedick, 70, Church Street, West Hartlepool ... (S O) Mar. 1893

P.

Park, Robert, Lauriston, Blackhill, Co. Durham ... ... (A) Dec. 1897
Parker, George, 62, John Street, Sunderland ... ... (A) Dec. 1899
Petersen, William, Kenton Lodge, Gosforth, Newcastle-upon-Tyne (S O) Nov. 1893
Pilditch, Alfred, Grange Villa, Jarrow-on-Tyne ... ... (A) Nov. 1903
Pinkney, Thomas, 3, Ashbrook Terrace, Sunderland ... ... (SO) Dec. 1886
Pringle, George Frederick, 8, Grainger Street, Newcastle-upon-Tyne... ... ... (E A) May 1901
Proctor, J. H., 45, Percy Gardens, Tynemouth ... ... (I M) Nov. 1893

R.

Ramsay, Norman F., 131, Osborne Road, Newcastle-upon-Tyne (B F) Jan. 1902
Reichwald, A., Finsbury Pavement House, Finsbury Pavement, London, E.C. ... ... (A) Nov. 1884
Reid, Sidney, Printer, Akenside Hill, Newcastle-upon-Tyne ... Nov. 1884
Renwick, G., Messrs. Fisher, Renwick & Co., Collingwood Buildings, Newcastle-upon-Tyne ... ... (S O) Nov. 1884
Rimer, William Thomas, E, Milburn House, Newcastle-upon-Tyne (M) Nov. 1900
Ritson, Arthur, 30, West Sunniside, Sunderland ... ...(S O) Feb. 1899
Robinson, J., Secretary, Clarendon House, Clayton Street, Newcastle-upon-Tyne ... ... Oct. 1904
Robson, John William, F, Milburn House, Newcastle-upon-Tyne... (M) April 1896
Rogers, Thomas W., 284, Beverley Road, Hull ... ... (A) May 1901
Rumford, George, Messrs. Shipping & Coal Co., Ltd., Proctor House, Newcastle-upon-Tyne ... ... (A) Jan. 1907

ELECTED.

Davis, R. N., 10, St. George's Terrace, Jesmond, Newcastle-upon-Tyne ... ... (S) Nov. 1907

Deas, Charles Douglas. 30, Harrogate Street, Sunderland... ... (E) May 1908

Dent, E. L., 2, Bath Terrace, Tynemouth ... ... (E) Nov. 1907

Denton, R. A. E., 9, Poplar Crescent, Gateshead-on-Tyne... ... (E) Nov. 1907

Driver, John Wm., 21, Grosvenor Place, North Shields ... ... (E) Feb. 1904

Dymond, C. H., 1, Windsor Terrace, Newcastle-upon-Tyne ... (E) Aug. 1908

E.

Edwards, A. G., 29, Argyle Street. Hebburn-on-Tyne ... ... (S) Nov. 1907

F.

Farina, Victor, J.P., 27, Crown Street, Newcastle-upon-Tyne ... (E A) Nov. 1905

Finlay, George, 27, Clayton Park Square, Newcastle-upon-Tyne... (E) Nov. 1902

Fleming, Tom, jun., Heathfield, Hebburn-on-Tyne ... ... (S) Dec. 1906

G.

Goddard, James Alan, 34, Denmark Street, Gateshead-on-Tyne .. (E A) May 1906

Graham, E., Morro House, Tynemouth ... ... (S) Nov. 1907

Green, Fred. Wm., Rutherford College, Newcastle-upon-Tyne ... (E) Jan. 1902

H.

Haddock, Gilbert Forster, 16, Azalea Terrace South, Sunderland (E) May 1908

Hamilton, Francis A. W. ... ... (E E A) Dec. 1905

Harney, J., 13, Stanley Street, Blyth ... ... (S) Nov. 1907

Harwood, F. A., Messrs. Santaro Nitrate Co., Ltd., Taltal, Chili, South America ... ... (E) Nov. 1907

Haslam, Ed., 22, St. George's Terrace, Newcastle-upon-Tyne ... (E) Mar. 1907

Hawthorn, Edwin D., 38, Falconar Street, Newcastle-upon-Tyne (E) Jan. 1907

Heckels, Thomas G., 83, Falmouth Road, Heaton, Newcastle ... (E) Dec. 1906

Henderson, Joseph Nevison, 60, Woodbine Street, Gateshead-upon-Tyne ... ... (E) Dec. 1903

Hill, Anderson C., c/o Messrs. Hawthorn & Co., Ltd., Junction Bridge, Leith ... ... (E) May 1908

Huggins, Walter, 27, Mundella Terrace, Heaton, Newcastle ... (E) Nov. 1907

Hunter, Summers, jun., South Preston Lodge, North Shields ... (E) Nov. 1907

I.

Inglis, K., 22, Rosemount, Consett, Co. Durham ... ... (E) April 1907

J.

James, Chas. A., "Fernleigh," Westbourne Road, Birkenhead ... (S) Nov. 1903

Jennings, Edward C., 36, Beaconsfield Avenue, Low Fell, Gateshead-on-Tyne .. .. (E) Nov. 1901

Johnson, John, 17, Osborne Terrace, Carville Road, Wallsend-on-Tyne . . .. (E) Jan. 1907

Johnstone, S. R., 3, Balmoral Gardens, Monkseaton, Northumberland . . . ... (S) Nov. 1907

K.

	ELECTED.
Knight, Stanley C., Moorlands, Highbury, West Jesmond, Newcastle-upon-Tyne	(E) Jan. 1907
Knoph, R. G., 120, Trewhitt Road, Heaton, Newcastle-upon-Tyne	(S) Nov. 1907

L.

Lee, Charles R., 71, Lyon Street, Hebburn-on-Tyne	(S) Dec. 1906
Little, John, High Street, Felling-on-Tyne	(E) Feb. 1903
Lovatt, John James, 15, Kingsley Place, Heaton, Newcastle-upon-Tyne	(E) Jan. 1903

M.

MacDonald, Hector Duncan, 5 Park Parade, Westmorland Road, Newcastle-upon-Tyne	(E A) Jan. 1906
Mallet, James F., Ivy Road, Gosforth, Newcastle-on-Tyne ...	(E) Nov. 1904
Manners, A. W., 95, Waterloo Road, Blyth	(E) Nov. 1907
Markham, M., 9, Eldon Square, Newcastle-upon-Tyne	(E) Jan. 1908
Matheson, Ian Ross, The Clack, Hebburn-on-Tyne	(S) Dec. 1902
Matthews, John Wm., 15, Hillside, Tunstall Road, Sunderland ...	(S) Feb. 1904
McClelland, W., 14, Oaks West, Sunderland	(S) Jan. 1907
Mountain, Kenneth A., The Hermitage, Gateshead-on-Tyne	(E E A) Dec. 1905
Mountney, Chas. F., 7, Caroline Street, Jarrow-on-Tyne	(E) Feb. 1908

N.

Neill, John, B.Sc., c/o Messrs. Scott's S. & E. Co., Ltd., Engine Works, Greenock	(E) Nov. 1901
Nixon, William, 4, Bath Terrace, Blyth	(S) Jan. 1907

O.

Osbourne, Thomas B., The Oaks West, Sunderland	(E A) Nov. 1905
Oxberry, John A., 21, Grasmere Street, Gateshead-on-Tyne ...	(E) Mar. 1907

P.

Pellow, Ernest John, 3, St. Bede's Terrace, Sunderland Road, Gateshead-on-Tyne	(E) Feb. 1908
Pike, F. N., 1, Parade Crescent, Walker-on-Tyne	(S) Nov. 1907
Pile, John	(E) Jan. 1907
Pinder, John, c/o Messrs. Adamsez, Limited, Sanitary Engineers, Scotswood-on-Tyne	(E) Mar. 1904
Pledge, Harry, 132, Fairholme Road, Benwell Grove, Newcastle-upon-Tyne	(E E A) Nov. 1905
Porter, Norman, 13, Queens Square, Belfast, Ireland	(E E) April 1905

R.

Reed, A. P., "Mayfield," Jarrow-on-Tyne	(E) Nov. 1907
Reed, E., "Mayfield," Jarrow-on-Tyne	(E) Nov. 1907
Robinson, Joseph, 31, Percy Gardens, Tynemouth	(E P) Dec. 1905
Robinson, William E., 32, Percy Gardens, Tynemouth	(S) Nov. 1907
Robson, G., 37, Rothbury Terrace, Heaton, Newcastle-upon-Tyne	(S) Nov. 1907
Robson, S. J., 7, Claremont Terrace, Blyth	(S) Nov. 1907
Rolland, John, 49, Lovaine Place, Newcastle-upon-Tyne ..	(E) Oct. 1906
Routledge, R. B., 27, Harrison Place, Newcastle-upon-Tyne ...	(E) Nov. 1907

S.

ELECTED.

Scott, Keith S. M., B.Sc., Woodcote, Long Benton, near Newcastle-upon-Tyne ... ... (E) Nov. 1905
Sedcole, W. J., 17, Westoe Lane, South Shields ... ... (E) Feb. 1905
Sewell, Thomas R., Highcroft, Whitburn, near Sunderland ... (E) Dec. 1906
Shackleton, William L. C., 64, St. George's Terrace, West Jesmond (E A) Nov. 1905
Sims, G. P. W., ... (E) Nov. 1907
Smith, Thomas, 15, Eslington Terrace, Newcastle-upon-Tyne ... (E E) Jan. 1906
Snowdon, W., 1, Bell Grove Villas, Newcastle-upon-Tyne... ... (E) Nov. 1907
Stirzaker, Stanley C., 46, Highbury, Newcastle-upon-Tyne ... (E) Nov. 1901

T.

Talbot-Palmer, Edward, 94, Warwick Road, Romford Road, West Ham, London ... ... (E) Feb. 1904
Taylor, Hugh Lamport, 2, Prior's Terrace, Tynemouth ... ... (E) Mar. 1908
Taylor, John Allibon ... ... (E) Feb. 1904
Todd, Surtees, jun., 2, Egremont Drive, Sheriff Hill, Gateshead ... (E) May 1907
Tomlin, G. V., 123, Woodstock Avenue, Shawlands, Glasgow .. (E) Nov. 1907
Treweeks, H. C., Kingsdyke House, North Road, Wallsend-on-Tyne (E) Nov. 1907
Turner, G., 4, Queen's Road, Monkseaton, Northumberland ... (E) Jan. 1908

W.

Wardroper, Arthur K., Walker Vicarage, Walker-on-Tyne ... (E) Dec. 1901
Watson, Arthur William, Assistant Constructor, H.M.S. "Dominion," Chatham ... ... (S) Dec. 1903
Weatherley, Norman S., 5, Lynnwood Avenue, Newcastle-upon-Tyne ... ... (E) Dec. 1906
Webb, Edmund, 15, Oxford Terrace, Gateshead-on-Tyne ... ... (E) Nov. 1903
Weetman, John H., 11, Barkeley Drive, Seaforth, Liverpool (E P) Nov. 1905
White, William, 8, Poplar Crescent, Gateshead-on-Tyne ... ... (S) Nov. 1904
Whiting, W. R. G., B.A., 2, Ripon Gardens, Jesmond, Newcastle-upon-Tyne ... ... (S) Nov. 1903
Wilson, William, "Lancefield," Kellfield Avenue, Low Fell, Gateshead-on-Tyne ... ... (E) Feb. 1902
Winstanley, E. G., 5, Ash Place, Newcastle Road, Sunderland ... (S) Jan. 1908
Wood, G., 2, The Crescent, Gateshead-on-Tyne ... ... (E) Nov. 1907

Y.

Young, G., c/o Messrs. Donkin & Co., Engineers, St. Andrew's Engine Works, Walker Gate, Newcastle-upon-Tyne ... (E A) Dec. 1905
Young, James, 39, Westoe Parade, South Shields ... ... (S) Oct. 1906

GRADUATES.

A.

		ELECTED.
Aird, A., Gosforth House, Roker, Sunderland	(E)	Jan. 1908
Ashby, Edward, 2, Norman Terrace, Howdon-on-Tyne	(S)	May 1907
Atkinson, Harry, 137, High Park Road, Newcastle-upon-Tyne ...	(E)	Nov. 1901
Ayre, Amos L., 11, Green's Place, South Shields	(S)	Nov. 1904

B.

Ballard, Maxwell, c/o Mr. Marshall, St. Elmo, Greencastle, Belfast	(S)	Nov. 1904
Batty, George L., 6, Tweed Street, Berwick-on-Tweed	(EE)	Mar. 1903
Beattie, Walter, jun., 5, Beauclerc Terrace, Sunderland	(E)	Dec. 1906
Binns, Oswell Barritt, 76, Holly Avenue, Jesmond, Newcastle-upon-Tyne	(E A)	Jan. 1906
Blake, Leonard James, 20, Laburnum Avenue, Wallsend-upon-Tyne	(E)	Dec. 1903
Brown, George M., Messrs. Scott & Mountain, Close Works, Gateshead	(EE)	Mar. 1903
Brown, Rochester, 67, Osborne Road, Jesmond, Newcastle-upon-Tyne	(E)	Jan. 1905
Browne, John C., 15, Thornhill Gardens, Sunderland	(EE)	Dec. 1906
Brunton, Ernest C., 3, Prior's Terrace, Tynemouth	(E)	Dec. 1906
Burnup, E. Cyril, 2, Wentworth Place, Newcastle-upon-Tyne ...	(EE)	Mar. 1903

C.

Campbell, Hugh, c/o Messrs. N.E. Marine Engineering Co., Northumberland Engine Works, Wallsend-on-Tyne ...	(E A)	Nov. 1905
Carr, Stuart, Thornleigh, Jesmond, Newcastle-on-Tyne	(EE)	Nov. 1904
Challoner, Rex. T., 11, Lansdowne Terrace, Gosforth, Newcastle-upon-Tyne	(E A)	Nov. 1905
Champness, E. L., 35, Eskdale Terrace, Jesmond, Newcastle-upon-Tyne	(S)	Nov. 1907
Champness, E. T., 35, Eskdale Terrace, Jesmond, Newcastle-upon-Tyne	(E)	Nov. 1907
Chisholm, J. P., 48, Falmouth Road, Heaton, Newcastle-upon-Tyne	(E)	Nov. 1907
Clark, Ewbank, 162, Albert Road, Jarrow-upon-Tyne	(E)	Nov. 1907
Coates, John, 15, Park Place, E., Sunderland	(E)	Mar. 1908
Cookson, James Ambrose, 6, Primrose Hill, Low Fell, Gateshead	(E)	May 1907
Cothay, Frank H., 7, Valebrook Terrace, Sunderland	(E)	Feb. 1901
Cox, Harry Jasper, 177, High Street, Lewisham, London, S.E. ...	(S)	Dec. 1903
Cox, Theodore R., 8, Rothbury Terrace, Heaton, Newcastle-upon-Tyne	(E)	Dec. 1906
Creagh, Edward Curry, No. 1, Roker Gate, Roker, Sunderland ...	(E)	Nov. 1904
Cuttle, Henry H., 109, Castle Road, Scarborough	(E)	Jan. 1902

D.

Daglish, G., East Villa, The Green, Wallsend-upon-Tyne	(E)	Nov. 1908
Davis, Alfred, Seymour House, Lemington-on-Tyne, Scotswood, R.S.O.	(E)	Oct. 1906

ELECTED.

Davis, R. N., 10, St. George's Terrace, Jesmond, Newcastle-upon-Tyne ... ... (S) Nov. 1907
Deas, Charles Douglas, 30, Harrogate Street, Sunderland... ... (E) May 1908
Dent, E. L., 2, Bath Terrace, Tynemouth ... ... (E) Nov. 1907
Denton, R. A. E., 9, Poplar Crescent, Gateshead-on-Tyne ... ... (E) Nov. 1907
Driver, John Wm., 21, Grosvenor Place, North Shields ... ... (E) Feb. 1904
Dymond, C. H., 1, Windsor Terrace, Newcastle-upon-Tyne ... (E) Aug. 1908

E.

Edwards, A. G., 29, Argyle Street, Hebburn-on-Tyne ... ... (S) Nov. 1907

F.

Farina, Victor, J.P., 27, Crown Street, Newcastle-upon-Tyne ... (E A) Nov. 1905
Finlay, George, 27, Clayton Park Square, Newcastle-upon-Tyne... (E) Nov. 1902
Fleming, Tom, jun., Heathfield, Hebburn-on-Tyne ... ... (S) Dec. 1906

G.

Goddard, James Alan, 34, Denmark Street, Gateshead-on-Tyne .. (E A) May 1906
Graham, E., Morro House, Tynemouth ... ... (S) Nov. 1907
Green, Fred. Wm., Rutherford College, Newcastle-upon-Tyne ... (E) Jan. 1902

H.

Haddock, Gilbert Forster, 16, Azalea Terrace South, Sunderland (E) May 1908
Hamilton, Francis A. W. ... ... (E E A) Dec. 1905
Harney, J., 13, Stanley Street, Blyth ... ... (S) Nov. 1907
Harwood, F. A., Messrs. Santaro Nitrate Co., Ltd., Taltal, Chili, South America ... ... (E) Nov. 1907
Haslam, Ed., 22, St. George's Terrace, Newcastle-upon-Tyne ... (E) Mar. 1907
Hawthorn, Edwin D., 38, Falconar Street, Newcastle-upon-Tyne (E) Jan. 1907
Heckels, Thomas G., 83, Falmouth Road, Heaton, Newcastle ... (E) Dec. 1906
Henderson, Joseph Nevison, 60, Woodbine Street, Gateshead-upon-Tyne ... ... (E) Dec. 1903
Hill, Anderson C., c/o Messrs. Hawthorn & Co., Ltd., Junction Bridge, Leith ... ... (E) May 1908
Huggins, Walter, 27, Mundella Terrace, Heaton, Newcastle ... (E) Nov. 1907
Hunter, Summers, jun., South Preston Lodge, North Shields ... (E) Nov. 1907

I.

Inglis, K., 22, Rosemount, Consett, Co. Durham ... ... (E) April 1907

J.

James, Chas A., "Fernleigh," Westbourne Road, Birkenhead ... (S) Nov. 1903
Jennings, Edward C., 36, Beaconsfield Avenue, Low Fell, Gateshead-on-Tyne ... ... (E) Nov. 1901
Johnson, John, 17, Osborne Terrace, Carville Road, Wallsend-on-Tyne ... ... (E) Jan. 1907

[redacted]

K.

ELECTED.

Knight, Stanley C., Moorlands, Highbury, West Jesmond, Newcastle-upon-Tyne ... ... (E) Jan. 1907
Knoph, R. G., 120, Trewhitt Road, Heaton, Newcastle-upon-Tyne (S) Nov. 1907

L.

Lee, Charles R., 71, Lyon Street, Hebburn-on-Tyne ... ... (S) Dec. 1906
Little, John, High Street, Felling-on-Tyne ... ... (E) Feb. 1903
Lovatt, John James, 15, Kingsley Place, Heaton, Newcastle-upon-Tyne ... ... (E) Jan. 1903

M.

MacDonald, Hector Duncan, 5 Park Parade, Westmorland Road, Newcastle-upon-Tyne ... ... (E A) Jan. 1906
Mallet, James F., Ivy Road, Gosforth, Newcastle-on-Tyne ... (E) Nov. 1904
Manners, A. W., 95, Waterloo Road, Blyth ... ... (E) Nov. 1907
Markham, M., 9, Eldon Square, Newcastle-upon-Tyne ... ... (E) Jan. 1908
Matheson, Ian Ross, The Clack, Hebburn-on-Tyne ... ... (S) Dec. 1902
Matthews, John Wm., 15, Hillside, Tunstall Road, Sunderland ... (S) Feb. 1904
McClelland, W., 14, Oaks West, Sunderland ... ... (S) Jan. 1907
Mountain, Kenneth A., The Hermitage, Gateshead-on-Tyne (E E A) Dec. 1905
Mountney, Chas. F., 7, Caroline Street, Jarrow-on-Tyne ... ... (E) Feb. 1908

N.

Neill, John, B.Sc., c/o Messrs. Scott's S. & E. Co., Ltd., Engine Works, Greenock ... ... (E) Nov. 1901
Nixon, William, 4, Bath Terrace, Blyth ... ... (S) Jan. 1907

O.

Osbourne, Thomas B., The Oaks West, Sunderland ... ... (E A) Nov. 1905
Oxberry, John A., 21, Grasmere Street, Gateshead-on-Tyne ... (E) Mar. 1907

P.

Pellow, Ernest John, 3, St. Bede's Terrace, Sunderland Road, Gateshead-on-Tyne .. .. (E) Feb. 1908
Pike, F. N., 1, Parade Crescent, Walker-on-Tyne ... ... (S) Nov. 1907
Pile, John ... ... (E) Jan. 1907
Pinder, John, c/o Messrs. Adamsez, Limited, Sanitary Engineers, Scotswood-on-Tyne ... ... (E) Mar. 1904
Pledge, Harry, 132, Fairholme Road, Benwell Grove, Newcastle-upon-Tyne ... ... (E E A) Nov. 1905
Porter, Norman, 13, Queens Square, Belfast, Ireland ... ... (E E) April 1905

R.

Reed, A. P., "Mayfield," Jarrow-on-Tyne ... ... (E) Nov. 1907
Reed, E., "Mayfield," Jarrow-on-Tyne ... ... (E) Nov. 1907
Robinson, Joseph, 31, Percy Gardens, Tynemouth ... ... (E P) Dec. 1905
Robinson, William E., 32, Percy Gardens, Tynemouth ... ... (S) Nov. 1907
Robson, G., 37, Rothbury Terrace, Heaton, Newcastle-upon-Tyne (S) Nov. 1907
Robson, S. J., 7, Claremont Terrace, Blyth ... ... (S) Nov. 1907
Rolland, John, 49, Lovaine Place, Newcastle-upon-Tyne .. (E) Oct. 1906
Routledge, R. B., 27, Harrison Place, Newcastle-upon-Tyne .. (E) Nov. 1907

S.

ELECTED.

Scott, Keith S. M., B.Sc., Woodcote, Long Benton, near Newcastle-upon-Tyne ... ... (E) Nov. 1905

Sedcole, W. J., 17, Westoe Lane, South Shields ... ... (E) Feb. 1905

Sewell, Thomas R., Highcroft, Whitburn, near Sunderland ... (E) Dec. 1906

Shackleton, William L. C., 64, St. George's Terrace, West Jesmond (E A) Nov. 1905

Sims, G. P. W., ... (E) Nov. 1907

Smith, Thomas, 15, Eslington Terrace, Newcastle-upon-Tyne ... (E E) Jan. 1906

Snowdon, W., 1, Bell Grove Villas, Newcastle-upon-Tyne... ... (E) Nov. 1907

Stirzaker, Stanley C., 46, Highbury, Newcastle-upon-Tyne ... (E) Nov. 1901

T.

Talbot-Palmer, Edward, 94, Warwick Road, Romford Road, West Ham, London ... ... (E) Feb. 1904

Taylor, Hugh Lamport, 2, Prior's Terrace, Tynemouth ... ... (E) Mar. 1908

Taylor, John Allibon ... ... (E) Feb. 1904

Todd, Surtees, jun., 2, Egremont Drive, Sheriff Hill, Gateshead ... (E) May 1907

Tomlin, G. V., 123, Woodstock Avenue, Shawlands, Glasgow .. (E) Nov. 1907

Treweeks, H. C., Kingsdyke House, North Road, Wallsend-on-Tyne (E) Nov. 1907

Turner, G., 4, Queen's Road, Monkseaton, Northumberland ... (E) Jan. 1908

W.

Wardroper, Arthur K., Walker Vicarage, Walker-on-Tyne ... (E) Dec. 1901

Watson, Arthur William, Assistant Constructor, H.M.S. "Dominion," Chatham ... ... (S) Dec. 1903

Weatherley, Norman S., 5, Lynnwood Avenue, Newcastle-upon-Tyne ... ... (E) Dec. 1906

Webb, Edmund, 15, Oxford Terrace, Gateshead-on-Tyne ... ... (E) Nov. 1903

Weetman, John H., 11, Barkeley Drive, Seaforth, Liverpool (E P) Nov. 1905

White, William, 8, Poplar Crescent, Gateshead-on-Tyne ... ... (S) Nov. 1904

Whiting, W. R. G., B.A., 2, Ripon Gardens, Jesmond, Newcastle-upon-Tyne ... ... (S) Nov. 1903

Wilson, William, "Lancefield," Kellfield Avenue, Low Fell, Gateshead-on-Tyne ... ... (E) Feb. 1902

Winstanley, E. G., 5, Ash Place, Newcastle Road, Sunderland ... (S) Jan. 1908

Wood, G., 2, The Crescent, Gateshead-on-Tyne ... ... (E) Nov. 1907

Y.

Young, G., c/o Messrs. Donkin & Co., Engineers, St. Andrew's Engine Works, Walker Gate, Newcastle-upon-Tyne ... (E A) Dec. 1905

Young, James, 39, Westoe Parade, South Shields ... ... (S) Oct. 1906

NORTH-EAST COAST INSTITUTION

OF

ENGINEERS AND SHIPBUILDERS.

TWENTY-FOURTH SESSION, 1907-1908.

PROCEEDINGS.

THE FIRST GENERAL MEETING OF THE SESSION, HELD IN THE LECTURE THEATRE OF THE LITERARY AND PHILOSOPHICAL SOCIETY, WESTGATE ROAD, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, NOVEMBER 29TH, 1907.

W. H. DUGDALE, ESQ., M.INST.C.E., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the Closing Meeting of the previous Session, held on Friday, May 31st, 1907, which were confirmed by the members present, and signed by the President.

The PRESIDENT appointed Mr. Alfred Harrison and Mr. R. H. Muir to examine the voting papers for new members, and the following gentlemen were declared elected:—

MEMBERS.

Blackwood, M., Lloyd's Surveyor, Messrs. Lloyd's Register of Shipping, Maritime Buildings, Dundee.

Burnett, Edward J., Engineer, c/o Messrs. H. Watson & Sons, High Bridge Works, Walker Gate.

Elliott, E. E., Consulting Engineer, 31, Via S. Spirits, Florence, Italy.

Fawcus, Walter, Engineer Draughtsman, 110, Sandyford Road, Newcastle-upon-Tyne.

Hamilton, H. P., Engineer, Beech Holme, Imperial Avenue, Norton-on-Tees.

Hardy, Ed., Shipbuilder, 8, Sussex Street, Jarrow-on-Tyne.

Johnson, Alfred, Consulting Engineer, Victoria Buildings, Stockton-on-Tees.

Johnson, Charles, Engineer Draughtsman, 27, Charles Street, Heaton, Newcastle-upon-Tyne.

McKenzie, James, Engineer, 11, Holmwood Grove, West Jesmond, Newcastle-upon-Tyne.

Milne, W. J., Supt. Engineer, 18, Kirton Park Terrace, North Shields.

Prest, G. S., Engineer, 29, Eldon Street, Newcastle-upon-Tyne.

Ritson, Cuthbert, Shipwright, 5, Middleton Street East, Waterloo, Blyth.

Watson, Jacob, Surveyor, 12, East Avenue, Long Benton, Northumberland.

Welch, J. J., Naval Architect, The Hollies, Westfield Avenue, Gosforth, Newcastle-upon-Tyne.

Wilson, W. J., Shipbuilder, Messrs. William Crighton & Co., Engineers and Shipbuilders, Abo, Finland.

GRADUATES TO MEMBERS.

Bedlington, A. S., Shipbuilder, 15, Stanhope Road, South Shields.

Hobson, J. W., Locomotive Draughtsman, 53, Bishop's Road, Benwell, Newcastle-upon-Tyne.

Knight, R. C., Ship Draughtsman, 19, Highbury, West Jesmond, Newcastle-upon-Tyne.

Slee, Herbert T., Marine Engineer, "Underwood," Beaconsfield Road, Gosforth, Newcastle-upon-Tyne.

ASSOCIATE.

Nettleship, G., Assistant Secretary, 39, Trent Street, Norton Road, Stockton-on-Tees.

GRADUATES.

Champness, E. L., Ship Draughtsman Apprentice, 35, Eskdale Terrace, Jesmond, Newcastle-upon-Tyne.

Champness, E. T., E. Apprentice, 35, Eskdale Terrace, Jesmond, Newcastle-upon-Tyne.

Clark, Ewbank, E. Apprentice, 40, Burdon Terrace, Newcastle-upon-Tyne.

Daglish, G., E. Apprentice, East Villa, The Green, Wallsend-on-Tyne.

Dent, E. L., E. Apprentice, St. Luke's Vicarage, Wallsend-on-Tyne.

Denton, R. A. E., E. Apprentice, 9, Poplar Crescent, Gateshead-on-Tyne.

Davis, R. N., S. Apprentice, 10, St. George's Terrace, Jesmond, Newcastle-upon-Tyne.

Dymond, C. H., E. Apprentice, 1, Windsor Terrace, Newcastle-upon-Tyne.

Edwards, A. G., Ship Draughtsman, 29, Argyle Street, Hebburn-on-Tyne.

Graham, E., Shipbuilder Apprentice, Morn House, Tynemouth.

Harney, J., Ship Draughtsman, 13, Stanley Street, Blyth.

Harwood, F. A., E. Student, 75, Thornton Street, West Hartlepool.

Hunter, Summers, jun., E Apprentice, South Preston Lodge, North Shields.

Johnstone, S. H., Ship Draughtsman Apprentice, 3, Balmoral Gardens, Monkseaton.

Knoph, R. G., Ship Draughtsman 2, Alexander Street, Newcastle-upon-Tyne.

Manners, A. W., Engineer and Draughtsman, 95, Waterloo Road, Blyth.

Pike, F. N., Ship Draughtsman, 1, Parade Crescent, Walker-on-Tyne.

Reed, A. P., E. Apprentice, "Mayfield," Jarrow-on-Tyne.
Reed, E., E. Apprentice, "Mayfield," Jarrow-on-Tyne.
Robinson, William E., Shipbuilder Apprentice, 32, Percy Gardens, Tynemouth.
Robson, G., Shipbuilder Apprentice, 3, Cheltenham Terrace, Heaton, Newcastle-upon-Tyne.
Robson, S. J., Ship Draughtsman Apprentice, 7, Claremont Terrace, Blyth.
Routledge, R. B., E. Apprentice, 27, Harrison Place, Newcastle-upon-Tyne.
Sims, G. P. W., Engineer and Draughtsman, 82, Meldon Terrace, Heaton, Newcastle-on-Tyne.
Snowdon, W., Engineer, 1, Belle Grove Villas, Newcastle-upon-Tyne.
Treweeks, H. C., E. Apprentice, Kingsdyke House, North Road, Wallsend-on-Tyne.
Tomlin, G. V., E. Apprentice, 1, Windermere Street, Gateshead-on-Tyne.
Wood, G., E. Apprentice, 2, The Crescent, Gateshead-on-Tyne.

DEATH OF A MEMBER.

The President said—It is with very much regret that I have to state that Mr. J. C. Stirzaker, who was one of the founders and first members of the Institution, and also for many years a member of Council, died suddenly on Sunday last (November 24th).

The Secretary submitted the report of the Council on the work of the Twenty-third Session, 1906-1907:—

COUNCIL REPORT.

(TWENTY-THIRD SESSION, 1906-1907.)

The Twenty-third Session of the Institution was opened on Friday, October 26th, 1906. The new President, Mr. W. H. Dugdale, was duly installed by the immediate Past-President, The Right Hon. Lord Armstrong, and delivered his Inaugural Address.

During the Session the following papers were read and discussed:—

PAPERS.

"On the Training of Cadets for the Mercantile Marine." By Mr. J. Denholm Young.

"Suggested Method for Experiments on the Wind Resistance of Ships." By Mr. F. H. Alexander.

"The Application of Machinery to the Driving of Pumping Engines and Graving Docks." By Mr. W. C. Mountain.

"Marine Steam Turbine Development." By the Hon. C. A. Parsons and Mr. R. J. Walker.

"Trim Curves." By Mr. A. E. Long.

"Sectional Work in Ship Construction." By Mr. J. L. Twaddell.

"Some Experiments on the Magnetic Character of Vessels." By Capt. W. Bartling.

GOLD MEDAL.

The Engineering Gold Medal for the Twenty-second Session was presented to Mr. J. Mitchell Moncrieff for his very interesting and instructive paper on "Commercial Dry Docks."

DINNER.

The Institution dinner was held in Newcastle-upon-Tyne on Friday, December 7th, 1906. There was a good attendance of members and guests.

Lloyd's Committee.

The term for which the representatives of this Institution had to serve on Lloyd's Technical Sub-Committee having expired, the Council was called upon to elect four representatives to serve for a further period of four years. The following gentlemen were elected:—

Shipbuilders—Mr. W. H. Dugdale and Mr. Henry Withy.

Engineers—Mr. Summers Hunter and Mr. Andrew Laing.

A brief summary of the proceedings of the Sub-Committee during the last four years having been submitted, it was printed and inserted in the twenty-third volume of the *Transactions* of the Institution.*

Board of Trade Committee.

The Report of the work of the Consultative Committee appointed to confer with the Marine Department of the Board of Trade for the year ended 5th March, 1907, not having been received prior to the publication of volume xxiii. of the *Transactions*, it is now appended to this Council Report.†

New Offices.

It being considered advisable that steps should be taken to secure more suitable accommodation for the Institution, also that the Institution should, if possible, have its offices and rooms in the same building as those of the Federated Employers' Associations of Engineers and Shipbuilders, a committee was appointed to meet the representatives of the above Associations to consider the question of obtaining suitable premises. The labours of this joint committee have extended over a period of two years. The Newcastle-upon-Tyne Literary and Philosophical Society having offered to erect a building adjoining their premises, to meet the necessary requirements, the above Associations accepted the offer and have agreed to lease the premises for a term of years; and the Council of this Institution has agreed that the Institution shall become sub-tenants of the above Associations and shall pay to the Associations an annual sum to cover rent, rates, cleaning and all general charges.

* *Transactions N.E.C. Inst. of E. & S.*, vol. xxiii., p. 113.

† See page 15.

SCHOLARSHIP.

Shortly after the delivery of his Inaugural Address, the President (Mr. W. H. Dugdale) addressed a circular letter to various friends and members of our Institution, asking them to subscribe towards a fund to provide a Scholarship for deserving Graduates of this Institution. This has met with a cordial response, and the following gentlemen have been appointed a committee to carry out the scheme in its entirety:—

Chairman—Mr. W. H. Dugdale.

Trustees—Mr. William Boyd, Sir W. Theodore Doxford, Mr. Henry Withy.

Tyne and Blyth—Messrs. G. J. Carter, Summers Hunter, H. B. Rowell, W. G. Spence, R. L. Weighton, R. Saxton White.

Wear—Messrs. Henry Clark, F. Dickinson, Hugh Laing, James Marr.

Tees and Hartlepools—Mr. D. B. Morison.

The Committee has not completed its labours. A sum of £1,300 has already been invested and a further appeal is now made to the general body of members with a view to increase this amount and enhance the value of the scholarship.

MARINE SCHOOL.

A letter was received from the Secretary of the Board of Education, South Kensington, London, enclosing a copy of the scheme drawn up by the Board of Education for the administration of the foundation of the Marine School of South Shields and asking our Institution to appoint a representative on the governing body. The Council has appointed Mr. Harry Eltringham to act as representative of this Institution.

CONSTITUTION AND BYE-LAWS.

In order to comply with the requirements of Act 6 and 7 Vict. cap. 36, exempting this Institution from the payment of rates, etc., a slight alteration has been mac of the Constitution and the following new Bye-

47.—The Income and Property of the Institution, whencesoever derived, shall be applied solely towards the promotion of the objects of the Institution as set forth in Constitution II., and no portion thereof shall be paid or transferred directly or indirectly by way of dividend, division or gift, bonus in money, or otherwise howsoever, by way of profit, to the persons who at any time are or have been Members of the Institution, or to any of them, or to any person claiming through any of them.

Provided that nothing herein shall prevent the payment in good faith of remuneration to any Officers or Servants of the Institution, or to any Member of the Institution, or other person, in return for any services rendered to the Institution.

The following addition has also been made to Article IX. of the Constitution:—

"The Chairman of the Graduate Section shall be *ex-officio* a Member of the Council with power to vote."

Conversazione.

The Secretary having received letters and also personal opinions from various members of the Institution expressing their disapproval of each President being called upon to give a Conversazione during his term of office, the matter was brought before the Council, and having been fully considered, it was unanimously resolved "that in the future no 'Presidential Conversazione' shall be given or held."

Finances.

The financial statement for the year ending 31st July, 1907, is appended to this report. The Council regrets having to state that the sum of £20 9s. 6d. for subscriptions in arrears has been written off as irrecoverable and in addition there is still due to the Institution the sum of £61 8s. 6d. for unpaid subscriptions for the last year.

New Members.

During the year the following additions have been made to the roll of members:—Two Honorary Members: The Principal of the Armstrong College (Sir Isambard Owen, D.C.L., M.D.) and Sir Philip Watts, K.C.B., F.R.S.; 1 Life Member, 57 Members, 4 Associates, 26 Graduates, and 14 Graduates have passed into the Members' Section.

DEATHS.

The Council regrets having to record the loss by death of the following:—Members: Charles H. Bailey, Newport, Mon.; L. M. Bodin, Sunderland; Charles Brockett, Hull; William Dobson, Newcastle-upon-Tyne; Ernest G. Gearing, Leeds; P. Micheli, Genoa; and James Rowan, Glasgow. Associates: John Brunton, Tynemouth; A. Fellows, Jarrow-on-Tyne; and Sir J. D. Milburn, Bart., Newcastle-upon-Tyne.

RESIGNATIONS.

The Institution has also lost by resignations and other causes:—40 Members, 11 Associates, and 23 Graduates.

The total number of members now enrolled is as follows:—

Honorary Members	7
Life Members	8
Members	835
Life Associates	2
Associates	110
Graduates	83
	1,045

The Council desires every Member to use his influence towards promoting the objects of the Institution by regularly attending the Meetings, contributing papers, or taking part in the discussions, and by introducing new Members.

GRADUATE SECTION.

The Eighteenth Session of the Graduate Section was opened on Saturday, October 27th, 1906. The Chairman (Mr. H. Jasper Cox) delivered an interesting address on "The Equipment and Arrangement of a Modern Shipbuilding Yard," and during the Session the following papers were read and discussed:—

Papers.

"The Structural Development of the Cargo Steamers." By Mr. Maxwell Ballard.
"High-speed Steam Engines for driving Electric Generators Direct." By Mr. W. J. Sedcole.
"Vibrations in Steamships." By Mr. A. W. Watson.
"Some Notes on Freeboard." By Mr. A. L. Ayre.
"The Modern Locomotive Boiler." By Mr. J. W. Hobson.

The attendance at the General Meetings showed a perceptible increase over that of the previous Sessions.

The following awards were granted to the authors of papers read before the Section during the Seventeenth Session:—

The sum of £4 to Mr. J. Neill for his paper on "Producer Gas for Power."
The sum of £3 to Mr. Kenneth Watson for his paper on "Notes on Natural and Mechanical Draught."

The former paper by Mr. J. Neill was published in the twenty-third volume of the *Transactions* of the Institution.

Works Visited.

The following engineering and shipbuilding works were visited:—

Messrs. the North Eastern Railway Co.'s Locomotive Works, Gateshead-on-Tyne.
Messrs. Palmer & Co.'s Shipbuilding and Ironworks, Jarrow-on-Tyne.
Messrs. Hawthorn, Leslie & Co.'s Locomotive Works, Newcastle-upon-Tyne.

The thanks of the Institution are due to the principals and officials of these establishments for the kindness extended to the junior members and the interesting manner in which they were conducted through the various works.

The Committee of the Section desires to place on record the appreciation of the Graduate members of the privilege granted to them by giving their Chairman a seat on the Council of the Institution.

Mr. Hugh Campbell has been elected Chairman and Mr. W. J. Sedcole Hon. Secretary for the current (Nineteenth) Session.

The Balance Sheet for Session ending 31st July, 1907.

Liabilities.

		£ s. d.	£ s. d.
Gold Medals' Fund—			
Amount at 31st July, 1906 ...	£327 15 1		
Interest on Investment ...	9 2 2		
		336 17 3	
Less Medal Awarded...		5 10 0	
			331 7 3
Graduates' Award Fund—			
Amount at 31st July, 1906 ...	£223 4 4		
Interest on Investment ...	7 3 6		
		230 7 10	
Less Awards for Papers		7 0 0	
			223 7 10
Payments by Life Members and Associates—			
As at 31st July, 1906		252 0 0	
Add Life Member this Session		21 0 0	
			273 0 0
General Capital—			
As at 31st July, 1906		3,105 12 5	
Revenue Account		166 11 2	
			3,272 3 7
			£4,099 18 8

Audited and certified,
R. W. & J. A. Sisson,
Chartered Accountants.

24th October, 1907.

Assets.

		£ s. d.	£ s. d.
Subscriptions in Arrear—			
Session 1905-1906		6 6 0	
Session 1906-1907		55 2 6	
			61 8 6
Stock of Transactions, valued at			258 16 9
Office and Library Furniture,			
Safe, etc., as at 31st July, 1906	£98 1 0		
Additions	4 15 6		
		102 16 6	
Less—Depreciation		9 16 0	
			93 0 6
Books in Library—			
As at 31st July, 1906 ...	£382 3 9		
Less—Depreciation ...	42 0 0		
		340 3 9	
Additions this Session—			
Purchases		17 8 4	
Books received in exchange for Transactions		30 0 0	
			387 12 1
Tyne Improvement Commissioners—Investment in respect of the following Accounts, viz.:—			
Gold Medals' Fund		274 0 0	
Graduates' Award Fund and Payments by Life Members and Associates		331 0 0	
General Capital—			
As at 31st July, 1906		2,000 0 0	
			2,605 0 0
Cash—At Bank			694 0 10
			£4099 18 8

Note.—The Scholarship Fund inaugurated during the Session is not included in the foregoing Accounts.

NORTH-EAST COAST INSTITUTION OF

STATEMENT OF RECEIPTS AND PAYMENTS

Receipts.

				£	s.	d.	£	s.	d.
To Balance at Bank brought from last Account							487	10	8
,, Subscriptions received for Session 1906-1907—									
219 Members at £2 2s.	£459	18	0						
589 Members „ £1 1s.	618	9	0						
115 Associates „ £1 1s.	120	15	0						
82 Graduates „ 10s. 6d.	43	1	0						
				1,242	3	0			
1,005									
,, Association of Foremen Engineers and Draughtsmen— One year's Subscription				20	0	0			
,, Life Member—J. MacHaffie				21	0	0			
,, Arrears from Session 1905-1906—									
11 Members at £2 2s.	£23	2	0						
38 Members „ £1 1s.	39	18	0						
3 Associates „ £1 1s.	3	3	0						
2 Graduates ,, 10s. 6d.	1	1	0						
				67	4	0			
							1,350	7	0
,, Transactions sold this Session				33	3	4			
,, Copies of Members' Papers supplied				24	10	8			
							57	14	0
,, Advertisements							57	3	0
,, Tyne Improvement Commissioners—									
One Year's Interest to 21st June, 1907, on £605, at 3½ per cent.				21	3	6			
Viz.:—Medal Fund	£274	0	0						
Graduates' Award and Life Members' Fund	331	0	0						
	£605	0	0						
Less—Income Tax				1	1	2			
							20	2	4
One Year's Interest to 10th July, 1907, on £500, at 3¾ per cent.				18	15	0			
Less—Income Tax				0	18	8			
							17	16	4
One Year's Interest to 4th May, 1907, on £300, at 3 per cent.				9	0	0			
Less—Income Tax				0	9	0			
							8	11	0
One Year's Interest to 13th July, 1907, on £300, at 3¼ per cent.				9	15	0			
Less—Income Tax				0	9	8			
							9	5	4
One Year's Interest to 9th June, 1907, on £300, at 3¼ per cent.				9	15	0			
Less—Income Tax				0	9	8			
							9	5	4
One Year's Interest to 8th May, 1907, on £300, at 3½ per cent.				10	10	0			
Less—Income Tax				0	10	6			
							9	19	6
One year's interest to 5th May, 1907, on £300 at 4 per cent.				12	0	0			
Less—Income Tax				0	12	0			
							11	8	0
General Capital Invested .. £2,000							£2,039	2	6

ENGINEERS AND SHIPBUILDERS.

FOR SESSION ENDING 31ST JULY, 1907.

Payments.

	£	s.	d.	£	s.	d.
By Transactions and Papers—						
Lithographing	77	15	6			
Printing and Binding	222	8	1			
				300	3	7
„ Stationery and Circulars				87	9	9
„ Reporting				20	10	0
„ Rents—						
Offices and Electric Light Fittings	112	12	9			
Lecture Rooms and Assembly Rooms	17	2	0			
Telephone	7	15	0			
				137	9	9
„ Rates, Gas, Electric Light, and Insurance...				4	12	6
„ Salaries—						
Secretary, Salary	400	0	0			
„ Commission	66	10	4			
Assistants'	65	0	0			
				531	10	4
„ Representative on Institute of Civil Engineers' Educational Committee				15	15	0
„ Postages, Stamps, Post Cards, Parcels, etc.	126	18	1			
„ Secretary's and Office Expenses, Coal, Cleaning, etc. ...	70	2	10			
„ Measured Mile Posts—Rent...	6	6	0			
„ Auditors' Fee	5	5	0			
„ Lantern Expenses	3	7	6			
				211	19	5
„ Library Account—						
New Books	9	5	0			
Bookbinding	8	3	4			
				17	8	4
„ Additions to Transactions				0	17	6
„ Gold Medal Fund—						
Gold Medal awarded				5	10	0
„ Awards to Graduates				7	0	0
„ Furniture Account—						
Additions				4	15	6
„ Balance at Bank				694	0	10
				£2,039	2	6

The PRESIDENT, having invited any remarks or questions, and there being none, declared the report and financial statement adopted.

The SECRETARY submitted the report of the work of the Consultative Committee appointed to confer with the Marine Department of the Board of Trade for the year ended 5th March, 1907.

The PRESIDENT (Mr. W. H. Dugdale) delivered his opening address.

Mr. J. H. HECK read a paper on "Notes on the Effect of Work and Time on the Properties of Mild Steel and Iron."

REPORT OF THE WORK OF THE CONSULTATIVE COMMITTEE APPOINTED TO CONFER WITH THE MARINE DEPARTMENT OF THE BOARD OF TRADE, FOR THE YEAR ENDED 5TH MARCH, 1907.

The following matters have emerged, and have been dealt with, or have been considered by this Committee since the date of their last Report:—

Mr. Lloyd-George, the President of the Board of Trade, having, during the progress of the Merchant Shipping Bill through the House of Commons, intimated his intention of forming one Grand Committee or several Divisional Committees, to advise the Board of Trade on matters relating to Shipbuilding, Marine Engineering and Shipping, the Secretary of this Committee, by their instructions, wrote to Mr. Lloyd-George explaining very fully the objects, history, and position of this Committee.

This was followed up by a Deputation to Mr. Lloyd-George on 24th October last, and the proposal that the New Advisory Committee proposed by the President to deal with Shipbuilding and Engineering matters could, with advantage, be constituted on similar lines to this Committee seemed to commend itself to his favourable consideration.

When the Merchant Shipping Bill became Law the Board of Trade, under Section 79 of the Act "The Merchant Shipping Act, 1906," got power to appoint Advisory Committees; and the subject of the formation of such Committees is at present under consideration by the President.

Mr. Seaton, the Chairman of this Committee (who with Mr. D. J. Dunlop, the Vice-Chairman, addressed the President at the interview), took the opportunity of pressing the question of getting written approval from the Board of Trade to Boiler and other Plans submitted to them, and it was agreed by Mr. Howell, the Assistant-Secretary Marine Department Board of Trade, who was present, that this should be done—the matter having received the approval of Mr. Lloyd-George.

This question (which is a very important matter with Engineers and Shipbuilders) has received much attention from this

Committee, and a good deal of correspondence on the subject has passed with the Board of Trade, but it is hoped that the question has at last been settled; and that it is not out of place under the circumstances to refer to it at this stage of the Report.

The Consultative Committee formerly understood that legislative sanction would be required by the Board of Trade before such written approval could be given by them, and clauses which this Committee considered would be necessary were after a good deal of work framed during the passing of the Merchant Shipping Bill through the House, to be added to the Act, by Mr. Seaton and Mr. Adamson with the assistance of other Members of this Committee, but the Permanent Secretary and President of the Board of Trade seem to consider that the Department already possessed the power.

On 27th December last the Board of Trade—stating that the provisions of the Merchant Shipping Act with regard to Advisory Committees do not come into force until June next or they would have referred the matter to such a Committee—forwarded for the observations or suggestions of this Committee certain Draft Regulations which the Board proposed to issue under Section 10 (which deals with the loading of Timber) of "The Merchant Shipping Act, 1906," with the least possible delay.

The principal points in which the new law differs from the old are that heavy wood goods are allowed to be carried under certain conditions as deck cargo, and that an increased amount of light wood goods is also allowed to be carried in certain cases.

Heavy wood goods, however, under Section 10 (2) (b), can only be carried in such classes of ships as may be approved by the Board of Trade for the purpose, and under Section 10 (2) (c) they must be loaded in accordance with Regulations made by the Board of Trade. Further, in the case of light wood goods it is necessary under Section 10 (3) (c) to comply with Regulations to be made by the Board of Trade for the protection of the crew.

The matter was at once dealt with, and the observations of this Committee on the Regulations were communicated to the Board of Trade.

On 15th February last the Board of Trade wrote to this Committee transmitting for their information a copy of the Rules made by the Department on the subject, but adding that owing to the limited time available it had not been possible to consult an Advisory Committee with regard to the new Rules (which came into effect on the 7th of February), and that the Board proposed to lay the Rules before such a Committee before next winter, when suggestions made to the Board, but for various reasons not now adopted, will be presented for further consideration.

This Committee some time ago very thoroughly considered the question as to the furnishing of Plans of Pumping Arrangements to the Board of Trade, but the question as to the fitting of Hand Deck Pumps as required by the Board of Trade and Lloyd's in the Holds and Engine and Boiler Spaces of large Steamers was raised quite recently by a large Shipbuilding Firm. The Committee consider that these Pumps are practically useless and that they should be dispensed with. The matter was exhaustively dealt with in the last report of the Committee (*vide* pages 2 and 3), but the Committee offered, if wished, to again approach the Board of Trade on the Subject. The Firm referred to, however, do not appear to object to the matter being deferred. Probably it may form one of the matters for consideration by the New Advisory Committee.

Questions as to the Measurement of Tonnage have from time to time occupied the attention of the Committee and of their Sub-Committee on Tonnage.

A question raised by a Scottish Firm of Shipbuilders as to the inclusion in tonnage of Hopper Barges and like vessels of Water Ballast Compartments in side wings and exemption of Peak Ballast Tanks, after consideration by the Committee, was remitted to the Sub-Committee on Tonnage.

That Sub-Committee were of opinion that spaces to all intents and purposes similar have been exempted in the cases of certain ships built by Messrs. Sir Raylton Dixon & Co., Ltd., under their Patent and others, and they recommended the Firm to approach the Board of Trade themselves referring to these cases.

In a case referring to tonnage of shelter deck vessels, the Committee have expressed an opinion in a question raised by a Firm of Shipbuilders on the North East Coast as to the refusal of the local surveyor of the Board of Trade to exempt shelter deck space from tonnage if coaming of tonnage opening was more than 12 inches above shelter deck, that such refusal was not unreasonable seeing that these spaces are not measured into tonnage, and the policy of the Board of Trade is to prevent them from being fit to carry dry and perishable goods, while they are covered sufficiently for the safety of the ship.

The subjects following have been previously under the consideration of the Committee—or subjects which were in close connection with them have already engaged their attention.

The reduction of Weight of Stays in Boilers and reduction of Scantlings is still under consideration, but with the exception that the Deputy Chairman, Mr. D. J. Dunlop, has prepared a statement as to the details for Marine Boilers as demanded by Lloyd's, the Board of Trade and the British Corporation, this Committee have nothing further to report but hope that the matters will receive attention as soon as an Advisory Committee is appointed by the Board of Trade, and the Board of Trade, Lloyd's, and the British Corporation have ended their conference on this question.

The conditions which this Committee considered should be fulfilled before an Engineer is eligible as a Candidate for a Board of Trade Certificate, and which appear in the last report, were, as therein stated, submitted to the Board of Trade, but your Committee regret that they have failed to convince the Board of Trade of the propriety of the proposals respecting the training of seagoing Engineers, and they feel powerless at the present time to re-open the question. The Committee, however, trust that when the new Advisory Committee to be appointed by the Board of Trade have got into working order, the question will be again considered, and the views of those interested impressed on its members.

It should be added that the Board of Trade, on 10th April, 1906, sent for the observations of this Committee a Bill which the Marine Engineers' Association had presented to them for their consideration.

The receipt of the Bill, and also that each of the three Scientific Institutions had referred the Bill to this Committee, by whom it had been referred to their Sub-Committee on the training of Marine Engineer Apprentices, was duly intimated to the Board of Trade.

The matter is still under consideration, but this Committee have already, as above stated, submitted to the Board of Trade the conditions which this Committee considered should be fulfilled before an Engineer is eligible as a Candidate for a Board of Trade Certificate, and a report to a similar effect upon the proposed Bill was duly made to the Board.

The Committee have been in communication with the Board of Trade on the position of the Lamp Room in Steam Fishing Vessels, and sanitary arrangements on board of these ships, and they have again pressed the desirability for uniformity of practice among the Surveyors, as far as possible, on the Board of Trade.

A copy of the last letter from the Board of Trade on the subject was recently communicated to those interested.

The Committee have also been in communication with the Board of Trade on the subject of Fitting Freeing Ports in shelter 'tween decks, and on a further question raised by a Scottish firm as to the thickness of Cabin Flooring, and on some other questions which have been dealt with more or less in previous Reports.

On the question of Poop Openings, reports as to the practice of Shipbuilders in the Tyne, Wear, and Clyde districts have been obtained, and have been under consideration by the Committee.

A question raised by a firm on the North East Coast as to a request by the Board of Trade for complete designs of Turbines when Special Certificates are required was considered, but the firm afterwards intimated that they desired that the question might lie in abeyance at present.

The Institution is represented on this Committee by the following gentlemen:—

Shipbuilders—Mr. W. H. Dugdale and Mr. George Jones.
Engineers—Mr. J. H. Irwin and Mr. D. B. Morison.

PRESIDENT'S OPENING ADDRESS.

[DELIVERED ON NOVEMBER 29TH, 1907.]

The PRESIDENT (Mr. W. H. Dugdale) said—You have just received the report of your Council for the Twenty-third Session, by which you will observe that the Institution is still doing good work in the interest of the industries we represent, and can do still greater work if we all realise its necessity.

There are a few points in the report to which I would like to draw your attention. We refer to the fact that your Council has appointed four representatives to serve for a further period of four years upon Lloyd's Technical Sub-Committee. When this Institution, during the Session 1887-1888, undertook to co-operate with the Institution of Naval Architects and the Institution of Engineers and Shipbuilders of Scotland to obtain a better representation upon Lloyd's Committee, it was regarded by that Committee as an organised opposition to their rules, but gradually they realised that the intention of the Institutions was not to oppose their rules *per se*, but to assist Lloyd's Committee in their deliberations, when from time to time it has been found necessary to alter or modify the regulations for the construction of ships and machinery by the experience we are able to obtain in our various districts, so that now I think it will be generally admitted that this Technical Sub-Committee has proved to be to the mutual advantage of Lloyd's Registry and ourselves.

The next point referred to is the Consultative Committee appointed to confer with the Board of Trade, and so that you may know how that august body is constituted, I will give you one or two extracts from the report of the Committee appointed to consider the position and duties of the Board of Trade and of the Local Government Board, and dated 10th May, 1904, viz.:—

"The present constitution of the Board of Trade dates from 1786. In that year a Committee of Council was created 'for the consideration of all matters relating to Trade and Foreign Plantations,' and the following were appointed members of it:—

The Archbishop of Canterbury.
The First Lord of the Treasury.
The First Lord of the Admiralty.
The Principal Secretaries of State.
The Chancellor of the Exchequer.
The Speaker of the House of Commons.

Such Privy Councillors as hold any of the following offices, viz.:—

The Chancellor of the Duchy of Lancaster.
The Treasurer of the Navy.
The Master of the Mint.

Also:—

The Speaker of the Irish House of Commons.
Such holders of office in Ireland as are Privy Councillors in England.
Ten other members specified by name.
At the same time a President and Vice-President were appointed.

It appears to us evident that the above constitution is obsolete and we do not recommend its continuance.

We understand that the Board of Trade never meets, and that the responsibility for the conduct of its business rests upon the President."

However, I am not going to give you a paper upon the methods, procedure, etc., of the Board of Trade, but wish to point out that your Council thoroughly realises the necessity for reform; that sufficient notice of any alterations in rules and regulations should be given to engineers and shipbuilders; that greater uniformity in the administration of Board of Trade rules should obtain in the various ports, and that the Consultative Committee which represents the engineers and shipbuilders of the country should be recognised in a more authoritative manner than it is at present. We have endeavoured to get this Committee recognised as a Statutory Committee under the Merchant Shipping Act Amendment Bill, 1906, but, so far, have been unsuccessful; however, the President of the Board of Trade has certain powers under the Act just referred to, and as he is taking an active interest in his department, we hope that the disabilities we have experienced will be removed.

The next point I wish to refer to is the Institution Scholarship Fund, and I am glad to say that we now have £1,500 invested in the names of the three trustees of the Institution, and next September we shall be able to offer a scholarship of £50, tenable at the option of the Council, for two years to some deserving graduate, desirous of obtaining his degree in Engineering or Naval Architecture.

The first scholarship will be open to the student who obtains the best marks, irrespective of district, in the North-East Coast, and whether he be engaged in engineering or shipbuilding.

After that the scholarship will be awarded bi-annually until the Institution has sufficient funds to grant one annually, and will be awarded to students in engineering and naval architecture alternatively, and also in rotation in the various districts in the North-East Coast as far as practicable.

We intend to keep the subscription list open in the hopes that more members and friends will respond to our appeal and enable us to award two scholarships, not only as an incentive to our apprentices to become Graduates of the Institution, but also to qualify themselves for higher positions in their profession. Details of the scheme will be forwarded to the Graduates and others as soon as they have been adopted by the Council.

You will also note, upon reference to the Council Report, that arrangements have been made to obtain more suitable accommodation, and that we have arranged to take rooms in the building now being erected for the Engineers and Shipbuilders' Associations. This, we hope, will bring the Institution into close relationship with the principals of the works on the North-East Coast and prove beneficial.

Our present Session looks encouraging, as we already have several papers promised, and your Council hopes that the attendance will be better and that we shall have good discussions.

The Institution has lost during the Session through various causes 74 Members, Associates and Graduates, the total number now being 1,045, but I am glad to say that we commence our new Session with 48 applications for membership in the various grades, so that we shall start again with a membership of practically 1,100, which we hope will soon be further increased.

I am very glad that the Graduate Section had such a successful Session last winter, and hope the current Session will be still more so, and I am sure that you will at once realise that your Council has acted wisely in giving the Chairman of the Graduate Section a seat on the Council with power to vote in order that the Graduates may be more closely in touch with us.

In view of the active interest taken by this and kindred Institutions in the Naval Engineer question, I have received a great number of requests from all parts of the kingdom to give a brief report on the progress which has been made by the Admiralty towards the solution of this national problem. You will remember that prior to 1902 the naval engineer branch of the service was so unsatisfactory and so unpopular that, notwithstanding unusual efforts on the part of the Admiralty, engineers refused to enter this branch of the service and candidates for the official examination fell to zero. Such an alarming state of affairs was ample proof that something was radically wrong with the Admiralty policy regarding the engineer branch, and, as you know, Mr. D. B. Morison laid before this and other Institutions a series of papers which thoroughly aroused professional, public and parliamentary interest throughout the kingdom and indeed throughout the empire.

As a result of combined parliamentary and professional deputations to the First Lord of the Admiralty, the new scheme of naval training was promulgated by Lord Selborne at the end of 1902. This scheme completely revolutionized the previous system, in that it recognized the importance of engineering training and made such training the basis of future naval education; and it also promised reforms with reference to the existing personnel, with the object, presumably, of giving effect to what engineers both inside and outside the service had been for years advocating in the interests of naval efficiency. In view of this apparent appreciation of engineering by the Admiralty, and their apparent desire and intention to deal with the matter in a straightforward and thorough manner, this and other Institutions decided to await developments, and felt confident in the hope that traditional prejudice against the engineer branch of the service would at last not be allowed to prejudice the solution of this national problem on the lines of maximum efficiency. It is impossible in these few notes for me to lay before you the inner history of the past few years, but briefly I may say that our confidence appears to have been misplaced, as the solution has again been blocked by that traditional animus which has unfortunately been associated with this subject ever since the introduction of steam into the Navy. It is true that a

[redacted]

new scheme, but history will prove once again that the country's engineers are better qualified to estimate the influence of engineering on naval efficiency than are the non-technical officers of the executive branch, who have given such continuous evidence of their traditional hostility to engineering recognition and engineering reform. The Institutions, you will recollect, advocated an independent corps of Royal Naval Engineers, who would be trained as engineers and who would devote their whole lives to engineering—the officers to have a military status with military control in their own department, but in no case to succeed to command of ships. The Admiralty's decision was, however, that there should be fusion of the deck and engineer branches, and that officers in the engineering branch should have opportunities for succeeding to command equal to the officers of the gunnery and torpedo branches. In fact, the prevailing interpretation given to the Admiralty policy was that it was their desire and intention to stop once and for all the bickerings and jealousies which were playing such havoc with efficiency, by the fusion of the existing engineer officers with the executive branch and by giving them military status and control in their own department, with the adjustments in pay, uniform, promotion, pensions, retirement, seats on courts-martial, etc., which have been so repeatedly referred to as being urgently necessary. Had this policy been faithfully and promptly carried out all would at least have been able to work harmoniously together with the one aim and one object of maximum efficiency. Instead of which, by a system of elaborate finesse, the new scheme of training has been utilized to glorify the dominant executive branch of the service and to depreciate the value of the engineering branch. There has been a succession of broken promises, petty pin-pricks and intentional depreciation of the existing engineering branch which, if set out in detail, would be amazing. Take as an example the increased pay and earlier promotion definitely promised to engineer commanders. The improved promotion was given, but the corresponding pay was withheld. The improved pay is still withheld, and by a recent Admiralty decision the accelerated promotion is soon to cease.

It is unnecessary for me to say that, fortunately for our national respect, no parallel of such treatment could be found in our civil life.

It is, of course, well known that economy is the order of the day, and also that considerable sums must of necessity be allocated in the Navy estimates for the present long list of repairs to the fleet, but it is to be hoped that whilst adequately maintaining the *materiel*, the all important question of an efficient and contented *personnel* will not be overlooked.

The new system of training cannot produce better engineers than the present system. Any system which loses to the Navy the cumulative engineering experience of a lifetime, such as is now acquired by officers of the existing engineer branch, is open to grave objections. There is also serious danger to engineering efficiency in the recent Admiralty policy of lowering the status of the engine-room artificers and in placing stokers as engine-room watch-keepers instead of the present mechanically trained and skilled engine-room artificers.

A recent decision of the Admiralty to remove the care and maintenance of the gunnery and torpedo machinery of the fleet from the professionally trained engineer branch to the mechanically untrained and unskilled gunnery and torpedo branches has already in one notable case produced serious inefficiency.

No steps have yet been taken to improve the authority of the engineer officer by investing him with the necessary powers of control over the discipline of his department.

In less than four years we shall have the engineer officer of the new creation, invested with military rank and authority, serving in the engine-room as the subordinate of the existing engineer officers to whom military rank and authority are denied: How can departmental efficiency be maintained or even expected under such extraordinary conditions?

The preceding observations sufficiently show the present dangerous trend of Admiralty policy in engineering matters.

In my remarks at the closing meeting of last Session I referred to the Admiralty Committee which had been sitting to consider the unsatisfactory position of the engineer and marine branches, resulting from the non-fulfilment of the promises contained in and the spirit of Lord Selborne's Memorandum.

It is an open secret that the deliberations of that Committee resulted in a deadlock, owing to the bitter and uncomprising hostility of a certain section of executive officers on the Committee. This attitude appears to be condoned, if not approved, by the Admiralty, judging from the studiously evasive replies given to questions on the subject which have been asked in Parliament, and their consistent refusal to publish the reports of the Committee of a section of which they are apparently ashamed.

It will thus be seen that the situation is as unsatisfactory as ever. It is the bounden duty of the great engineering profession of the country to pursue this matter to a satisfactory termination, and to see that the country does not suffer from the antipathy of a certain section of the present military branch of the Navy to carry out those engineering reforms which become more necessary and pressing year by year.

I would commend to those officers who are obstructing engineering efficiency in the Navy the following remarks of Lord Charles Beresford at the Salters' Company in London on the 21st inst.: "Those engaged on ships must have confidence in each other. They must have a chivalrous sentiment for each other and be good comrades in every way. Let them never do anything to exalt themselves for the moment at the expense of their comrades. They should have one object, the efficiency of the Service, the good and the safety of the Fleet."

VOTE OF THANKS TO THE PRESIDENT.

Mr. William Boyd said—As I am rather an unusual visitor here to-night, you must excuse me if I am transgressing the usual rules of the Institution, but I have a feeling that on the first night of a session like this, when we have received from the President a most interesting inaugural address, we ought not to separate without recording our thanks to him for that paper, and for the opening which he has given to the session which begins to-night. The address which he has read to you clearly shows that he has studied very carefully the various topics that are of interest, and that have come before this Institution, and I venture to take upon myself to ask you to accord a vote of thanks to Mr. Dugdale for the address which he has delivered at the opening of the Twenty-fourth Session.

Colonel R. Saxton White said—I have very much plea in seconding the vote of thanks proposed by Mr. Boyd to President for his address.

The proposal was carried by acclamation.

The PRESIDENT, in reply, said—I can only thank you for the very kind way in which this vote of thanks has been proposed, and accepted by you, I am sure it is a very great pleasure and honour to have been re-elected President for the second year of office, and I only hope we shall have a successful session—that we shall have largely-attended meetings and good discussions.

NOTES ON THE EFFECT OF WORK AND TIME ON THE PROPERTIES OF MILD STEEL AND IRON.

BY JOHN H. HECK, VICE-PRESIDENT.

[READ IN NEWCASTLE-UPON-TYNE ON NOVEMBER 29TH, 1907.]

It is now over twenty years ago since mild steel, on the Siemans Martin, acid open-hearth system was first made in this district. At the present time it has quite ousted iron for use in all kinds of constructional work, and experience shows that for such purposes mild steel is the most useful and reliable material that we have to stand hard and continuous work.

One of the reasons for its rapid growth and use is no doubt due to the fact that its quality has always been kept good, either for ship or machinery purposes, by the care which has been taken during its manufacture and by the prompt and rigid testing of the material directly after its production at the steel works. Steel-makers have always been willing to make tests, and much credit is due to them, even from the early times, for the wise and far-seeing policy which they urged, as time went on, that the character and the testing of the material should not in any way be reduced or made less stringent.

At first, as many of the older members of this Institution will remember, there was a good deal of natural hesitation to use a material about which, so far as the effect of time and work was concerned, we had so little knowledge and experience. It was the consistent and continual production of good steel which gradually inspired confidence and therefore helped on the general adoption of mild steel for all classes of constructional work.

The uniform and regular testing to which it was subjected gave a " hall mark " to steel over all other metals, as a material which had been proved and could be relied on. The testing was fair all round and was at least one of the main factors which caused the use and production of steel to grow year after year to greater dimensions.

When iron was chiefly employed in the construction and repairing of ships and boilers, the quality of the material was always a question entailing anxiety and consideration; while at the present time, with steel, vessel after vessel is built or repaired without the slightest question or anxiety arising. It is a very rare occurrence for a steel plate or angle to fail in the shipyard or boiler works. It is quite as easy to make bad steel as to make bad iron; it is also as easy to burn steel as to burn iron. It therefore speaks volumes for the care which must be taken in the manufacture of steel when a comparison is made between the great quantity of good material supplied with the small quantity which fails during construction in the shipyard or boiler shop.

The North-East Coast is one of the largest shipbuilding districts, and so far as the repair of vessels and their machinery is concerned, it is also one of the largest repairing districts. It is, therefore, a daily and common experience for those engaged in such work to see on a large scale how well mild steel will stand the test of time, severe damage and wear-and-tear.

In the dry docks, steel vessels, owing to damage caused by stranding, collision, or other causes, come under repair with plates and angles much indented and distorted, in some cases the damaged material, although not cracked or fractured, having the appearance presented by a sheet of note paper when crumpled up in the hand.

In connection with steel boilers also, working with high pressure of steam, cases are met with where, owing to over-heating and other causes, furnaces and plates are found much distorted and strained, without any serious consequences having ensued. To see steel vessels and boilers which have sustained such damage brought safely into dry dock for repairs is a fact which speaks for itself, and compels one to feel there can be no deterioration, or else it can only be of a trifling extent, in the quality of a material which will stand such a test after years of work in all parts of the world and in all kinds of weather, and this conclusion is confirmed if samples are sheered off such damaged material and thoroughly tested.

In the early days of steel making in this district I was engaged in testing the material which was used in the construction of vessels and machinery intended for classification in Lloyd's Register. Since then tests have been made from time to time on samples of old steel which had been in use and at work for a number of years in different parts of the hull and machinery of steam vessels. The samples tested were sheared from plates, angles, bars, etc., which had been removed owing to damage, corrosion, pitting, wear-and-tear and other causes. The tables at the end of the paper show some of the results of the tests. The number given for the purpose of illustration was deemed sufficient.

It is of value to note that the samples which were tested for tenacity broke practically within the limits required by the rules when the material was made. In no case was the tenacity above, and in only a few instances was it below, the lower limit, and even in these few exceptions the difference was trifling and confined to those samples which were corroded or in which the surface and section was not uniform.

In the majority of cases, after the samples had been pulled asunder to determine the tenacity, the broken pieces could be bent cold through an angle of 180°.

In pieces which were tested by bending only and not for tenacity, if the samples were sheared off by a machine in good order, they could in the majority of cases also be bent cold through an angle of 180°.

The hot and forge tests were very satisfactory, even with the very corroded and damaged specimens. In many instances the pieces were hammered down very thin and to a chisel edge without any signs of fracture, and this also, in my opinion, is a very satisfactory result.

Samples which were cut from furnace plates which had been exposed for many years to the most intense heat stood the most severe mechanical tests.

The elongation of the material on a length of 8 inches was measured in all the pieces tested for tenacity and is considered satisfactory when allowance is made for damaged and corroded surfaces, and the variation in thickness and section at different portions of the length.

In regard to iron, the samples tested were not in any way so satisfactory as in the case of steel, working under the same conditions. Some of the old and thick samples, in fact, broke off in pieces directly they were touched by the shears.

In a paper which was read in 1881 at Newcastle-upon-Tyne before the Institution of Mechanical Engineers, a well-known shipbuilder, during the discussion, stated that he had to pay a good deal more for the material of an iron ship he had to build because it was specified that the iron should have an extension of 5 per cent. with and 2½ per cent. across the grain. This will give a good idea of what iron would stand at that time, and it is therefore of interest, in making a comparison, to know that if samples were now taken from mild steel ship plates which were made and tested twenty years ago and had been hard at work ever since, even if the material was damaged or much corroded, they would easily stand extension tests in any direction of double that amount.

With regard to corrosion in vessels, I have never been able to see any difference in its action between iron and steel of the same thickness. A half inch plate of steel, if the conditions are similar, appears to withstand corrosion just as well as a half inch plate of iron. In a corroded steel plate the part remaining will stand satisfactory tests; in a corroded iron plate it does not appear to do so.

Twenty-five years ago the average life of an iron boiler was about ten years, while at the present time, with much higher pressures, it is at least double that. In a paper read before the Institution of Mechanical Engineers in 1878, Mr. W. Boyd, the first President of this Institution, made the remark—"Time alone will prove whether this material (mild steel) can support the wear-and-tear of life on board ship." We now all know it does so uncommonly well, and for the purpose of record it may also be added that its quality and properties, after years of hard work, is practically unimpaired.

The early steel-makers who faced and solved the problem of making good mild steel at a moderate price, and shipbuilders like the late William Denny and others, who had the courage to use it, are really the men who are entitled to a great share of the credit for the progress which has been made in recent years. To continue this progress, further economy of material will be necessary, and this will no doubt be effected by the production and use of a still stronger and better steel.

The work on which this short paper is based is really due to many connected with the repair of vessels and the testing of steel.

The paper was illustrated by a number of photographs of damaged steel material (see Plates I. to IV.).

TABLE B.—SIEMENS MARTIN, ACID, OPEN HEARTH, BOILER STEEL.

SPECIMEN RESULTS OF TESTS OF OLD BOILER PLATES WHICH WERE REMOVED OWING TO DAMAGE OR CORROSION.

NOTE.—The bending tests were made on the broken pieces after the samples had been pulled asunder to determine the tenacity.

No. of Sample or Name of Vessel.	Description.	Cause of Removal.	Age of Sample in Years.	Thickness.	Tenacity. Tons per Square Inch.	Elongation in 8 Inches. Per cent.	Cold Bend Test. Angle Bent Through.
1	Furnace	Over-heating	8	·705	26·7	22	180°
2	Do.	Do.	8	·725	27·5	24	180°
3	Do.	Do.	8	·73	28·7	27	180°
4	Do.	Do.	8	·75	28·6	26	180°
5	Do.	Do.	12	·87	28·2	22	180° signs of fracture ar. 145°
6	Do.	Do.	12	·83	26·3	27	180°
7	Firebox	Corrosion	8	·62	27·3	28	180°
8	Do.	Do.	8	·62	27·3	25	180°
9	Bottom front	Much do.	14	·65	25·5	13	180°
10	Back end plates	New boiler fitted	25	·475	27·7	21	180°
11	Do.	Do.	25	·48	28·5	24	180°
12	Do.	Do.	25	·47	27·6	22	180°
13	Back tube plate	Do.	25	·5	28·6	18	180°
14	Do.	Do.	25	·495	29·3	20	180°
15	Combustion back	Much Corroded	13	·425	30·3	11	180°
16	Do.	Do.	13	·52	27·8	16	180°
17	Uptake	Corroded	13	·49	26·3	27	180°
18	Do.	Do.	13	·56	26·4	22	180°
19	Front tube plate	Do.	23	·54	27·5	27	180°
20	Do.	Do.	23	·53	27·0	16	Surface pitted, 135°-180° broken
21	Chamber stays	Do.	7	·74 dia.	26·2	35 in 4″	180°
22	Do.	Do.	7	·74 dia.	26·2	34 in 4″	180°
23	Boiler shell	Wasted	16	·57	31·4	25	180
24	Do.	Do.	16	·57	31·9	23	180°
25	Do.	Do.	16	·57	31·8	25	180°
26	Do.	Do.	23	·42	26·7	15°	Surface pitted 180°
27	Do.	Do.	23	·42	26·9	24	180°
28	Do.	Do.	23	·43	26·6	19	180°

Hot bend and forge tests good.

TABLE S.—SIEMENS MARTIN, ACID, OPEN HEARTH, SHIP STEEL.

SPECIMEN RESULTS OF TESTS OF OLD SHIP PLATES AND ANGLES WHICH WERE REMOVED OWING TO DAMAGE OR CORROSION.

NOTE.—The bending tests were made on the broken pieces after the samples had been pulled asunder to determine the tenacity.

No. of Sample or Name of Vessel.	Description.	Cause of Removal.	Age of Sample in Years.	Thickness.	Tenacity. Tons per Square Inch.	Elongation in 8 Inches. Per cent.	Cold Bend Test. Angle Bent Through.
1	Forecastle shell	Damage	9	—	29·3	20	180°
2	Frame bar	Do.	9	—	29·0	20	180°
3	Floor plate	Do.	11	·44	28·1	19	180°
4	Do.	Do.	11	·44	27·5	19	180°
5	Do.	Do.	11	·44	28·0	18	180°
6	Shell plate	Do.	9	·31	27·3	11	180° crack
7	Do.	Do.	9	·32	27·7	10	180° sign of crack
8	Do.	Do.	11	·485	28·6	10	180°
9	Do.	Do.	11	47	27·9	18	180°
10	Do.	Do.	12	·54	30·1	24	145° broke
11	Do.	Do.	12	54	30·3	25	115°-145° broke
12	Deck plate	Much corroded	13	·332	26·2	14	180°
13	Do.	Do.	13	·3	27·4	12	180°
14	Do.	Do.	13	·21	27·2	8	180°
15	Frame bar	Damage	13	·45	27·5	19	180°
16	Shell plate	Do.	11	·45	31·2	20	180°
17	Do.	Do.	11	·435	27·6	23	180°
18	Do.	Do.	1	49	27·4	25	180°
19	Do.	Do.	1	·5	27·3	17	180°
20	Do.	Do.	18	·36	28·3	16-24	180°
21	Do.	Do.	13	·5	28·5	20	180° signs of fracture
22	Do.	Do.	13	·425	25·6	18	180°
23	Do.	Do.	13	·17	25·1	17	180°
24	Do.	Do.	13	·17	24·7	23	180°
25	Do.	Do.	11	·44	31·0	20	180°
26	Do.	Do.	11	·43	27·7	23	180°
27	Do.	Do.	8	·71	28·3	22	120° broke
28	Keels on plate	Do.	8	·53	31·6	16	130° broke

Hot bend and forge tests good. (Nos. 12–20)

DISCUSSION.

Mr. William Boyd (Past-President) said—I have been asked y Mr. Heck to say a few words in connection with his paper on subject which must be of interest to all of us. He has made eference to a paper which I had the honour to read before the nstitution of Mechanical Engineers in April, 1878, and it is in onnection with the subject of that paper that I think a few emarks may be interesting

In the autumn of 1877 the firm of Henry Clapham & Comany, now the Clapham Steamship Company, presided over by our Treasurer, Mr. Macarthy, ordered a small steamer from the rm of C. Mitchell & Company, of Low Walker. She was only a nall vessel as we reckon size nowadays, being 207·7 by 29·9 r 16·3, 839 tons gross, and intended for the iron-ore trade from ilbao, in Spain. The interest of the case lies in the fact that e owners stipulated that she was to be built wholly of steel, at the boiler was also to be wholly of steel, and the small bes of steel also. I have not at hand sufficient data to decide e historical question, but I believe I am right in saying she s the first vessel built, for practical everyday service in the rcantile marine, in this district, and I have often thought that ficient credit has never been given to the firm of Henry Clapham d Company for their courage and enterprise in embarking such an undertaking. The steel plates of which the vessel s built were made by the Landore Steel Company, South Wales. e reduction of scantlings over iron, was, I believe, about 22 cent. She is still afloat, sailing from Gothenburg under the me of the "Ruth," and, I see, was fitted with a new boiler in 00, the original boiler having been in use for 23 years. She s fitted with compound engines, having cylinders 26 inches by inches by 30 inches stroke, with a working pressure of 65 unds.

But it is with the boiler that I am more particularly conned to-day. It was 13 feet 3 inches in diameter and 10 feet 8 hes long. Heating surface 1,880 square feet, and working pres-re 65 pounds. The design being submitted to Lloyd's in the ual way, they agreed to a certain reduction of thicknesses "as experiment only" and on certain conditions, viz.:—

1. That the plates should have a tensile strength of from 26 to 30 tons.
2. That a specimen of the longitudinal joint should be tested and shown to have a percentage of 74 per cent. of the solid plate.
3. That a shearing of every plate should be subjected to bending or tempering tests.
4. That the flat surfaces should be shown by experiment under hydraulic pressure—when stayed in the usual manner—to be as strong to resist buckling as ordinary iron plates.

These experiments were duly carried out with the assistance of Mr. Manuel Lloyd's surveyor, and were recorded in the paper in question, but they would hardly interest you now. Suffice it to say that the design was passed for 65 pounds pressure, with the following reductions in thicknesses:—

			Reduction. Per cent.
Boiler shell plates from	$\frac{7}{8}$ to $\frac{11}{16}$ inch	...	21·43
Boiler ends	$\frac{3}{4}$,, $\frac{9}{16}$,,	...	25·0
Furnaces and Combustion Chambers	$\frac{1}{2}$,, $\frac{7}{16}$,,	...	12·5
Front and back tube plates ...	$\frac{3}{4}$,, $\frac{11}{16}$,,	...	8·33

The experiments then carried out under the supervision of Lloyd's Registry may be said to have formed the basis of their present rules for the thicknesses of steel boiler plates, which, at a date subsequent to 1878, were issued to engineers and boilermakers engaged in the construction of marine boilers. Up to this time they had no rules for scantlings, and, as I have before explained, the reductions in thickness from the ordinary iron plates were allowed in this case "as an experiment only." If the same boiler were to be built now under Lloyd's *present* rules, there would be a further slight reduction of about 4½ per cent. in the shell plates and about 11 per cent. in the boiler ends. The inside work would remain pretty much the same. This shows that the advisers of Lloyd's Register thirty years ago were not very far off the mark.

The plates for the boiler were made by the late Mr. C. W. Siemens at the Landore Steel Company's works in South Wales, and, as before stated, were to have a tensile strength of from 26 to 30 tons. They were shown by test to have an actual mean breaking strain of 28·7 tons with an elongation of 26·5 per cent. of length -

They cost £14 per ton—the price of iron plates at that time being about £7 10s. per ton, and as you all know, the present basis price of steel plates, of very different dimensions and weight, is about £8 to £8 10s. per ton.

It is interesting to compare this tensile strength of 26 to 30 tons with that of the high tensile silicon steel plates used in the boilers of the "Mauretania," which, as you will see in *Engineering*, had a tensile strength of about 37 tons, an elongation of 21 per cent. and elastic limit of 21·8 tons. The success which attended these early efforts 30 years ago is evident to all engineers to-day, and the behaviour of the material under great "provocations" is also well known, and is well brought out by the figures given in Mr. Heck's paper.

In the discussion which followed the inaugural address delivered before this Institution in October, 1885, and in which the behaviour of steel plates in the bottom of a ship when stranded had been referred to, Colonel H. F. Swan observed "That he had no hesitation in saying that he believed before any of them were many years older an iron ship in construction would be as rare a thing as was a wooden one to-day." And I suppose you will agree that his prediction has been amply fulfilled.

I thought that perhaps these reminiscences might be of some interest to the Institution, as showing the progress that has been made during the last 30 years.

With regard to the effect of stranding on the bottom of a ship and the effect of falling down and distortion of the inside works of a boiler, there is no need to dilate, because any of us who have anything to do with either the one department or the other, know the great success which has attended the introduction of this material, and the extraordinary reliability which can be placed on its behaviour under exceptional circumstances. I believe Mr. Heck has some photographs there, showing the distortion of boiler plates. I have lent him a couple of photographs (Plate V. and VI.) showing the distortion of plates taken off the bottom of a ship in the early part of this year, to which perhaps rather a curious story is attached. The plates were made in the county of Durham, sent into Japan, built into a ship, traded to this country, stranded at Redcar, near the mouth of the Tees, was brought to the Tyne to be repaired, and had South Durham plates put back into her.

Mr. J. L. Twaddell said—I am sure we must all feel indebted to Mr. Heck for his useful addition to the *Transactions* of the Institution, more especially as it provides, for the first time, I think, a record of actual tests of the old material taken from boilers and ships' hulls after many years' wear and tear.

Although Mr. Heck's subject deals with the effect of work and time on the properties of mild steel and iron, I think it is to be regretted he did not give us some results of his experience in regard to the riveting attachments as well as the material itself. It might be said, of course, that little or no opportunity of determining the relative value of iron or steel rivets is available in vessels of the merchant service, on account of the almost universal practice of using rivets of iron only in steel ships, although steel rivets are used in boilers, and I regret I am unable to augment Mr. Heck's paper in this direction, although some other member may be able to do so. I would, however, suggest that, apart from the theoretical strength of a riveted joint, the effect of work and time on the material of which the rivets are made deserves some serious consideration.

The Admiralty practice is to have rivets of the same material as the plates they connect, hence mild steel rivets for mild steel plates and high tensile steel rivets for high tensile plates. No doubt this practice is the result of careful consideration, but it would be interesting to know how far this practice is justified by experience of the effect of work and time on the material forming the rivets. It seems reasonable to take into consideration the fact that while the quality of the material of the bars used for making rivets is the same as that of the plates, these bars have to be heated and worked into the form of the rivet, and again heated and hammered up in the structure, so that the finished rivet may not have quite the same quality as the bar from which it was made possessed. Again, it should be borne in mind that a very large percentage of the rivets in the main structure of a ship's hull are subject to shearing strain rather than tensile. In order to test in a small way the relative value of high tensile steel, mild steel and iron rivets, I recently made a little experiment in our test house at the Jarrow yard in the following manner:—

Two pieces of plate, 9 pounds per foot, connected together with a butt strap 11 pounds per foot, riveted by three half-inch diameter rivets each side of butt placed lengthwise in the plate as in a treble riveted strap. With high tensile plate and high tensile rivets the plate fractured at 19 tons 8 cwts. but the rivets did not shear. With a mild steel plate and mild steel rivets, prepared as already described, the rivets sheared at 16 tons. With mild steel plate and iron rivets, the rivets sheared at 14 tons 14 cwts. Then, in order to test similar rivets in tension, I had two smithed eyeplates riveted together with two half-inch diameter rivets and pulled them apart. The iron rivets broke at 10 tons 7 cwts., the high tensile at 18 tons 1 cwt. and the mild steel rivets at 18 tons 10 cwts., a noticeable feature being that while the high tensile rivets broke clean off at bottom of countersink, the mild steel and iron rivets sheared the countersink off almost in the form of a washer. You will also notice that the mild steel rivets, probably from the stress exerted in shearing off the countersink, withstood a greater strain than did the high tensile rivets which broke. I may say that the high tensile steel used in both plates and rivets was tested to 37 to 43 tons per square inch tensile, with an elastic limit of not less than 22 tons and a minimum elongation of 18 per cent. on 8 inches. The mild steel was of the usual Lloyd's tests. So that you can make your own deductions. The bars from which the iron rivets were made were of the usual rivet bar quality.

Mr. Heck, towards the end of his paper, says: "to continue this progress, further economy of material will be necessary, and this no doubt will be effected by the production and use of a still stronger and better steel." To a certain extent this is being followed by the Admiralty in small craft of high speed, where lightness is essential, and it appears to answer well where high tensile steel for the longitudinal material results in a great saving of weight over mild steel, without any reduction in strength. At the same time, my experience with this material is that towards the end of a vessel, where plates have to be worked much, whether cold or hot, high tensile steel should not be used. As a matter of fact its quality is not called for at the extreme ends, where mild steel would withstand the bumps better, besides admitting of moulding to the form required with less injury to itself.

Although having little bearing on shipbuilding generally, perhaps I may be allowed to mention the great advance which has been made in the manufacture of wire ropes since the introduction of steel. At the present time steel wire for high-grade ropes is commonly used of a tensile stress of 120 tons per square inch, while in some special cases, in comparatively fine gauges, wire is used of a tensile stress of 160 tons per square inch. Although the Admiralty breaking stress for an ordinary 4½ inches circumference flexible steel wire rope is 39 tons only, quite recently local makers have supplied wire of this size for boat hoists of a breaking strain guaranteed under actual test of 85 tons, while the rope actually broke at 93 tons. Compare this with the iron wire of some 50 years ago, the tensile strength of which was, I believe, 30 to 35 tons per inch and with nothing like the flexibility. I merely mention these facts to illustrate further some of the advantages which have attended the introduction of steel.

Mr. M. C. JAMES said—Mr. Heck is to be congratulated on having produced such an interesting paper. It has brought before us a phase of the question of the strength and endurance of steel and iron which has not hitherto been dealt with in any of the proceedings of this Institution; in fact, so far as my knowledge and reading go, I am not aware of any prior attempt to establish comparative tests between new material and old material removed from ships' hulls or boilers after being subjected to the wear and tear of time and stresses.

At the outset, Mr. Heck refers to the completeness with which steel has superseded iron for ship and boiler construction, and shows that this is largely due to the great care exercised in steel manufacture, and the thoroughly systematic and stringent system of testing to which it is subjected. In fairness to our old friend iron, it ought, I think, to be allowed that had Lloyd's and the other classification societies insisted upon greater care in the making of iron plates and bars, and subjected them to the same kind of regular and uniform tests, steel would not have made such rapid progress, nor would it so easily have ousted the older material. The early iron vessels were built of very excellent material. Some of these ships, still afloat and doing good work, fully testify to this, but as iron shipbuilding developed the iron used deteriorated in quality. It is true Lloyd's rules required that the iron used in shipbuilding should be of good malleable quality, capable of withstanding a tensile strain of 20 tons per square inch with, and 18 tons across, the grain, and to be subjected to tests at the discretion of the surveyors, brittle or inferior material to be rejected. Tests were, however, seldom if ever made, so iron got worse and worse, until it became necessary to get special plates for parts which required to be flanged or bent, such as garboard strakes and boss and oxter plates. Low Moor or Hawks' BBB iron, two famous brands, the latter now extinct, were sometimes used for these parts, and also gave splendid results when used for boiler fireboxes, etc.

A paper read before the Institute of Naval Architects in 1882 on the "Quality of Materials used in Shipbuilding," and the frightfully bad examples exhibited before the meeting at which this paper was read, aroused attention to the deplorably bad quality of shipbuilding iron then being used, and in the following year Lloyd's Registry of Shipping was sufficiently moved to issue a special circular calling attention to the inferior iron, and threatening that unless an improvement was effected the Committee might feel compelled to require more rigid tests with a view to obtaining iron of more uniform and better quality.

This circular, however, was too late. Steel had got a foothold by this time, and quickly elbowed iron out of the market for ship and boiler building. Dr. Siemens, who did much to secure the adoption of steel, in advocating steel as a suitable material for ship construction, made a very strong point that in the event of a ship receiving damage owing to the toughness of the steel, the plates were more likely to bend or buckle without breaking than iron, and consequently steel ships would be safer than ships built of iron. The superiority of steel over iron is most clearly demonstrated, as Mr. Heck points out, in cases of ships damaged by stranding or collisions. A damaged iron plate can rarely be put back, but a steel plate, if not too much stretched by excessive distortion, can easily be faired and refitted, and where steel plates are indented or buckled to moderate extent, tests seem to show that firing of such plate does not materially reduce strength.

The results of the tests made by Mr. Heck on steel plates and bars taken out of boilers and ships are very instructive. They would have been still more valuable had it been possible to trace the actual tests of the material when tested new at the maker's works. The figures, however, go to show that the material suffers little or no loss in tenacity and ductility due to time and strain as some of them were made for distorted plates. I cannot quite agree with Mr. Heck in his statement that there is apparently no difference in corrosion between iron and steel in vessels. My experience is that in certain parts of a ship, such as exposed decks, tank tops, and tank internals under boilers, steel corrodes much more rapidly than iron; but, as Mr. Heck points out, in a corroded steel plate the remaining parts yield satisfactory tests, whilst the contrary is the case in a corroded iron plate. Our thanks are due to Mr. Heck for the trouble he has taken and for having so kindly placed the results of his investigations before the Institution. He has proved, by patient investigation and testing what, I am afraid, most of us were content to assume, or take as granted.

The SECRETARY read the following communication:—

BIRKENHEAD,
November 25th, 1907.

DEAR MR. DUCKITT,

With the remarks, generally, of Mr. Heck, there is nothing to which exception can be taken. But there are two statements which do not coincide either with our experience, or the views which, I understand, are pretty widely held. These are dealt with below:—

Mr. Heck says: "Mild steel on the Siemens Martin (acid open hearth) system . . . has quite ousted iron for all kinds of structural work, and experience shows that mild steel is the most useful and reliable material that we have, to stand hard and continuous work." This statement is too sweeping in character, and contrary to our experience and deductions therefrom. Iron of good fibrous quality is less easily fatigued than steel, and will stand vibratory strains better. We had a striking instance of this in connection with the main bearing bolts of the engines of the earlier destroyers, which bolts were made in stud form. Fracture after fracture occurred with steel bolts of various tensile strengths; and it was only on the adoption of iron for these bolts that satisfactory results were achieved.

The iron used for the purpose was Whitwell's special Admiralty cable iron, which was adopted after a series of tests of various makes of iron, showing that it was the most suitable, that is, a fine iron with a reserve of quality or nature having been finished in the rolling mill just at the point when it began to make fibre, an important factor for subsequent smithing purposes, which develop the value of the iron. The breaking strain of this iron, after heating and working, was 24 to 24½ tons, with a stretch in 8 inches of 27 to 32 per cent.

Recently, for the reason mentioned above, iron has been specified by various engineers for the screwed stays in steel boilers, the quality used being cable iron to meet the Board of Trade requirements of 21½ to 24 tons per square inch tensile strength, with a stretch of 25 per cent. in 10 inches. Another point in which steel is not so reliable as iron is in welding. But Mr. Heck does not deal with this.

Again, Mr. Heck says: "With regard to corrosion in vessels, I have never been able to see any differences in its action between iron and steel." Under atmospheric conditions, we have found (wrought) iron to corrode less readily than mild steel, and the common iron less readily than the better qualities. Pitting or corrosion of exposed steel plates, angles, etc., is very rapid unless the black oxide or scale formed during manufacture is removed. In water—sea or fresh—there may be little difference, but what there is, is in favour of iron. In such parts of ships as coal bunkers, steel plates corrode much more readily than iron, and iron is frequently specified for these parts. Owners of the fish carriers which used to run between the fishing fleets and Liverpool also found that steel decks corroded much more easily than iron ones. For commercial marine boilers iron is invariably specified for the tubes, owing to the greater liability of steel to corrode. Iron boiler tubes last about ten years, steel about half that time. The weldless steel tubes used by railway companies in locomotive boilers are said to last about six years; and the life of weldless steel tubes in the water-tube boilers of war vessels is stated to be about three years.

Some years ago we had complaints from abroad about the pitting of (lapwelded) steel boiler tubes, which were exhaustively investigated by the makers and ourselves. The conclusion arrived at was that the pitting was due to the tubes being steel, and impurities in the water, therefore, more readily affected them.

Yours faithfully,

J. Hamilton Gibson.

Mr. D. B. Morison said—I congratulate Mr. Heck on his very interesting paper, but I quite agree with Mr. Gibson in his reservations, particularly with regard to my experience with propeller shafts. Some years ago, when many accidents occurred with propeller shafts, we took a great deal of trouble at Hartlepool to ascertain the weakening effect of the intense local corrosion which took place at the end of the brass liners. We made a series of drop tests on artificially grooved bars, and found that steel was much less reliable under this test than iron. Mr. Heck referred to the excellence of the manufacture of steel. I think that has been brought about largely by the excellence of the supervision of Lloyd's, and had the same attention been paid to the manufacture of iron it would have been of uniformly better quality than it is to-day. In engine specifications we often see, "the propeller shaft to be made of the best selected scrap iron." This expression means very little, as it is very difficult indeed to obtain iron, and the scrap which is generally bought as iron is largely of steel. Consequently, when a shaft is made up of ordinary scrap it is extremely unreliable, and it is for that reason that I always advocate, if a shaft is to be made of iron, it should be made of manufactured iron of good quality and of a known brand. My experience of propeller shafts made of manufactured iron is that they groove less locally and less speedily at the end of the brass liner, and instead of the intense saw cut with which many of you are familiar, the groove is of a more gradual character, and therefore the weakening effect of the groove is not so intense. With regard to the furnace plates, I quite agree with Mr. Heck. I have from time to time had submitted to me furnace plates or furnaces which have given trouble, either by collapse or cracking. Generally, it is intimated that there was no trace of oil in the boiler, therefore it must be the result of defective material. Well, I have had the steel tested repeatedly and I have never come across a single case which deviated to any appreciable extent from the original tests, thus bearing out directly what Mr. Heck has told us.

Colonel R. Saxton White said—I think all the members of the Institution present will be extremely pleased, as I have been, that the proceedings to-night have been graced by the presence of the first President of the Institution. Personally, I am very glad indeed that he has been able to refer back with such confidence to his earlier practice; for he was largely responsible, in fact, entirely responsible, for what was done at that time, and now, at the end of that long period, he comes and tells us that this boiler ran for twenty-three years, and that it has formed the basis upon which Lloyd's have been working practically ever since. Therefore, I say again, it is a source of congratulation to this Institution that its first President was a man who could look so far forward as has been exemplified in the working of this original steel boiler—or, if not original, at least one of the very earliest. I think the Institution is also to be very much congratulated upon the tone of the discussion to-night. I have listened on many occasions to discussions, not only at this Institution, but at others whose position in the scientific world carries at any rate greater seniority, but I have hardly ever listened to a discussion where all the points have been brought out so well as they have been to-night. I myself have nothing to add to the discussion beyond expressing the satisfaction and the confidence one gets from Mr. Heck's opinions, who, after his many years' experience, says that he himself sees little or no difference in the action of corrosion on steel. It was rather a startling statement, because one has always understood that in such parts of the ship's structure as have been referred to, more especially boiler-room floors, tank tops and deck plating, the corrosion going on in steel vessels was very serious, and far greater than was found to be the case when ships were built of iron. If Mr. Heck had added that where the steel is looked after and properly protected, I think he would be on safer ground. My own experience does not go far in this direction, because I have had principally to do with new ships and not repairs, but one has always been told that the effect of corrosion on steel is very great, and for new construction we are often asked to provide iron to put into these particular portions of the structure. It is one of our greatest difficulties, not only to get the iron readily, but to get it at all. Moreover, there is the fallacy that we are often required to pay more money for the inferior article than for the better one, there being no question as to the superiority of steel over iron, except possibly in the matter of resistance to corrosion, and therefore I am very glad if Mr. Heck, as one of the principal surveyors from Lloyd's, is satisfying himself that the corrosion of steel is not greater than that of iron, and that we may be relieved of a great deal of our difficulty and trouble in getting iron of good quality. This is the only point in the paper I desire to bring special attention to, because I think it is a very important one, and if Mr. Heck's opinion is confirmed and taken in conjunction with the steel being properly protected, and there are many materials for doing this most efficiently, I think with that proviso Mr. Heck may be perfectly right, and shipowners in the future may, with proper care, have more confidence in these parts of the ship than they have had in the past.

The discussion was adjourned, and the meeting dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWENTY-FOURTH SESSION, 1907-1908.

PROCEEDINGS.

THE SECOND GENERAL MEETING OF THE SESSION WAS HELD IN THE LECTURE THEATRE OF THE LITERARY AND PHILOSOPHICAL SOCIETY, WESTGATE ROAD, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, DECEMBER 20TH, 1907.

W. H. DUGDALE, ESQ., M.INST.C.E., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous meeting, held at Newcastle-upon-Tyne on November 29th, which were confirmed by the members present, and signed by the President.

The discussion on Mr. J. H. Heck's paper on "The Effect of Work and Time on the Properties of Mild Steel and Iron" was resumed.

Mr. W. G. SPENCE read a paper on "Notes from Four Years' Working of the Educational Committee's Recommendations."

ESUMED DISCUSSION ON MR. J. H. HECK'S PAPER ON "THE EFFECT OF WORK AND TIME ON THE PROPERTIES OF MILD STEEL AND IRON."

Mr. JOHN W. HOBSON said—I think Mr. Heck's interesting per appeals especially to the young members of the Institu- on. Of course, it deals almost entirely with ship and marine iler work. Now, although my experience has not been lengthy, ere are one or two remarks I should like to make with respect locomotive engineering and this subject.

Mr. Heck states that he fails to see any difference in iron or eel for withstanding corrosion. Well, that may be with sea ater in the case of ships and the feed water used in the case of arine boilers, but I must say that although steel locomotive ilers are in a large majority, still, there are many instances which the feed water is such that only Yorkshire iron boilers e able to withstand the corrosive action. I may state that the own agents who generally order steel boilers insist on having on boilers for service on the Ceylon Government railways. ere are also several local colliery companies possessing many omotives who find that Yorkshire iron boilers are more suitable d cheaper in the long run. The engineer for one such com- ny informs me that the respective lives of Yorkshire iron and eel boilers on his lines are 12 to 14 and 6 to 7 years.

On account of the high initial price of a Yorkshire iron loco- otive boiler and the difficulty in obtaining iron plates large ough, many interesting attempts have been made to circum- nt the effect of bad feed water on steel boilers, such as lining e barrels with sheet copper, iron and lead even.

Mr. Heck mentions the instance of a shipbuilder 30 years go having to pay more for the material because it was speci- d that the iron should have an extension of 5 per cent. with e grain and 2½ per cent. across. The iron plates in those days ust have been remarkably poor, as the iron plates used in the onstruction of locomotive boilers nowadays show, at any rate, 5 or 16 per cent. on 10 inches with the fibre and 11 or 12 across. With such an elongation the tensile strength comes out at 22 and 20 tons, with a contraction of area of about 27 and 18 per respectively. So much for boiler work.

Now, I have always been under the impression that a great difference of opinion existed as to whether locomotive crank pins should be of iron or steel? As far as I can ascertain, Yorkshire iron pins last longest, they are reliable—standing the severe push and pull extremely well. They case-harden satisfactorily and wear well—in fact, I have known cases where locomotives have come in for repairs, having been in hard service from 8 to 10 years, and the pins were to all appearances almost as good as on the day they were put in. It has been stated that a large percentage of Yorkshire iron crank pin forgings show flaws when machined, and consequently have to be scrapped, but I may mention that Messrs. R. and W. Hawthorn, Leslie & Company just recently forged a batch of 36, and out of this number only 2 were rejected, and they were certainly not to be called bad.

Mild steel pins case-hardened are most unreliable, having no fibre, the case-hardening having a detrimental effect, and neither do they wear well.

Steel pins oil-hardened are rather more reliable than the former, but the oil-hardening having a softer effect than the case-hardening they wear quickly, though certainly more evenly.

Hard steel pins wear very badly, becoming deeply grooved in a short time, but they are certainly very reliable as far as strength goes, and are worth turning up after grooving, whereas case-hardened ones are not.

I have several test pieces kindly given me by Messrs. R. and W. Hawthorn, Leslie & Company which I shall pass around. They are somewhat interesting and demonstrate the class of material now used for locomotive crank pins.

No. 1 is a specimen of Yorkshire iron case-hardened for 24 hours to a depth of $\frac{1}{8}$ inch, and made from a 22 to $23\frac{1}{2}$ tons bloom, giving 20 per cent. elongation on 8 inches and a reduction of area of 25 per cent.

No. 2 is a specimen of mild steel case-hardened for 24 hours to a depth of $\frac{3}{32}$ inch and made from 22 to 26 ton steel.

No. 3 is hard steel made from a 38 to 43 ton bloom, and giving an elongation of 25 to 20 per cent. on 2 inches.

Oil-hardened pins are generally made from 26 ton steel, giving an elongation of 25 per cent. on 2 inches.

I conclude, trusting that these few remarks have been of interest to you.

Mr. J. SIBUN, Jun. (by permission of the President) said—Before making any remarks upon Mr. Heck's valuable paper, I must thank you and the members of the North-East Coast Engineers and Shipbuilders for the kind invitation to be present to-night and take part in this discussion, and perhaps you will excuse me if I read the few remarks which I have to make and which I have hurriedly put together at very short notice.

Now, as regards the action of time and work on the properties of mild steel and iron, I notice that Mr. Heck quotes Mr. W. Boyd in 1878, who stated that "Time alone will prove whether mild steel can support the wear and tear of life on board ship." And I do think that time has proved conclusively that mild steel can do this and has done it. This, in my opinion, is amply proved by Mr. Heck in the tests he has made on samples of very old material, and I am sure that these tests would have given even better results if (in the case of badly pitted and corroded samples) the test pieces had been planed or filed so as to give an even surface, as without this not only is it very difficult to obtain the correct area of the sample, but, when the piece breaks in the testing machine, it always does so at a point where the greatest indentation occurs, or, in other words, at the weakest spot, and we thus lose, not only the actual tenacity of the good material, but also the amount of elongation which it otherwise would give. I may say that I had the pleasure of seeing some of the samples actually tested, and had I known at the time the purpose for which they were intended I would have made this suggestion to Mr. Heck, as I am quite sure that if this had been done the results would have been even better than the tables show.

As regards the iron samples, we find that they were not so satisfactory, many of the specimens breaking into pieces directly they were touched by the shears. Probably this may be due to the great difference in the "structure" of the two materials. Steel, for instance, in course of manufacture is in the fluid state, and when cast sets into a solid mass, and when rolled still retains perfect solidity, and thus any action of time, moisture, etc., can only take place on the surfaces, which is proved by the fact that even after years of work, when the plates are very badly corroded and pitted, there is still left a portion of good material, which gives a test relatively as good as when the original plate was made.

Iron, on the other hand, owing to its different process of manufacture is more or less composed of layers of the metal, and in the course of time the moisture from the atmosphere gradually penetrates into and under these layers, rendering the material practically useless, so that even if mild steel does corrode more quickly than iron, we have at any rate something left which is relatively as good as the original, whereas in the case of iron we have only a useless and probably dangerous substance.

Again, as regards the ageing of mild steel, if you will allow me to quote from a paper on this subject, read before the members of the Iron and Steel Institute this year by Mr. Stromeyer, of Manchester. In this, a very able and exhaustive paper, the author gave some very remarkable tables of tests showing very varying results. The conclusions to be drawn from these tests, he asserts, are that certain steels do possess ageing qualities; some varieties tend to improve with age, others to deteriorate. In the discussion which followed this paper, Mr. Ainsworth remarked that "if customers once came to the conclusion that steel was going to deteriorate into the condition described, in about 12 weeks, the steel industry would be but a short-lived one": but when they recalled instances of ships, built of steel, bumping on rocks on the other side of the world, and coming home without anything being done to them, with their plates bulged in all directions, he thought they must come to the conclusion that the cases mentioned by the author were exceptional cases, and could not apply to the steel which was generally produced. Mr. Stromeyer concluded his paper by saying that although he was responsible for the safety of over 8,000 boilers, he did not feel alarmed by the knowledge he had gained that steel and iron have ageing tendencies.

Now, I would like to say a few words on a point which Mr. Heck raises at the beginning of his paper, namely, the stringent testing of steel 20 years ago. I think he will agree with me when I say that this stringency has not only been maintained but very much increased in recent years, even after experience has taught us more about this material. I had a great deal to do with the testing (both chemical and mechanical) of the first mild steel made by Messrs. Palmers Company, over 20 years since, and at that time, if I am not mistaken, we had the following tests imposed: generally speaking, boilers, 26 to 30 tons, 20 per cent.; ship, 28 to 32 tons, 16 per cent. These requirements were practically unaltered for many years, until our engineers began to go in for higher boiler pressures, and, of course, not wishing to increase the weight of boilers they looked for steel plates of higher tenacity, and so gradually from 26 to 30 ton steel we had shell plates increased to 27, 28 and 29 tons minimum tensile strength, and even higher than this. This gradual tendency to increased tenacity with decreased thickness naturally caused the steel makers considerable trouble and anxiety, as the ductility of the steel had also to be maintained.

With this end in view, the firm of John Spencer & Sons, Ltd., with whom I have had the honour of being connected for nearly 16 years, placed upon the market a material which retains both the qualities of high tenacity and great ductility in very marked degrees. I refer to their high tensile steel, which is capable of withstanding a tensile strain of from 36 to 40 tons per square inch, and at the same time give you 20 per cent. elongation on 8 inches. The bends from this steel will stand the same bending tests as mild steel, either hot, cold or tempered, and when I tell you that the whole of the shell plates and butt straps used in the construction of the boilers for the famous Cunarder "Mauretania" were made by us of this material, and proved highly satisfactory in the working up, I think you will agree that it must be a steel of very high quality. Some hundreds of tons of this same steel were also used in the construction of the hull of the same vessel. All this was not accomplished without most stringent testing, not only by Lloyd's and the Board of Trade, but by every other corporation and insurance society.

I have pleasure in submitting for your inspection a series of tests made by Mr. Charles Kircaldy for Mr. Samson of the Board of Trade, both from plates and bars of this steel, the results of which speak for themselves and go to prove that Messrs. Spencer's high tensile steel is a thoroughly reliable material and well worthy of the consideration of our engineers and shipbuilders, who require a steel which at once combines high tenacity and great ductility. (See Tables 1, 2, 3 and 4, facing page 62.)

Whilst dealing with this tendency to higher tenacity steel, I might say that engineers are not alone in this respect, as shipbuilders are also demanding material of this quality. In fact, at the present time, the Admiralty are using, in the construction of warships, thousands of tons of nickel steel, having a tensile strength of 36 to 40 tons per square inch with an elongation of from 18 to 20 per cent. on 8 inches.

Mr. H. B. BUCKLAND said—Mr. Heck's paper is really a very interesting one, so far as the subject matter is concerned; the only fault I have to find is its shortness: he has brought it down to a very concise point indeed, so much so that one feels inclined to ask for more. If I read it aright I think he says there is no difference between steel and iron as regards the amount of corrosion which takes place, the one is as susceptible as the other. Am I right?

Mr. HECK—Quite right, provided the materials are of equal thickness.

Mr. BUCKLAND—I am afraid I shall have to disagree with him there. From the experience I have had I am led to believe that a greater amount of corrosion takes place in steel than in iron. Steel is undoubtedly a stronger material than iron of similar section and therefore we can do with a less body of the former than the latter to stand similar strains; but the crux of the whole matter lies in the attention which is given to steel to counteract corrosion; were this not done, I think, as regards corrosion, iron is superior to steel. I will put it this way: If steel had been subjected to the same want of attention as iron, I feel convinced that a greater amount of corrosion would take place in a given time in the steel than in the iron. But if proper attention is given to steel then, in my opinion, excessive corrosion either in ships or boilers should not take place. Mr. Heck knows I have had considerable experience both in the building and repairing of boilers and it is not saying too much to assert that the average life of a steel boiler, if properly looked after and cared for, is about 20 years against the old life of an iron boiler which averaged 10 years; and, in fact, with the extra care taken in the building of steel boilers, if they are properly looked after, I see no reason why they should not last 30 years.

Might I be allowed to make one suggestion: I think that a considerable amount of the corrosion that takes place in the steel tank plates of vessels might be greatly reduced if the plates were coated with white lead or zinc when hot. I thank Mr. Heck for his very interesting paper.

Mr. W. G. SPENCE said—There is just one point I would like to raise, and it is this. A number of years ago, probably 10 or 12, there was a good deal of uneasiness felt, in regard to the use of steel screw stays in marine boilers; and about that time a number of builders adopted wrought iron for this purpose. I have noticed also in repairs, when a steel stay has broken and had to be replaced, the majority of people request the replace stay to be of wrought iron. When iron stays replace steel stays the sectional area of the stay is increased in proportion to the reduction of the tensile strength of iron as against steel. A question that has never been altogether settled, and which I have sometimes heard raised, is, if instead of putting in the larger wrought iron stays we had increased the area of the steel stays to the same amount, would we not perhaps have obtained as good or a better result? I should like to know if Mr. Heck has any views on this point, or any experiments bearing thereon.

Mr. T. SHAW said—It was not my intention to speak on Mr. Heck's paper, as the results of the tensile and other tests given therein are conclusive and admit of no discussion, but as several of the previous speakers have taken exception to Mr. Heck's statement, " that steel of the same thickness and under the same conditions will withstand corrosion just as well as iron," I take the opportunity of giving my experience.

Weather Decks.—It is quite a common experience to renew deck plates when thirteen to seventeen years old, more particularly partial awning decks, the original thickness of which was $\frac{6}{20}$ inch steel, or if iron $\frac{6}{16}$ inch, but I have invariably found the diminution is *pro rata* to the original thickness. It is the practice of some shipowners to specify iron decks, this does not include the stringer plates which are always steel, yet I do not remember a single instance in which the stringer plates have had to be renewed at the same time as the deck, although the thickness of the stringer plate is only one pound per square foot heavier than the iron deck plate, and, of course, both had received the same treatment in regard to coating. Whilst taking decks as an example, the foregoing remarks apply equally to all other parts of the ship, and if the difference in thickness between iron and steel had been reversed, that is, steel made thicker instead of thinner than iron, we would not have heard so much about rapid deterioration of steel.

I do not entirely agree with Mr. Heck, inasmuch as I consider it more difficult to remove the first scale from steel than iron (also the latter takes paint more readily than steel), and therefore requires more supervision to see that *all* scale has been removed before coating. The custom now obtaining of chipping and painting steel work in the holds, when the vessel is at sea, does not lend itself to the necessary supervision, and it behoves owners to give strict instructions regarding same, as in a number of cases the work has been of such a slipshod character as to render it necessary to be all done over again.

Our thanks are due to Mr. Heck for his paper, the tabulated tests are *multum in parvo* and give no indication of the enormous amount of work involved in arriving at the results.

Mr. David Andrew said—I have little to say beyond complimenting Mr. Heck upon the useful information he has given us from his heap of scrap, information which I have no doubt will to a great extent eradicate the idea that steel as a material for shipbuilding has to be carefully dealt with in the matter of repairs.

In the early eighties an eminent authority on ship construction stated on a particular occasion that in cases of damage, great stress was brought on the steel plates, altering their condition and rendering them unfit for use, and even went so far as to say that cutting off the rivet heads, and cutting out the rivets, altered the character of the material very much, and that part of a plate locally heated to get it back to its original form was likely to render the material locally brittle.

The great respect for steel has faded very much, but it still lingers, and I am sure Mr. Heck's tables will show conclusively that steel can be treated in the same manner as iron is treated without suffering deterioration; I must admit that the iron which steel replaced in shipbuilding could not boast of a great amount of elasticity, as in cases of collision or stranding it did not bend to any extent, but broke readily enough, so probably rough handling in repairs could not possibly alter the character of this material to any extent.

The introduction of steel in place of iron in shipbuilding has been a great boon on account of its elasticity, as in cases of stranding or collision the plates will bend considerably before being fractured, therefore rendering salvage a more simple operation. It is not unusual to see plates on a ship's bottom bent up like an arch twelve or eighteen inches over a length of two to three feet.

I am not in accord with Mr. Heck in his statement that steel appears to withstand corrosion just as well as iron. I think he does not mean it seriously, but has thrown this out as a challenge to provoke discussion, as it is a well-known fact that steel is more liable to corrode than iron, requiring greater attention in scaling and painting in order to preserve it; if that is done I have no doubt steel will last as long as iron.

I have a clear recollection of one particular case in the early days of steel vessels. A steamer, about one year old, had been in collision, being struck in way of the fore hold, and in going into the hold in company with the superintendent we found an extraordinary amount of scale lying on the ceiling directly under the collision damage. The superintendent exclaimed, "Where has all this scale come from? I have no scale in this ship," but there it lay simply in sheets, and upon examination of the other side of the hold we found the coating of paint smooth, and no appearance of scale under it. I have no doubt the damaged side had the same appearance previous to the collision, but the blow had loosened the scale. This, I may say, was the experience of many in those early days, until it was realised that a steel ship is more liable to corrode than an iron ship. This rapid corrosion is more marked under the boilers of steel vessels, due to the presence of moisture heating, and cooling, but it is well known that this rapid deterioration did not exist under the boilers of iron vessels. It will be of the greatest advantage if the steel of the future, in addition to retaining its present good qualities, will resist corrosion equal to iron.

Mr. H. M. Wilson said—I am sorry I was not present to hear the paper. I think a good deal of the corrosion regarding steel is due to the atmosphere. From my knowledge of boilers I find there is certainly no difference in the corrosion, but as regards decks of ships I think it is severe compared with wrought iron.

ENGINEER-LIEUT. BAKER said—I had no intention of speaking to-night on this paper, but one or two remarks that have been made as to the corrosion of steel have reminded me of a fact which was brought to my knowledge quite recently, of the peculiar action in the case of steel plates in one of His Majesty's ships. The ship I am referring to is one of a class of six. Two have suffered considerably from corrosion, and in one case the corrosion was confined entirely to the bottom of the ship, and was of the ordinary description which one expects to find in a steel ship. The case of the other was different; that is, the action which took place on the two sides of the ship was different. In the case of the starboard side, from midships right aft, the corrosion there, where the paint had come away in blisters, showed the ordinary pits underneath the plate, with the usual black oxide of iron, but in the case of the port side there was a complete absence of this scale. But on the other hand what we found there was holes, so to speak, extending to the eighth of an inch in depth and perfectly clean—no sign of scale or of black powder, the oxide which is found in the case of steel pitting, and it was remarked, in the two different actions that took place, that they were confined entirely to their own side of the ship—on the starboard side dimples, with black powder; on the port side it looked as if it had been pock-marked. The matter was reported, and a certain number of rivets were renewed on the starboard side, and no further trouble was experienced. But another action was noticed some time afterwards on the inside of the ship, and that was in the port feed tank. For eighteen months there was no action at all, and then suddenly, in spite of precautions taken, corrosion took place along the top and the two ends, and the corrosion was found to be of the same nature, that is, pits of a depth of from $\frac{1}{16}$ to $\frac{1}{32}$ of an inch. Perhaps Mr. Heck or some of the members of the Institution, may be able to explain it. The peculiarity is that there was no action on the starboard tank, and on the port tank, similar to the action that had taken place on the outside of the ship.

MR. BUCKLAND—Perhaps that side of the ship had been exposed to the sun more than the other.

ENGINEER-LIEUT. BAKER—While the ship was building, for a matter of twelve months she was in a wet dock in the builders' yard, and lying alongside a wooden jetty, and on the opposite side, that is on the starboard side, about 100 feet away, was a sewer discharge, which sewer took away the refuse from a whiskey distillery. Whether that had anything to do with it I do not know.

There is a remark made in the paper about steel for cross head pins. I endorse that. Preference should be given to wrought iron case-hardened cross head pins rather than to steel. There seems to be a peculiar action going on when using steel cross head pins. In one case, when steel cross head pins were used, no matter how they were fitted, they would run for a trip and give trouble, and if they were not properly fitted they would be caught up, and after doing another week's running came out as bright as a shilling. There seems no satisfactory explanation as to why these steel cross head pins should give trouble. After they were replaced by case-hardened pins there was no trouble with the cross head or with the pins themselves.

The SECRETARY stated that he had received the following communications:—

WALLSEND-ON-TYNE, *December 18th*, 1907.

DEAR MR. DUCKITT,

I have to express regret at my inability to be present at the meeting on Friday evening first, but enclose a few notes which perhaps you will be good enough to read for me should time and circumstances permit.

Our thanks are due to Mr. Heck for his instructive and interesting paper, which appeals very forcibly to those of us who are more closely identified with the repair, as distinguished from the building of vessels, and where so many opportunities are afforded for observation as to the effect produced by wear and tear and damage.

I cannot agree with Mr. Heck when he states that there is no difference in the action of corrosion on iron and steel; true it is that a steel plate if corroded to the same extent will stand a tension test which an iron plate will not, but, on the other hand, from the point of wear and tear, I venture to state the result is in favour of iron. One is therefore forced to the conclusion that if the same durability is to be obtained from steel as from iron structural work, the former must receive more attention, especially in the early part of its existence, by way of cleaning and coating, than the latter.

In dealing with the repairs of the various types of vessels, one cannot but be impressed with the wonderfully good condition of the structure of an iron vessel—more particularly the shell plating, where except for a few trivial renewals, it is known to be the plating originally used in the construction of the vessel.

One factor, however, in the life of an average steel cargo steamer must not be lost sight of, namely, except for a thorough cleaning and painting when the vessel is being overhauled for re-classification, the internal structure gets but little attention, as, owing to the growing demand for rapid loading and discharging, time does not permit of any appreciable cleaning being done, as was the case, say, when vessels were detained for long periods for, say, loading, besides which a good deal was done by the crews, but this practice does not obtain to the same extent as in former days.

With regard to the tables of tests which are shown under Table "S," it would be interesting to learn whether, in the column "Age of Sample in Years," the figures given represent the age of the vessel, or merely the age of the plate from which the sample was taken, as it is, of course, quite possible for a vessel of say 30 years to have undergone repairs for damage of various kinds, in which renewals were necessary, and such material might provide the samples taken.

The superiority of steel over iron for withstanding shock and strain is simply proved in the cases of stranding and collision with which most of us are familiar, and the fact that such vessels are salved after being badly stranded or brought to port after being severely damaged in collision bears witness to the splendid quality of steel, a result which it would not be possible to obtain in the case of iron.

I venture to state that where steel receives very close attention as to cleaning, etc., in the early stages of its existence, it is quite equal to all that can be desired of it.

Yours faithfully,

J. W. Tocher.

20, Northumberland Avenue, Forest Hall,
Newcastle-upon-Tyne, *December 19th*, 1907.

Dear Mr. Duckitt,

I regret I will not be able to attend your meeting to-morrow night to hear the discussion on Mr. Heck's able and interesting paper, read at the meeting on the 29th ultimo.

I however hope the members present will give this matter their careful consideration and express their views freely thereon. There is no doubt as time goes on we find it more difficult each year to get good reliable iron, either in the shape of ship's plates or for engineering purposes, and although iron for certain shipbuilding and engineering purposes will "die hard" with some people, I think the sooner it is discarded altogether for shipbuilding purposes, and replaced by good mild steel, the better it will be for all concerned.

I have had considerable experience with iron decks in steamers, and about eight years' experience with steel decks in the same class of steamers, and I am quite convinced that exposed decks of steel, the same thickness as if they had been plated with iron, if well looked after, are much preferable to iron decks, and would last quite as long if not longer. What trouble there has been with exposed decks of steel has been due, in my opinion, to the reduced thickness of the plates in the first instance, and the want of ordinary care and attention. Iron decks being thicker in the first place than steel decks they stand more neglect, and hence get the credit of being less liable to corrosion than steel decks, whereas it is due to the thickness of the material used. The same thing applies to the framing of steel-built vessels, which has been a source of trouble with shipowners for years. This is also traceable to the reduced thickness of the material used in the constructions, the difficulty of scaling and painting frames fitted with reverse bars, and last, but by no means least, the very inferior quality of the so-called paint used, which in many cases has to last for four to five years.

I feel we are indebted to Mr. Heck for his paper, and I trust the members will take full advantage of this opportunity and have the matter well thrashed out.

Yours faithfully,
C. Landreth.

The discussion was again adjourned.

NOTES FROM FOUR YEARS' WORKING OF THE EDUCATIONAL COMMITTEE'S RECOMMENDATIONS.

By W. G. SPENCE, Vice-President.

[Read in Newcastle-upon-Tyne on December 20th, 1907.]

In the month of December, 1903, a Committee of this Institution recommended the adoption of a system of marking for recording the timekeeping, industry, and evening study of engineering apprentices. The system was recommended by the Committee on general lines, each firm being at liberty to make such amendments as might better suit the special conditions obtaining at their works.

Four years having elapsed since the Committee's report was issued, it has occurred to the writer to submit to the Institution certain data, in the form of curves, showing the result of the four years' practical working of the system at the Neptune Engine Works. These curves, together with the deductions drawn therefrom, he hopes, may be of interest to the members and lead to results of practical value. .

Details of the arrangement of marks suggested in the Committee's report will be found on pages 56 and 57, vol. xx. of our *Transactions*. The marking adopted at the Neptune Works differs from the suggested schedule in some details. Marks are awarded on a graduated scale for examination passes; details of the scale will be found in the Appendix at the end of this paper. The results of each apprentice's timekeeping, industry in works, and evening study for 1907 will be found in Curves A, B, and C, respectively (Plate VII.). These three curves are combined in one curve, D (Plate VIII.), which shows at a glance, above the name of each apprentice, his exact relative position in order of merit, the weekly rate of supplementary pay he has earned for the current year and the marks he gained in each preceding year (shown by spots above or below his position on the curve). A framed copy of this diagram is hung up in each department of the works and remains on exhibition until replaced by the following year's results.

These curves are at best only an imperfect indication of "character," and character, or "gumption," to use a shop phrase, is probably the most important ingredient in anyone's composition and one which often developes late. They form, however, to some extent, an indication thereof, and the relative position of each youth, measured on this basis, is easily noted.

In order to analyse these records for the years 1904-5-6-7, and to show the annual variation, the curves D′, E, F, G, H, J, K, L (Plates IX. and X.), have been constructed.

Curve D′ (Plate IX.) shows the combined curve, D, for the years 1904-5-6-7. This has been plotted with a view of ascertaining if the yearly variations recorded in curves E to L (Plate X.) arise from any marked deviation in the form of the curves. It will be noted that, generally speaking, while the whole curve has been raised, this is especially so in regard to the portion towards its lower extremity.

Curve E (Plate X.) shows the average total number of marks gained per apprentice in each yearly period.

It is perhaps somewhat premature to attempt the deduction of general conclusions from only four years' data, but, so far as it goes, this curve appears to show that the introduction of the system caused a general and very creditable "bucking-up" among the youths. As the novelty of the system wore off, the human tendency to backslide appears to have asserted itself to some extent, and it is probable the eventual mean will be found to be somewhere above 1904 and below 1905. This curve seems to the writer to indicate that, up to the present, the introduction of the system has been justified.

Curve F (Plate X.) shows the average number of timekeeping marks gained by each apprentice out of a total possible of 120. This curve indicates a distinct improvement in timekeeping. The importance of timekeeping is, in the writer's opinion, considerable, quite apart from its assistance in the maintenance of discipline and production of work. As a rule, he considers it a fair indication of character, and the training in character induced by having to turn out of bed early, especially in winter, is a distinct asset in a youth's apprenticeship.

Curve G (Plate X.) shows the average number of conduct marks gained in each year per apprentice, the possible maximum being 120. These marks are awarded quarterly by the respective foremen and are intended to indicate the relative industry and ability in the works shown by each apprentice. This idea is good in principle but its practical application is affected by the introduction of the "personal equation." The foremen undoubtedly endeavour to allocate their marks conscientiously, but there is naturally a wish on the part of every foreman to see the names of the young men under his charge well up on the list, which is liable to bias the judicial faculty, and it is extremely difficult for anyone to place each youth in correct perspective.

Curve H (Plate X.) shows the average evening study marks gained per apprentice.

Curve J (Plate X.) gives the percentage of the total number of apprentices who gain any class marks.

Curve K (Plate X.) shows the average class marks gained by each of these apprentices who actually gain any class marks.

It will, perhaps, be more convenient to consider these three curves together, as J and K are really based on H and intended as an analysis of the latter.

The curve, J, is intended to indicate the percentage of youths who show any results at all from their evening study.

The curve, K, is plotted with a view to indicating the quality of such work.

The impression the writer gathers from a study of these three curves is that the number of apprentices who do efficient evening class work forms a very small percentage of the whole, and that, except in a few exceptional cases the work is of quite a rudimentary character. It will be noted that little more than one out of every five apprentices show any results at all. One has heard much of late years as to the dangers attached to over-attention to book work. The results indicated by these curves should permit those who fear we are going to perdition from this cause to slumber in peace. Incidentally, the writer considers the curves indicate a justification for the argument that the attention of those responsible for the allocation of educational grants should be specially directed to seeing that such grants are so arranged that the small percentage of specially able and hard working youths are granted facilities for passing on to the higher technical schools and colleges, and that the chief business of evening classes should not be the production of a light crop over a large area, but rather the giving of assistance enabling a few to raise themselves above the average and to pass on to further advancement.

This was clearly the aim of your Committee when they recommended that special facilities should be given to "selected" youths. It is a waste of labour to try to polish lead, but if the small percentage of silver contained in the lead be extracted a high polish can with advantage be given to the rarer metal. The Scholarship about to be founded by our Institution is a right step in this direction.

Only a very exceptional youth, strong both mentally and physically, can make any great headway by evening study, and, at the same time, work regularly and well in the works from 6 a.m. to 5 p.m. With a view to minimising this difficulty in favour of the really deserving, it is now arranged at the Neptune Works that the apprentice at the head of the curve each year shall, between the 1st October and 31st May next succeeding winter, commence work at 9 a.m. instead of 6 a.m., full-time pay being credited over this period. Should the same youth or youths be leading for a second or a third year in succession they will retain their privilege and, in addition, the next in order will obtain it. In other words, the head apprentice of those required to attend at 6 a.m. will always be selected in each year.

Curve L (Plate X.) indicates the percentage of the total number of apprentices who fall below the zero line, in other words, gain no marks whatever. It will be seen that since the introduction of the system there has been a healthy decrease in the numbers under this category. The "scallywag" we have always with us, and while the extinction of this species is unattainable, its reduction is desirable.

The above-described system of marking and curve records is in operation in both the engine department and boiler department, but each is kept distinct, and the curves from the former department only have been dealt with in this paper. Apprentices after commencing in the drawing office are not included in the curve.

In conclusion, the writer wishes to state that he is satisfied that the exhibition of these curves in the works is a healthy stimulus to the apprentices, and he hopes their submission to the Institution may lead to a useful d[illegible]n.

APPENDIX.

Neptune Engine Works.

At the end of September in each year, each apprentice will be awarded marks as follows:—

For each approved examination in science or in mathematics (not exceeding three in number) passed during the year (see Schedule A below).

For time-keeping: a maximum of 120

For good conduct, industry and progress in the workshops: a maximum of 120

Marks for time-keeping will be deducted at the rate of one mark for every hour lost, but no deduction will be made for special leave, or for sickness if certified by a doctor.

Conduct marks will be awarded quarterly on the following scale:—Very good, 120 marks; good, 90 marks; fair, 60 marks; moderate, 30 marks.

SCHEDULE A.—Evening Science and Art Classes.

		Marks. 1st Class.	Marks. 2nd Class.
Board of Education, South Kensington—			
Science Subjects	Stage 1 ...	30	20
" "	" 2 ...	50	30
" "	" 3 ...	85	50
" "	Honours ...	110	70
Mathematics—Division I.	Stage 1 ...	30	20
" "	" 2 ...	50	30
" "	" 3 ...	85	50
" "	" 4 ...	85	50
" "	Honours ...	140	80
" Division II.	Stage 5 ...	85	50
" "	" 6 ...	85	50
" "	" 7 ...	110	70
" "	Honours ...	170	100
Freehand Drawing	...	36	—
City and Guilds—			
Science Subjects—Preliminary	...	30	20
" " Ordinary	...	50	30
" " Honours	...	85	50

Armstrong College (Evening Classes)— Division	I.	II.	III.	IV.
Elementary Stage	30	20	15	10
Senior Stage	50	35	25	15
Advanced Stage	100	70	50	30

An apprentice obtaining 180 marks in the aggregate will have the sum of sixpence added to his weekly rate of pay for the ensuing year, for marks in excess of 180 his rate will be proportionately increased.

No payment under this scheme will be made to apprentices obtaining less than 180 marks, and apprentices who fail to obtain a reasonable number of marks for time-keeping, good conduct, industry and progress will be subject to dismissal.

Apprentices commencing their apprenticeship between October 1st and March 31st will be entitled to half-rates for their first year.

Marks will only be given for examinations passed in the year for which the certificate is issued, except in the case of those students who sit for the "Honours" examination having already passed the advanced stage in some previous year, such students, in case of failure to pass the "Honours" examination, will be allowed to count the marks they earned previously at the advanced examination. This is done with a view to encourage apprentices to take the higher courses of study.

Students will be expected to show improvement each year in the results of their examinations and the full marks allowed for any given pass can only be obtained in one year. Should the student only succeed in obtaining the same pass a second time the marks obtainable will be reduced by 10 per cent.

DISCUSSION.

Professor R. L. Weighton said—I commence by congratulating Mr. Spence on the paper which he has presented. It is of an order which I think I am right in saying must be of perennial interest to all of us, inasmuch as it deals with the human factor, the human element, the human part, in engineering, and that part can never become obsolete or be superseded. I also congratulate him on the fact that so far as I know he is the first to apply the graphic method to the analysis of the subject. Without this graphic method I think we should have had great difficulty in grasping the general tendency of the operation of these regulations. With that method it is obvious to us all how the matter is shaping. There is another point on which we may congratulate Mr. Spence, that this is the first harvest of results, as it were, that has been presented, at least before this Institution, of the operation of these regulations, which were embodied in the report of your Educational Committee some three or four years ago.

Speaking from a cursory view of the diagrams, the first thing that strikes one will probably be the fact that so few of these young men attain to any degree of success in evening study. It is only in the evenings, of course, that they can study, being apprentices as distinguished from pupils. Like Mr. Spence, I do not think that is so, and a closer examination of the results, and a consideration of the bearing of the whole question will show that the results, even in that sense, are very good indeed. We must not forget that this paper deals with only one section of that report to which Mr. Spence refers, namely, the regulations for increasing the efficiency of the apprentice artizan in works, leaving out altogether the apprentice engineer or pupil. The artizan, as an artizan, is supposed never to rise out of the workshop. He might rise to the position of foreman, but he is not supposed to rise to positions in the higher branches of engineering and its allied industries; if he does so he ceases to be an artizan. Dealing then only with the apprentice class, I think it will be found on examination that these diagrams show wonderfully good results. Take only the first four in Mr. Spence's diagram who are at the head. I think if there were no more than those four, which is about 6 per cent. of the total, it is a very considerable success, because if you can offer facilities for these four (and they are evidently youths who can take advantage of these facilities) for further increasing their acquaintance with theoretical study, they will rise in the business and be of great service to their employers. And if we have much more than four, if we had much more than 6 per cent., I suggest we would have a difficulty in retaining any of them as artizans at all, because once they get up certain steps in the ladder they cease to be artizans, and rightly so. And here comes in the vexed question how far an artizan as a handicraftsman, is improved by education in the technical sense. Some say you cannot educate him too highly. Others say he has got quite enough, and you had better not give him any more after he has left school. I will not enter further into that question. I am rather inclined to think it need not concern us, because the absorption of knowledge in the evening after the day's work, means a strenuous life, and there is no danger of too great a number becoming too clever. There is one point which I should like to bring forward here. I venture to submit, for the consideration of Mr. Spence and those with whom he is associated, a slight alteration, and that is in respect of the marks awarded for evening study. I have made a small portion of a diagram which will possibly show this, although it is shown, in a sense, quite as well as Mr. Spence's diagrams.

Here is a little diagram (Plate XI.) which I have extracted from Mr. Spence's diagram and re-arranged. I have arranged all the men who have got any marks at all for study first. Superadded to the lowest curve are the marks for timekeeping, and then superadded again the marks for conduct in the works. The point I wish to emphasize is this: that you will observe the man at the top, No. 1, only obtains, I think, 80 marks for class work; 120 is the maximum, and it is closely obtained by him, and obtained by many others for timekeeping and also for good conduct, but there is no one gets anything like 120 for class work, and I submit no one could get 120 class marks under this scheme. I suggest that the class marks should be about doubled. When we consider, from the appendix to Mr. Spence's paper,* that a first-class obtainable in an elementary subject carries with it only 30 marks, and that the number of all passes are limited to three, 90 marks is the possible a boy could get. Compare that with 120 for conduct and 120 for timekeeping. I consider that is handicapping application in the evening to some extent, and that the marks might well be raised, imposing, if you will, a limit of, say, 120, so no boy would be credited with more. But that again is quite a moot point as to whether he should not be allowed to earn more for study than for conduct or timekeeping. I see no reason why he should not. My advocacy of this alteration may be said to be based upon the following considerations: First, the object of these regulations by your Committee was twofold—first, to increase the efficiency of the artizan, the man who would never be else than an artizan. That is a very important object to aim at indeed, and that, of course, would be obtained by encouraging good timekeeping, good conduct, and efficiency in the shops, and, doing so, that would be sufficient for the present. That was the first object,

* Page 67.

and it has evidently been fulfilled fairly completely in operation. Secondly, there was another object, which was to provide means whereby a few youths might be selected from the large number of artizan apprentices by means of evening study, and who would be encouraged to proceed further. We all know that brains are not confined to the upper classes, nor to the wealthy, but are very often indeed found amongst the lowest classes in every country, and it ought to be our object to encourage the sons of working men to rise, and unless we do so we lose a valuable asset of our country. That was our object—to encourage the few to rise. I submit we handicap these few by putting such a low value on studious work in the evenings. It should have as high a value for the possible maximum as the others have. I hope I shall not be misunderstood. Punctuality, good conduct and discipline in works are most important, and I yield to no one in my admiration and advocacy of these. Indeed, in my usual professional sphere now, I stand almost alone in the Institution with which I am connected in perpetually advocating these qualities. In season and out of season I am telling my students of the value of these qualities, and that if they do not exhibit them during their college career they will have to exhibit them afterwards or fail in their career. Perhaps I may be looked upon as a kind of a "crank" for advocating that so often. I say this so that you will not misunderstand when I am pleading the case now of the evening student. It does not depreciate the other two qualities, but there is no reason why we should not give due value to each of the three. Now, the third reason why I make this suggestion of a change in the number of relative marks is this: I submit that of all the means of self-discipline, self-denial and self-help which go towards the formation of character, and which is of excessive value in the young, there is nothing I know of better and more valuable and more powerful than evening study, strenuous exertion of the mental faculties. All engineers are accustomed to deal with the inertia of matter, but there is another thing much more difficult to deal with, and that is the inertia of mind; and these youths can only overcome this natural inertia by training and cultivating their minds when young. If we are going to admit that such training and cultivation is inferior to timekeeping and good conduct, I submit we are not doing right. Fourthly, and this is the last reason I give for the change, whatever value we as an Institution give to evening study, that value the boys will put upon it, and if we depreciate evening study by making it such that it is impossible for a boy to gain more than about 80 marks, I say again we are not doing right. There is one point about these results of Mr. Spence's which one cannot help noticing. It bears again on this question of evening study, and it is this: While some of the most studious boys are at the head of them all—(you remember from Mr. Spence's diagram four of the best boys at the head are there because they engaged in evening study)—none of the studious boys are at the bottom. There are none of them below zero. We cannot help noting also that in the case of all those boys who study in the evening (except the first one who is a long way ahead of the others) there has been associated with evening study a considerable amount of lost time. I do not know quite why that should be, but it is so according to those diagrams. I think that there is no doubt whatever that these regulations which the Committee framed, and which have been adopted by several firms, and especially by that large company in Hartlepool, Messrs. Richardson, Westgarth & Company, in somewhat the same form, are doing an immense amount of good; and I feel that if every manager of works took the same interest in the boys that Mr. Spence does they would do a great deal more good still.

Mr. R. Hinchliffe said—Mr. Spence's valuable paper contains a great deal of interesting and instructive matter; indeed it is not until one has looked into it, and given it some study, that one realises what a mass of information is graphically represented in these zigzag lines. Whilst all the curves are of interest, I personally am most interested in those which deal with the results of evening study. Having been engaged for a number of years in connection with technical classes, I heartily welcome this record of an employers' appreciation of the work done by their apprentices at evening classes. I possibly appreciate it more because it bears out a number of my own theories, arrived at as the result of my experience, which theories I am pleased to see Mr. Spence quite agrees with in his paper, although hitherto I have met several authorities who held different views.

The first lesson which these records clearly teach us is, think, that when we consider any large body of apprentices we must realise that a large proportion of them are either not suitably educated for or do not properly appreciate the advantages to be gained by evening study. I had that fact brought home to me very clearly about four years ago while teaching a class at Walker. This was the first year that Messrs. Swan, Hunter and Wigham Richardson, Ltd., introduced their present system of apprenticeship marks.

After my class had been in progress a week or two, I got a sudden influx of some 12 students who my past experience enabled me to perceive were not of the usual type. A little inquiry informed me that the foremen of the works mentioned had been round amongst their apprentices threatening with dire penalties all who did not join one or more evening classes. I had no reason to find fault with these new additions as far as conduct was concerned, but they quickly demonstrated the fact that though you may lead a horse to the water you cannot make him drink. They listened to me with all courtesy and sympathy, but seemed to think it strange that a man who spent all day in a shipbuilding yard should want to talk about shipbuilding at night. The most of them disappeared in the course of a week or two and by Christmas they had practically all vanished, only however to return again for a short period when they had been again threatened by their respective foremen. I think I finally put two of these students in for the examination. A similar result has been found in practically all the technical classes in that district, proving clearly that there is only a small percentage (about 20 per cent. say) that really have the inclination to take technical study seriously. Up to the present time it has undoubtedly lowered the efficiency of the classes devoted to the elementary stages of technical subjects that they have contained a certain number of students unsuited for the work to be done there. It is with pleasure I learn that the Newcastle Education Council is introducing a scheme which will enable this necessary work of separating the suitable from the unsuitable students to be done in the evening continuation classes and will thus leave the technical classes proper only to deal with those students who are suitable for their stages. This will add greatly to the efficiency of these classes, for a technical class is not unlike an army, the speed of progress is decided by the slowest unit, and a number of unfit students, who have not sufficient elementary education will retard the progress of the whole class.

I take it that Mr. Spence has put this paper forward for criticism, and that he will not object if I find a little fault with some points in his firm's system. I agree most heartily with Professor Weighton that they should give more marks for science subjects. Secondly, I would like to see them alter their system, and not give the marks entirely upon examination results. It is now being generally recognised by education authorities that the examination, as a test of efficiency, is not absolutely perfect. For instance, in the Board of Education examinations there are two standards of success, namely, first class and second class. Necessarily, there is a certain minimum number of marks which will place a student in either of these grades. The marks are generally understood to be 75 per cent. for first and 40 per cent. for second class. If a student gets 74 marks in the elementary stage examination he gets 20 marks, according to the system described by Mr. Spence. If he gets 75 he gets 30, a difference of 1½ per cent. in examination marks producing a difference of 33 per cent. in his works marks, nor is this the only objection. You have the whole result of the student's year's work in that one subject at stake depending entirely upon what he can accomplish during the three or four hours given him in an examination. If a student should be a little off colour at that time the whole of his year's work is jeopardised on that account. Further, the student recognises what he has at stake, and frequently suffers from a form of stage fright. Others, again, do not possess that fluency of expression which is so necessary in most Board of Education examinations if you are not to be seriously handicapped by the time limit. I would much prefer if Mr. Spence could persuade the authorities of his department to substitute for the examination marks an efficiency percentage mark which would be settled by the head of the college or education centre at which the student obtained his technical instruction. That efficiency mark might be made up of a total derived from home-work marks, attendance marks, and marks given for general attention and efficiency. This, I think, given by the educational authorities, would be absolutely without prejudice and would be a much fairer test of the student's efficiency than the present system. Once we realise that there is only a small proportion of our students that are likely to benefit by technical instruction, it logically follows, I think, that we should give them all the facilities for improvement we can, and with that object I would like to ask Mr. Spence if his department cannot give a little more in the way of privileges to evening students. I know of a number of works in the Birmingham district where the student, provided he can give a signed certificate that he has attended a class the night before, is allowed an hour's leave in the morning. I notice that Mr. Spence's firm admits the necessity of this, inasmuch as they grant to their senior student this privilege, but that is only one student, and if they could make it as a universal privilege it would be of great advantage. As Professor Weighton pointed out, the necessity for some such reform is borne out by Mr. Spence's diagrams, inasmuch as, leaving out the first, who is evidently an exceptional student, there is no other who has obtained any marks in evening study who has secured full time marks, and I do not think this is altogether to be as much wondered at as the professor seems to imagine. When one realises the amount of energy it takes to start at six in the morning and go on until 9.30 at night, practically without a break, one is not surprised if there is a tendency to sleep in in the morning. Whilst touching upon this subject may I put forward a claim for greater attention being given to students, especially those who work in offices, in connection with the subject of overtime. If there are any teachers here they will agree with me that technical schools are handicapped by students being unable to follow up their studies on account of the demands made upon them by overtime. Most works now make a point of not keeping any student on his class night, but this is not sufficient. A lecture delivered at a class loses half its efficiency unless followed up by another night's private study. A number of my students repeatedly apologise to me for not having done their home work on account of overtime. Under such conditions it is impossible for technical students to make that advance we desire they should all make.

And might I remind employers that technical students are not entirely composed of apprentices. Our industries are now so scientific that in most cases it seems impossible during an ordinary apprenticeship to become thoroughly equipped, and in consequence we find a number of young journeymen who are still technical students, and on their behalf I would especially plead for consideration in connection with the subject of overtime. I must apologise for taking up so much of the time of the meeting, but I am always anxious to speak on behalf of technical students. My experience leads me to believe we have in this district a number of students second to none in any other part of the kingdom, and given fair opportunities the shipbuilding and engineering industries will be in safe hands.

Mr. G. Vardy said—I have not much to add to what Mr. Spence has said in his paper. I have been associated with this subject in the same way as Mr. Spence since the scheme commenced. Mr. Spence's figures relate entirely to an engine works. My experience has been with a shipyard at Wallsend, and I have prepared a set of figures of our results for the Session 1906-7 on the same basis as Mr. Spence's curves. At Wallsend we have a member of the staff part of whose duties it is to see that apprentices attend evening classes and also to keep records of timekeeping, conduct, etc. The attendance results are got from the class teachers each week and continual absentees are sent for and talked to as may be required. We give bonuses for good marks and no boy gets a bonus who does not show some result at a class. This result need not necessarily be a pass at an examination, very regular attendance being accepted as well. Eighty per cent. of the boys in the works attended the evening classes during the last session, but from the figures I have got we only get 4½ per cent. who passed any examination in science subjects, and if we add such elementary subjects as arithmetic or mensuration then the examination results amount to about 8 per cent. of the total number of apprentices reported upon. I might add that apprentice rivetters are not included in the lists.

The total number of boys who earned bonuses amounted to about 14 per cent. Referring to what Mr. Hinchliffe has just said, I feel that I can quite sympathise with him regarding the cases where the boys are practically forced to attend, as with all the inducements we hold out to them, and where a regular attendance only is required to earn a bonus, we yet find that of the total only 14 per cent. take the trouble to do that. The improvement we have principally noticed has been in timekeeping, which has been very marked, and in plotting down the whole of the curves, mine and Mr. Spence's practically agree that the improvement has taken place at the lower end amongst what was previously the worst class of boys, and the curves generally follow a line like that indicated on his diagram.

In the more mechanical trades you get, generally, a better result of timekeeping and class work. I do not think the point raised by Professor Weighton about the value of the class marks would make a great deal of difference. Class marks do not alter the general shape of the curves. The conduct does not affect it much, the general shape being due to the timekeeping. Four-and-a-half per cent. of the boys obtaining marks will not make a great deal of difference, and I do not think that doubling the marks would add another ½ per cent. to it. A certain number of boys will study. A great part of them will not, and the remainder cannot. What we want to do is to get hold of the one or two who will and the many who cannot. The first will study in any case, and the second do not understand what study is.

Professor Weighton—There is no reason why you should handicap study.

Mr. Vardy—I do not think it is handicapped. You will find the boy who studies is good in his conduct and good in his timekeeping. My experience is based on the facts just stated, that where every inducement is offered, even financial reward given for mere attendance, such attendance is most difficult to obtain.

In running over the various trades in the shipyard you find greater tendency to study and best timekeeping among the engineers, joiners, etc., but when you get among the ironworkers you find no class marks nor fair timekeeping. Conduct, of course, is constant. A word ought to be said with reference to the great number of boys who cannot study. I do not think this is due to any physical defect, but I do think it is in a large measure due to faulty and defective teaching in the elementary schools where, in many cases, the boys are not intelligently taught, and leave school after attaining a mere smattering and no understanding of even the most elementary rudiments of education and so are quite unfitted to study fu[illegible] without an immense expenditure of energy which [illegible] life do not all.—

The SECRETARY submitted the following communications:—

SCOTIA ENGINE WORKS,
SUNDERLAND,
December 17*th*, 1907.

DEAR MR. DUCKITT,

As it is quite impossible for me to attend the meeting on Friday, and the subject of Mr. Spence's paper is particularly interesting to me, I will be glad if you will kindly submit my views thereon in writing.

The thanks of the Institution are due to Mr. Spence for bringing this matter forward so clearly, and as the results can scarcely be expected to materially improve with a longer trial, I do not consider his paper premature.

Curves A, B and C may roughly show the quality of the youths relatively to each other, but unfortunately there is nothing to show whether the extra wage earned has given any better results than obtained before the system of marking was started.

Curve A shows very moderate timekeeping, only 6 out of 65 youths get full marks, and more than half do not get 50 per cent. of possible marks.

Curve B is most unreliable, and appears to me quite unnecessary, and to some extent misleading. The foreman in the shop is always able to powerfully influence and control both the conduct and the industry of those working for him, and the mere fact of giving a boy a few extra pence per week will not have the slightest effect on the youth morally. Again, this foreman is asked to grade the boys into no less than five qualities of conduct, namely, "very good," "good," "fair," "moderate," and we must include "bad." This is beyond the skill of any man to do correctly, and further, no foreman would be so unwise as to show his department in a worse light than others, as it would reflect most seriously upon himself. It is just as likely that the improvement, if any, in the curve D′ is due to the foreman's realisation of his own position, and I certainly think marks for "conduct and industry" should be done away with as misleading. If a youth's conduct is not up to a reasonable standard he should be dismissed.

absolute failure of the Education Committee's desires. The primary object of this Institution's 1903 Education Committee was to secure increased technical education. Here again the little additional remuneration offered as an inducement to attend classes has not influenced anyone, and simply goes to prove that the mere earning of a few extra pence per week can never have any good moral effect on the boys; it is not possible to influence "character" by such means.

Compulsory attendance at evening classes is the only solution of the difficulty. For many years I have made it a condition that every boy who comes to the Scotia Engine Works, Sunderland, to serve his apprenticeship as an engine fitter, must attend science classes two nights per week during the winter months, and we look to the teachers to advise us of any who do not take proper interest in the class work. Two nights per week at a class, with possibly two nights home-work, for a youth working from 6 a.m. to 5 p.m. is no hardship, his evening work is a complete change of thought, and only operates during the winter session. The result of such an arrangement is that out of all our apprentices who have served their time with us—218 in all—

4 are in business of their own as engineers.
9 ,, managers and foremen.
5 ,, draughtsmen (2 with chief's tickets).
4 ,, chargemen in works.
4 ,, in charge of electric power stations.
7 ,, consulting engineers.
2 ,, boiler inspectors.
3 ,, in His Majesty's Navy.
3 ,, at college.
95 ,, chief engineers at sea.
38 ,, 2nd engineers at sea.
15 ,, junior engineers at sea.
3 ,, working abroad.
3 ,, in their father's business.
8 ,, deceased.
15 only are fitters and turners (mostly working with us).

218 total.

A complete list giving the names and present positions of all old apprentices is every few years posted on our works' notice board.

It will be seen from the above that compulsory attendance at evening classes has been most successful; and as every boy with his head screwed on properly would a thousand times rather have promotion in the workshop than a trifling rise in wages, I prefer to secure the best from my lads by seeing that the foremen take a proper interest in them, and encourage them by frequent and regular advancement in the workshop during apprenticeship.

Many of our members will have heard of cases where boys have been kept a couple of years at one machine simply because it entailed less work on the foremen than frequent changing, whilst other boys are doing labourer's work for a considerable portion of their time.

The interest taken in our boys is of mutual benefit to apprentice and employer. The boys get such a thorough training that they are in constant demand by inspecting engineers, and there is little difficulty in getting rid of them when their apprenticeship is completed. As employers, we command a large number of applicants, and select our boys carefully; we not only make compulsory attendance at evening classes one of the conditions of servitude, but we will not take any as apprentice fitters who have not passed into the Ex. VII. standard, or, if from a private school, are equal to this. In connection with our local colleges we have always permitted a much larger percentage of our fitting shop boys the privilege of attending the three year day course for the B.Sc. degree than any of the other large works in this district. In 1907, out of a total of 55 fitting shop apprentices, 10 were attending college on this sandwich arrangement, and as 10 is the largest number we can at present arrange for and more have passed their entrance examination and are waiting their turn, preference is given to those who secure a free studentship at our Sunderland Technical College.

The better quality lad, working under more encouraging conditions, requires less supervision, and in reply to some who seemed inclined to dismiss the whole subject by saying "it was easy to control boys in a small shop," on the ground that there were fewer boys per foreman, I have compared our 301 men and 89 apprentices with another engine works' 616 men and 173 apprentices, and find that for every £100 of wages paid to men and boys, our supervision costs us £4 14s. as against £7 3s. in the larger shop, and while this is the fairest comparison I can conceive, I see no reason to believe that there are more foremen than necessary in the larger works.

The question as to how we are to improve the quality of our engineers is of vital importance to the nation, and I am firmly convinced that a small rise in wages to the boys will never have the beneficial effect the Education Committee of 1903 desired.

Yours faithfully,

ALFRED HARRISON.

SOUTHWICK ENGINE WORKS, SUNDERLAND,

December 20th, 1907.

DEAR MR. DUCKITT,

I am sorry I am unable to be present at the reading of Mr. Spence's paper, but, in response to your invitation, I beg to offer some brief comments, based on our experience of a similar apprenticeship encouragement scheme.

I agree generally with the deductions so clearly expressed by Mr. Spence. An apprentice scheme, with its system of records, is an advantage from the employer's point of view, in giving him information as to his apprentices, and it gives the apprentice the chance of making his worth known, and those advantages alone would justify the trouble and time taken to carry it out.

Timekeeping.—I think rewards encourage the probable premium winner to adhere to his good timekeeping, but they do not materially help to general good timekeeping. The large majority of apprentices are either indifferent, or find the conditions too difficult, and their timekeeping has to be cared for by other methods.

Science Classes.—We find that a larger number of boys attend classes, and this is a gain; but there has been no increase in the number of examination passes, and the number as yet is regrettably small.

Conduct and Industry.—For the reasons mentioned by Mr. Spence, and our own experience confirms them, there is an undesirable uncertainty in the allocation of these marks, which may unduly affect the results. At the same time the reports are useful, as records of conduct, and help to keep the official in charge in touch with his apprentices. I think a fair compromise might be made by reducing the marks allowed under this heading to half, say 60, the minimum qualification marks of 180 being reduced to 150.

I send you particulars of our system, and some figures showing the results of three years' working. Our results are not so favourable as those shown by Mr. Spence, partly because our minimum qualification for premium requires 60 per cent. of the full marks for timekeeping, and is therefore more stringent, and partly because the premiums under our scheme are lower. In these respects, however, we may, after a little further experience, amend our system.

I have not included particulars of the premiums earned in other departments, as these are not included in Mr. Spence's figures, but shall, of course, be glad to give these, and any other information, if it is wanted.

Yours faithfully,
HENRY CLARK.

P.S.—Our system does not credit the apprentice with any overtime worked, although we have complaints that it is the cause of lost time in the mornings. Does Mr. Spence provide in any way for the effect of overtime worked?

APPRENTICE ENCOURAGEMENT SCHEME.

Results of Three Years' Working at the Southwick Engine Works, Sunderland.

YEAR 1904-1905.

	Number Employed.	Number Awarded Bonus.	Percentage of Number Employed.
Fitting shop	111	39	35·2
Pattern shop	20	14	70·0
Plumbers' shop ...	5	2	40·0
	136	55	40·5

YEAR 1905-1906.

	Number Employed.	Number Awarded Bonus.	Percentage of Number Employed.
Fitting shop	135	42	31·1
Pattern shop	21	11	52·3
Plumbers' shop ...	6	1	16·7
	162	54	33·4

YEAR 1906-1907.

	Number Employed.	Number Awarded Bonus.	Percentage of Number Employed.
Fitting shop	152	40	26·3
Pattern shop	22	20	90·9
Plumbers' shop ...	5	2	40·0
	179	62	34·6

TOTAL NUMBER OF MARKS ASSIGNED TO APPRENTICES IN FITTING SHOP, PATTERN SHOP, AND PLUMBERS' SHOP.

	1904-1905.	1905-1906.	1906-1907.
Timekeeping	2090	2040	2219
Conduct and ability ...	2516	2179	2583
Day classes	178	280	985
Evening classes ...	277	275	110
	5061	4774	5897

AVERAGE NUMBER OF MARKS PER QUALIFIED APPRENTICE.

	1904-1905.	1905-1906.	1906-1907.
Timekeeping	38·00	37·80	35·8
*Conduct and ability ...	45·75	40·42	41·6
†Day classes	3·24	5·19	15·9
Evening classes ...	5·03	5·09	1·8
	92·02	88·50	95·1

AVERAGE TIME AND CONDUCT MARKS PER APPRENTICE (BASED ON TOTAL NUMBER EMPLOYED IN WORKS).

	1904-1905.	1905-1906.	1906-1907.
Timekeeping	15·4	12·60	12·40
Conduct and ability ...	18·5	13·45	14·30

NUMBER OF APPRENTICES RECEIVING MARKS FOR CLASS RESULTS.

	1904-1905.		1905-1906.		1906-1907.	
	Day.	Evening.	Day.	Evening.	Day.	Evening.
Fitting Shop	—	7	2	7	4	2
Pattern Shop	1	2	1	1	1	2
Plumbers' Shop ...	—	—	—	—	—	—
Total	1	9	3	8	5	4

* The average number of marks for conduct and ability should have been considerably larger for the year 1906-1907, as the scheme was modified to the advantage of the apprentice.

† These are the marks assigned to those apprentices who competed successfully for studentships at the Technical College, namely:—1904-1905—Currie; 1905-1906—Currie, Duncanson, Sutcliffe; 1906-1907—Currie, Duncanson, Sutcliffe, Snowball, Bentham.

Scheme for Encouragment of Apprentices.

Messrs. George Clark, Ltd., Southwick Engine Works, Sunderland.

1.—With the object of encouraging Technical Education and advancement of Apprentices employed at these Works, it has been decided to award marks each year, commencing from September, 1904. These marks will be apportioned as follows:—

A.—For good time-keeping, maximum 60 marks.

One mark will be deducted for every three hours lost time.

No marks will be deducted when an Apprentice is absent with leave, or when a certificate is produced, from some responsible person, proving illness.

B.—For progress and general ability in the Shops, 60 marks maximum. These marks will be awarded in accordance with reports furnished by the Foremen.

*C*1.—For each approved Science and Art Examination in Engineering Subjects marks will be awarded according to the following scale:—

Honours Stage	1st Class,	80	marks.
" "	2nd "	60	"
Stage III.	1st "	50	"
" "	2nd "	40	"
Stage II.	1st "	25	"
" "	2nd "	15	"
Stage I.	1st "	10	"
" "	2nd "	5	"

*C*2.—Should the Apprentice be attending the Technical College, marks for positions in class lists at the Local Examination (Evening Classes) will be awarded as follows:—

1st	Class in any	D	Class ...	100	marks	*maximum.*
2nd	"	D	" ..	80	"	"
3rd	"	D	" ...	60	"	"
1st	"	C	" ...	60	"	"
2nd	"	C	" ...	45	"	"
3rd	"	C	" ...	30	"	"
1st	"	B	" ...	30	"	"
2nd	"	B	" ...	20	"	"
3rd	"	B	" ...	10	"	"

For 1st Class in A College Classes, or in Local Institutions (such as Y.M.C.A., Hendon Church Institute, Hudson Road, etc.) where the Examination is held under College supervision ... 10 marks.

For 2nd Class do. ... ... 5 "

NOTE 1.—The marks in group $C2$ are the *maximum* obtainable for those Examinations, and include an allowance for regularity of attendance and home-work, consequently full marks can only be obtained in this section by success in home-work and good attendance, as well as success at the Examination.

NOTE 2.—GROUPS OF STUDIES.

Advanced and Honours Students are advised to take complete groups of five subjects, all to the same grade, as given in the College Evening Prospectus, for certificate courses. Those students who are successful in passing these groups of subjects will receive a bonus of 50 marks.

II.—APPRENTICE STUDENTS.

Apprentices who obtain a free studentship under the Techical College Scheme will be allowed for time-keeping 30 marks aximum, and for good progress in Works 30 marks maxium, and marks for College work will be awarded on conideration of the results obtained by the student, an allowance eing made for regularity of attendance, etc., at the College.

Those Apprentices who enter for the Annual Open Competion for Apprentice Studentship will be allowed a bonus of not ore than 25 marks if their papers are sufficiently well reported n.

III.—Apprentices will notice that the marks for Evening lasses are proportioned in such a way as to encourage more specially attendance at the Technical College and the Technical ollege Examinations; and also to encourage a systematic course f education by giving a bonus to those Apprentices who take the groups" of subjects advised in the Technical College Prosectus.

Marks will only be given for Examinations passed in the curent year, except in the case of those students who take the onours or D Classes, having already passed the Advanced or C age in some previous year; such students, in case of failure to ass the Honours Examination, will be allowed to count the arks they earned previously at the Advanced or C Examinaions. This is done with a view to encouraging Apprentices to ke the higher courses of study.

Students will be expected to show improvement each year in the results of their Examinations, and the full marks allowed for any given pass can only be obtained in one year. Should the student only succeed in obtaining the same pass a second time, the marks obtainable will be reduced by 10 per cent.

IV.—A bonus at the rate of £1 per 100 marks gained will be paid to all Apprentices who obtain not less than 60 per cent. of the possible marks for timekeeping.

Apprentices will be refunded the amount of fees paid by them for Approved Evening Technical Classes on production of the Teacher's certificate that their attendance has been within 20 per cent. of the possible number of attendances.

Special consideration will be given to the applications of those Apprentices obtaining the best results during their apprenticeship, with reference to admission into the Drawing Office, and promotion in the Shops.

Apprentices attending Evening Classes will not be required to work overtime on Class evenings.

Apprentices who fail to obtain any marks for timekeeping will be liable to dismissal.

The Firm reserve the right to modify or withdraw this Scheme.

St. John's College, Cambridge,
December 19th, 1907.

Dear Mr. Duckitt,

It gives me much regret that I am unable to be present at the meeting next Friday to join in the discussion of a subject of such exceptional interest and importance. Mr. Spence cannot be praised too highly for his systematic and scientific way of grappling with the question of engineering education. It is only by carefully tabulating actual results as he has done that a departure can ever be made from the chaos in which everyone considers his own idea the obvious settlement of the matter and cannot understand why other people will not see it too.

One or two points are especially suggestive. What was the school education of the better lads? In most cases that have come under my personal notice the lads who did well at evening classes were those who had stayed rather longer at school and obtained somewhat of a grounding in mathematics and science;

and, which is of much greater importance, somewhat also of the art of learning. For it is just about the age of sixteen that this begins to be acquired. One especially notices the superior education of Scotch lads and this no doubt largely accounts for their success. I have been astonished to find that an ordinary Scotch fitter had gone quite far when at school in such subjects as Latin, Algebra, Euclid, Physiology, etc.

This is an important point. We want to know whether staying on late at school means an ultimately more intelligent *man*; whether it means a more or less highly skilled *workman*, and what steps are to be taken to keep the right boys longer at school?

This also introduces the question of a systematic scheme of evening classes. Would it not be possible for the Education Committee of this Society to sanction one or two definite courses of study, starting from the first year of apprenticeship, in continuation of the school course? There might be two or three grades according to the level of attainments of the lads when they start. The course to be followed by any one student could be determined by a qualifying examination, leaving certificate or something of the kind. These courses might not be rigidly adhered to, but at least they would serve as a guide for the lad who does not know what to take. As things are, he selects at random from those classes which have the most practical names and two or three years later finds that he has missed the grounding necessary to tackle the more difficult subject.

The only other point is that I am inclined to value the effect of evening classes for the less capable lad more highly than Mr. Spence. The subject usually chosen by these is machine design and does a great deal to train their observation of the things around them: making them better workmen, although they may never have the character to rise to the highest positions.

Yours faithfully,

HAMMOND B. JENKINS.

The discussion was adjourned.

The meeting was dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWENTY-FOURTH SESSION, 1907-1908.

PROCEEDINGS.

THE THIRD GENERAL MEETING OF THE SESSION WAS HELD IN THE LECTURE THEATRE OF THE LITERARY AND PHILOSOPHICAL SOCIETY, WESTGATE ROAD, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, JANUARY 10TH, 1908.

W. H. DUGDALE, ESQ., M.INST.C.E., PRESIDENT, IN THE CHAIR.

THE LATE MR. ROBERT THOMPSON.

The PRESIDENT said—Before commencing our business this evening, I feel that I shall only be expressing the very deep regret of this Institution, in recording our sympathy with the family of the late Mr. Robert Thompson, upon his death. You will remember he was one of the founders and one of the first members of this Institution. I need hardly tell you how this Institution originated; how a letter, which was written to the papers by a gentleman who is among us this evening, was afterwards followed up by meetings held in Newcastle and Sunderland, and that Mr. Robert Thompson, and one or two others present to-night, attended the Sunderland meeting and supported the scheme. He was, therefore, one of our first members, and I do not think that any member has taken a more deep and real interest in the well-being of the Institution and the welfare of its members than Mr. Thompson. He was, as you know, the fifth President of the Institution, from 1892 to 1894, and those of us who are members of Council deeply regret the loss of one who has been of great assistance to us in our deliberations, and I think few of us sufficiently realise the deep and continuous interest which he has taken in this Institution; and not only in the Institution itself, but also in the associations and institutions with which we are more or less associated. For instance, Mr. Thompson was one who took the deepest and most active interest in promoting and founding the Chair of Engineering at Armstrong College, and rendered not only personal, but financial, assistance, in order to obtain the experimental engine and boiler, and all the necessary apparatus for the engineering laboratory. There have been very few members who have been so ready at all times to lend a helping hand, financially and otherwise, towards the interests and well-being of this Institution. Unfortunately, "the evil that men do lives after them: the good is often interred with their bones." I hope, however, in this case the converse will prove equally true, and the good Mr. Thompson has done, not only to the Institution, but also to the industry with which he was connected, and the various scientific institutions with which he interested himself, will act as an incentive to us who are still working on, to follow in his footsteps.

The President's remarks were acquiesced in by the members present rising to their feet in silence.

The SECRETARY read the minutes of the previous meeting held in Newcastle-upon-Tyne on Friday evening, December 20th, 1907, which were confirmed by the members present, and signed by the President.

The discussion on Mr. J. H. Heck's paper on "The Effect of Work and Time on the Properties of Mild Steel and Iron" was r med and closed.

d ıssion on Mr. W. G. Spence's paper on "Notes fro s' Working of the Educational Committee's Recor ns" was resumed.

. H. R. JARVIS read a paper on "Floating Docks."

RESUMED DISCUSSION ON MR. J. H. HECK'S PAPER ON "THE EFFECT OF WORK AND TIME ON THE PROPERTIES OF MILD STEEL AND IRON."

The PRESIDENT said—With reference to the adjourned discussion on Mr. Heck's paper, we have a short communication from Mr. James Sibun, Jun., who, by permission, spoke at the last meeting. You will remember that three or four gentlemen spoke afterwards upon the corrosion of steel, and I asked Mr. Sibun if he had anything to say on that subject, as he did not touch upon it in his remarks, and he has sent us a small communication.

The SECRETARY read the following communication from Mr. Sibun:—

54, LINDEN ROAD, GOSFORTH.
January 8th, 1908.

DEAR MR. DUCKITT,

I should just like to add a few words to my remarks regarding the difference between the effect of corrosion on iron and steel.

Both metals being subjected to the same corrosive agent, it may be expected that in the case of steel, with the exception of surface irregularities, the corrosion will proceed fairly uniformly from that surface, *i.e.*, the point of attack is from the surface only. Not so in the case of puddled iron; this not only possesses surface irregularities, but these lead to innumerable cavities (most of them filled with porous slag), which permeate the whole mass of the iron, and once corrosion is well started, it goes on, not only from the surface, but also from each cavity which may have become saturated with the corrosive liquid.

I think this will explain the reason that Mr. Heck obtained such bad results from his old iron tests, and goes to prove what I said before, that even if steel did corrode quicker than iron, we have, at any rate, something left which is relatively as good as the original material, whereas in the case of iron it is a brittle and useless mass.

Yours faithfully,
JAMES SIBUN, JUN.

The discussion was closed.

MR. HECK'S REPLY.

Mr. J. H. HECK, replying to the discussion, said—I must thank Mr. Boyd for his remarks and the interesting information he gave. It is very satisfactory to know that the first vessel built in this district entirely of mild steel, although 30 years old, is still afloat, sailing from Gothenburg, and that the first boiler built in this district of mild steel by Mr. Boyd's firm enjoyed a long life and lasted for 23 years. These facts are all the more gratifying when it is remembered that the scantling for both the vessel and the boiler was considerably less than that required for iron. None the less striking was Mr. Boyd's quotation in regard to the difference in size and price between the early mild steel plates and those of the present day, or the comparison he made as to the increase of tensile strength between the steel boiler plates of the "Ruth" and those of the "Mauretania."

In regard to Mr. Twaddell's remarks, I am unable to say anything new concerning rivet attachments, or as to the effect of time on iron and steel rivets. In boilers which have been working under high pressures for many years, it is remarkable how tight the joints are kept by steel rivets; they seem in this respect, under severe conditions, to be superior to iron rivets. To build steel boilers with iron rivets would, in my opinion, raise the rate of corrosion and reduce the tightness of the joints. The rest of Mr. Twaddell's remarks were most interesting, but need no comments on my part.

Corrosion.—I am practically in agreement with Mr. James and Colonel White, the difference between us is only one of detail and degree; it refers to the passage in my paper on page 32, "a half-inch plate of steel, if the conditions are similar appears to withstand corrosion just as well as a half-inch plate of iron." Colonel Wright says very rightly, that I would have been perfectly safe if I had added, where the steel is "properl[y] looked after and properly protected." Of course, this is quite true, and steel ships so treated will not cost much, even over long periods, for repairs due to corrosion; none the less it [is] also true that the omission of such treatment has to be paid f[or] in iron as well as steel structures.

I can only reply to the points on corrosion in a brief a[nd] general way. Its action is due to chemical and mechanic[al] causes, acting either singly or together, the effects being different in appearance, under varying conditions, such as work, temperature, vibration, buckling and other causes. When tested by the light of careful research and patient observation, it is difficult to uphold the tradition which has been touched upon, that mild steel corrodes more quickly than iron, and for that reason, ever since it was started some 30 years ago, the great majority of scientific men have been against it, and have held that the corrosion between the two metals is not very different and that discrepancies could be explained because the conditions were not similar, nor the comparison free from interfering circumstances. The comparative rates of corrosion of the two metals iron and steel is a subject which has occasioned much discussion and experimental work, but never with very satisfactory or conclusive results. There is often more difference in the rates of corrosion of two different iron plates than in that of a steel plate and an iron plate.

In order to study the law of corrosion you must have similar conditions; a little difference in the conditions may cause a much greater difference in the results. Experiments made in a house or laboratories give different results to those made on a ship. The results obtained from suspending a piece of iron or steel in a boiler or ballast tank are different to those which would be obtained if the same material formed part of the boiler or tank and had work to do.

Form and dimension has also influence as well as work. In a bunker a plain angle will not withstand corrosion, wear and tear and hard conditions so well as if the same material was made into a bulb angle. Sharp surfaces and lines invite corrosion; they can also not be painted. A thin plate attached to frames 20 inches apart will not corrode nearly so much as if attached to frames 26 inches apart. A thin sheet of iron or steel of rectangular or square form, if it has work to do, will not stand corrosion so well as if the same material was rolled into the form of an ordinary tin canister, having a bottom at one end and a cover at the other. In the same way the shell of a cylindrical boiler will not corrode nearly so much as if the same material was made up into a rectangular form of boiler as was common years ago. The higher the tenacity of the iron or steel the better it appears to withstand corrosion.

It is often misleading to judge at first sight the relative corrosion between thin and thick material, such as a thin corroded steel plate and a somewhat thicker corroded iron plate. While the amount of loss by gauging may be found equal in both cases, to even the trained eye, at the first glance, the thin material appears to have suffered to a greater extent. If two plates are taken, respectively one-quarter of an inch and one-half inch in thickness, and both lose one-eighth in thickness, the loss in the thin plate will be 50 per cent. and in the thick plate only 25 per cent. The eye at once detects this and receives the impression that the thin plate has suffered most; the actual loss of material, however, in amount and weight, will, of course, be the same in both cases. Some poor material which is called iron is only partially iron, as it contains a large amount of non-metallic impurities such as cinder and slag. The effect of work and time upon such material appears to impair the properties of the metal it contains and to make it unreliable, while it may not appear to waste so much as material of fair or good quality; the waste, although not apparent to the eye, is none the less there.

All my observations have led me to form the general opinion that steel or iron of good quality and of equal thickness, if the conditions are similar, will withstand corrosion equally as well. Thin material, whether iron or steel, if it has work to do, owing to its greater flexibility, will corrode to a greater extent and at a more rapid rate than thicker material. For the same reason thin material, whether iron or steel, under the same condition, is more liable to corrosion than thicker material, because it is more difficult in the case of thin material to keep the surface covered or protected. Thickness of material, therefore, for more reasons than one, either for iron or steel, is an important factor in all structures subject to corrosion or wear and tear. It is also, therefore, not correct to compare either the amount or rate of corrosion of a thinner steel material with that of a thicker iron material; if the comparison is to be accurate, it should be made with material of equal thickness, and it is on such comparison that the statement made in the paper is based.

It is known that when corrosion is allowed to take place in a vessel it is usually confined to the weather deck plates, the inside of the bunker and the double bottom just under the boiler, and the reason why this is so is well known and has often been pointed out. In such parts, if no effort is made to cope with or stop its progress, especially in the early stages of a vessel's life when, owing to the shedding of the mill scale, a little care and attention is of the most use, then corrosion, in some cases much corrosion, is bound to take place, and it would be a miracle if it did not do so. In such cases and in such places, if the steel scantling is of less thickness than the iron scantling, it follows, for the reason already given, that corrosion will go more rapidly through the thinner steel material. If, however, the scantling, whether iron or steel, is of equal thickness, then it will take corrosion just as long to go through either, and the amount and rate of wasting will be practically equally the same in both cases.

Colonel White has told us it is difficult and troublesome to get iron of good quality. That difficulty will increase in the future, and for that reason, before many years are over, vessels will be made entirely of steel. When that time comes, parts which are now sometimes made of iron will also no doubt then have iron thickness.

In regard to marine boilers there is no need to say much; in my opinion it would be a waste of time to do so. Time has clearly shown that the corrosion in a marine boiler made of steel is less than that which took place in marine boilers when made of iron. The greater life of the modern marine boiler is at all events partly due to the material of which it is made, to its form and to the thickness of its scantling. Steel as a material is now almost exclusively used for the great majority of all kinds of boilers.

Mr. Morison's contribution is most useful. I share his opinion in regard to ordinary scrap iron shafts. He is quite right; if a shaft is to be of iron it should be made of manufactured iron of good quality and of a known brand. Such a shaft is more to be relied on; it is an open question and there is a difference of opinion. I believe, however, that before long all shafts will be made of ingot steel. It was very gratifying to hear Mr. Morison, in reference to the material of old steel furnaces, make the remark that he had tested the steel repeatedly and had never come across a single case which deviated to any appreciable extent from the original tests.

Mr. Shaw stated that stringer plates corrode less than deck plates; the reason is simple, stringer plates are always thicker, therefore the amount and rate of corrosion is less. Mr. Shaw also stated that while taking decks as an example, his remarks were also intended to apply equally to all other parts of the ship; I agree with him. Take his illustration of a partial awning deck, with steel decks ·3 inch thick, and an iron deck ·375 inch thick; he tells us he has always found the diminution is *pro rata* to the original thickness. That does not differ much from my experience, that with equal thickness the amount of corrosion is practically the same with either material.

Mr. Hobson is no doubt right, that with some feed waters iron may be better for locomotive boilers; they are, however, exceptional cases and do not alter the fact as stated by himself, "the steel locomotive boilers are in a great majority." The iron he showed us is good material and somewhat different to the iron referred to by Mr. John in this room in 1881, at the meeting of the Institution of Mechanical Engineers. In regard to the best material for locomotive crank pins, that is not touched upon in my paper and I do not care to discuss it now. Mr. Hobson is a young man, and I believe that the members generally much appreciated his action in taking part in the discussion, and I hope he will do so again. In my opinion, a young member misses a good chance of lifting himself out of the ordinary rut and making himself known and felt, if he omits to take part in the discussions of this Institution.

I am generally in agreement with what Mr. Sibun said. I must thank him for the tables of results he has given us in regard to tests of high tensile steel; I believe they will be of interest and value to the members.

In reply to Mr. Spence, in a marine boiler the short screw stays have to withstand other strains than those of a purely tensile nature; iron stays, if fitted, require to be of a larger diameter than steel stays; in such cases I would prefer iron stays. If, however, the short screw stays were made of steel and of the same diameter or section as required for iron ones, then I would strongly recommend the shipowner to have the steel stays; they would do more service in many ways.

I do not share the views of Messrs. Andrew and Tocher; in my opinion they are not in accordance with careful and patient observation.

Mr. Landreth's experience, as stated in his letter, agrees much more closely with what I hold time has shown to be sound.

The paper was only intended to deal with constructional work, such as the hulls of vessels and their boilers, and the tables confirm this view. The discussion, however, has travelled over a wide range of subjects, such as the best material for bolts of reciprocating engines for torpedo destroyers; lap-welded and other tubes for locomotive and other boilers; the relative welding properties of steel and iron, and other subjects foreign to the tenor of my paper. It is manifestly impossible for me to deal with such important matters in a reply to my short paper. If I might venture to suggest, it would be that papers should be given by the various gentlemen on such points, stating their views and the reasons for their views; the subjects could then be discussed in a complete and suitable manner.

I have again to thank those gentlemen who took part in the discussion, and also those who so kindly helped to make the many tests which formed the basis of the paper.

On the motion of the PRESIDENT, a hearty vote of thanks was accorded by acclamation to Mr. J. H. Heck for his interesting paper.

RESUMED DISCUSSION ON MR. W. G. SPENCE'S PAPER ON "NOTES FROM FOUR YEARS' WORKING OF THE EDUCATIONAL COMMITTEE'S RECOMMENDATIONS."

Mr. D. B. MORISON said—I have read Mr. Spence's paper with great interest and was particularly struck with the fact that the percentage of boys obtaining a position under the scheme was practically identical with that at Hartlepool, namely, round about 40 per cent. The Apprentice Advancement Scheme was introduced at the Hartlepool Engine Works in October, 1902, and is set forth below, together with a tabular and diagrammatic report for 1907 (Plate XII.). There are two leading features in these results, namely, the small number of boys gaining a high range of marks and the absence of any evening class work in a large number of departments, such as the foundries, boiler shop, lathe shop and smith shop. On making enquiries as to the cause of the latter, I was informed that the boys stated that the evening class work was so difficult that they were discouraged, and gave up attending. So, with a view of testing the accuracy of this statement, and also of encouraging these boys to take some little interest, I arranged for a special examination in simple arithmetic and writing to be held at the works. The boys who passed were each credited with 20 marks, so that a boy in the foundry, for example, who passed this examination and also obtained full marks for timekeeping and conduct would be entitled under the scheme to a weekly addition of tenpence to his pay for a whole year.

Mr. F. H. R. Alderson, Headmaster of the Grammar School, Hartlepool, very kindly offered his services as examiner, and notices were posted in all the departments of the works setting forth the conditions, one of which was, that twelve attendances should be made at some evening class in the town, equivalent to, say, 12 hours per annum. I was gr tly sur to find only nine presented themselves for this disappointed that only two obtained the pass, but with the object of stimulating some enthusiasm, we passed every boy. The following year our Works Manager, Mr. Kennedy, arranged with the various chiefs of departments to interview some of the likely boys and do all they could to make the examination a success. The result was that there were fourteen applicants, or five more than the previous year. Last year the usual notices were posted in the works; there were, however, only two applicants, one of whom was disqualified. We have in the works 369 apprentices, and of these 40 per cent. or 147 obtained positions under the Advancement Scheme, but only 10 per cent. obtained marks for evening classes. The remaining 60 per cent., or 222 boys, were all eligible for the works elementary examination, and yet last year only one boy qualified.

When in Germany some time ago I was shown over the very large works of Messrs. Thyssen & Co., of Mulheim, and in reply to an enquiry as to how many boys attended evening classes in the winter I was informed that fully 90 per cent. went to some class or other. At these Mulheim works the manufacture of boiler plates, boiler furnaces, sheet steel, band steel and the like is carried on, so that they are more akin to steel works than they are to the works of Messrs. Richardsons, Westgarth & Co., Ltd. I have no idea how many boys from the local steel works attend evening classes, but I should assume the number would be practically nil.

From a technical educational standpoint, my original enthusiasm has been modified into hopefulness, and we have decided to continue the scheme, which last year involved an expenditure of £210, and as time goes on perhaps the boys will realise that on the manner in which they spend their time during their apprenticeship will largely depend their success hereafter.

There is another phase of this scheme, however, apart from the educational uplifting of the boy, namely, the effect it has on the internal economy and discipline in the works, and I will leave Mr. Kennedy, the works manager at Hartlepool, who has taken a great personal interest in the scheme since it was inaugurated to relate his experience and give you his views. Mr. Kennedy will tell you that from a works management point of view the scheme has been a great success, and that is also my opinion.

ADVANCEMENT OF APPRENTICES.

The following scheme for the advancement of apprentices employed at the Hartlepool Engine Works was adopted as from October 1st, 1902.

At the end of September in each year, each apprentice is awarded marks as follows:—

For each approved examination in Science or in Practical Mathematics passed during the year	20 marks.
For each approved examination in Science or in Practical Mathematics passed during the year: advanced stage—first class	40 marks.
For time-keeping, a maximum of	40 marks.
For good conduct, perseverance and progress in the workshops, a maximum of	40 marks.

Marks for time-keeping will be deducted at the rate of one mark for every three hours lost, but no deduction will be made for special leave, or for sickness if certified by a doctor.

Conduct marks are awarded by the chief foremen of departments on the following scale:—

Very good ...	40 marks.	Moderate ...	10 marks.
Good	30 marks.	Bad	Nil.
Fair	20 marks.		

An apprentice obtaining 60 marks has the sum of sixpence added to his weekly rate of pay for the ensuing year, and for marks in excess of 60 his rate is proportionately increased.

FOR EXAMPLE.—An apprentice passing in two Science subjects at the Evening Science Schools in May is entitled to 40 marks; for very good time-keeping during the past year, 40 marks; and for general good conduct, perseverance and progress in the workshops, a maximum of 40 marks; total 120 marks. This entitles him to an increase of one shilling per week on his rate of pay from October 1st in each year, for one year only, but payments under this scheme cease on the termination of apprenticeship or on dismissal.

Should an apprentice obtain say 30 marks for time-keeping, and 40 for good conduct, perseverance and progress, or a total of 70 marks, his rate of pay is increased sevenpence per week, and so on.

No payment under this scheme is made to apprentices obtaining less than 60 marks, and apprentices who fail to obtain any marks for time-keeping, good conduct, perseverance and progress are subject to dismissal.

Apprentices commencing their apprenticeship between October 1st and March 31st are entitled to half rates only for their first year for good conduct and time-keeping.

Promotion in the workshops and admission to the drawing office will depend on marks obtained.

RICHARDSONS, WESTGARTH & Co., LTD.

D. B. MORISON, Managing Director.

RICHARDSONS, WESTGARTH & CO., LTD.,

HARTLEPOOL ENGINE WORKS.

APPRENTICE ADVANCEMENT SCHEME.

LIST OF SUCCESSFUL APPRENTICES FOR THE YEAR ENDING SEPTEMBER, 1907.

Those marked * commenced their Apprenticeship between October 1st and March 31st, and are entitled to Half-rates only for Good Conduct and Timekeeping.

NAME	MARKS.			Advance in Pence per Week.
	Time-keeping and General Conduct.	Science Classes.	Total.	
Drawing Office—				
W. Alcock	71	20	91	9
F. Morley	75	...	75	7
W. Daughtry	69	...	69	6
Electrical Dept.—				
H. Beyer	77	120	197	19
A. Davidson	80	...	80	8
E. Hardy	71	...	71	7
W. Duncan	60	...	60	6
C. Smith	60	...	60	6
Turbine Dept.—				
G. Dormand	47	40	87	8
J. B. Willis	66	20	86	8
T. Carter	80	..	80	8
H. Mirams	64	...	64	6
Pattern Shop—				
A. Maclean	64	80	144	14
R. Leffage	56	60	116	11
B. Wileyman	56	40	96	9
T. Martin	75	20	95	9
E. Kirby	80	...	80	8
J. Charlton	76	..	76	7
A. Jones	67	...	67	6
M. Longstaff	65	..	65	6
W. Kydd	64	...	64	6
T. Carr	44	20	64	6
C. Bowden	64	...	64	6
Machine Shop—				
J. Allen	80	...	80	8
C. Wood	77	...	77	7
J. Addison	74	...	74	7
C. Watt	68	...	68	6
F. Wanley	68	...	68	6
A. Lund	67	...	67	6
H. Relton	62	...	62	6
E. Sargeant	60	...	60	6
T. Brackstone	60	...	60	6
J. Todd	60	...	60	6
*R. Coverdale	80	...	80	3
*L. Gillen	73	...	73	4
*W. Lawson	64	...	64	4

APPRENTICE ADVANCEMENT SCHEME—*continued.*

NAME.	MARKS.			Advance in Pence per Week.
	Time-keeping and General Conduct.	Science Classes.	Total.	
Fitting Shop—				
G. Stevenson	64	80	144	14
E. Donkin	60	60	120	12
C. Pounder	70	40	110	11
W. Hobbs	47	60	107	10
W. Stoddart	62	40	102	10
S. Winpenny	70	20	90	9
A. Rickson	67	20	87	8
G. Ramsay	67	20	87	8
E. Dale	65	20	85	8
F. Pinder	65	20	85	8
J. Cook	60	20	80	8
A. Jenner	60	20	80	8
J. McBrooker	31	40	71	7
N. Graham	70	...	70	7
R. Lamb	70	...	70	7
A. Butcher	69	..	69	6
E. Carroll	67	...	67	6
R. Warren	67	...	67	6
A. Spence	66	...	66	6
A. Smurthwaite	66	...	66	6
F. Thompson	64	...	64	6
G. Nicholson	63	...	63	6
A. Richardson	62	...	62	6
W. Payne	60	...	60	6
J. Evans	60	...	60	6
T. A. Dale	60	...	60	6
J. Watson	60	...	60	6
J. Spence	61	...	61	6
*V. Burns	30	100	130	11
*T. Heads	72	20	92	5
*W. Hester	78	...	78	4
*E. Browell	67	...	67	3
*A. Reynard	64	...	64	3
*G. Parkes	61	...	61	3
*W. Leighton	61	...	61	3
*A. Metcalfe	60	...	60	3
Erecting Shop—				
R. G. Rossiter	80	80	160	16
T. Lamb	69	40	109	10
T. Hart	67	40	107	10
O. Hopps	64	40	104	10
R. Hotham	53	40	93	9
F. South	31	60	91	9
S. Robinson	28	60	88	8
W. Ritchie	40	40	80	8
H. Wallace	57	20	77	7
W. Adamson	34	40	74	7
A. Bowe	70	...	70	7
C. Rickson	70	...	70	7
J. Cassidy	48	20	68	6
B. Metcalfe	66	...	66	6
H. Smith	66	...	66	6
C. Peters	25	40	65	6

APPRENTICE ADVANCEMENT SCHEME—*continued.*

NAME.	MARKS.			Advance in Pence per Week.
	Time-keeping and General Conduct.	Science Classes.	Total.	
Erecting Shop—continued.				
H. Porteous	65	...	65	6
W. Harrison	64	...	64	6
T. Warrand	64	...	64	6
J. Shepherd	63	...	63	6
A. Brown	63	...	63	6
J. Frain	62	...	62	6
F. Prentice	62	...	62	6
R. Stead	61	...	61	6
J. Waites	60	...	60	6
T. Reed	60	...	60	6
A. Prentice	60	...	60	6
*J. Mackey	66	...	66	3
Outside Erecting Dept.—				
T. Broadhead	71	...	71	7
Brassfinishing Shop—				
H. Monaghan	76	...	76	7
G. Newson	73	...	73	7
N. Hall	68	...	68	6
A. Parkes	66	...	66	6
E. Lee	65	...	65	6
G. Taylor	60	...	60	6
*F. Summers	80	...	80	4
*G. Nelson	69	...	69	3
Millwrights—				
Joe Davison	75	...	75	7
Jas. Davison	70	..	70	7
G. Smith	67	...	67	6
E. Atkinson	63	..	63	6
*J. Tyson	61	...	61	3
Boiler Shop—				
J. Reeves	60	40	100	10
T. Naisbitt	80	...	80	8
J. Young	69	...	69	6
W. Martindale	68	..	68	6
A. Davison	66	...	66	6
O. Frampton	63	...	63	6
H. Macklam	63	...	63	6
A. Cairns	63	...	63	6
M. Low	62	...	62	6
J. Ingram	61	...	61	6
W. Garvey	61	...	61	6
Smith Shop—				
J. Shingles	60	..	60	6
Iron Foundry—				
G. Sayers	74	...	74	7
W. Goodwin	72	...	72	7

Apprentice Advancement Scheme—*continued.*

Name.	Marks. Time-keeping and General Conduct.	Marks. Science Classes.	Marks. Total.	Advance in Pence per Week.
Iron Foundry—continued.				
W. Lee	71	...	71	7
T. Elliott	66	...	66	6
M. Wall	66	...	66	6
R. Horsley	66	...	66	6
G. Day	63	...	63	6
J. Hunter	63	..	63	6
A. Cappleman	62	...	62	6
C. Byers	61	...	61	6
W. Bage	60	...	60	6
*P. Bastow	67	...	67	3
*J. Burns	65	...	65	3
*A. Piller	63	...	63	3
*E. Mayes	62	...	62	3
*H. Ord	61	...	61	3
*W. Goodall	60	...	60	3
Brass Foundry—				
G. Calvert	80	...	80	8
T. Tongue	75	..	75	7
W. Lovatt	73	...	73	7
*E. Guy	74	...	74	4
*E. Bage	65	...	65	3
Copper Shop—				
J. Simpson	78	...	78	7
S. Chappell	68	...	68	6
T. Kirk	62	...	62	6
F. Copeland	60	...	60	6

Mr. W. Kennedy said—Reports about the Apprentice Ad-ıcement Scheme, which have, from time to time, reached those ›st interested in the question, have raised doubts as to its ›bable ultimate success. I hope that by the time we have ched the end of the discussion on Mr. Spence's valuable ›er the doubters will have been replaced by enthusiastic sup-·ters.

Now, having had, from a works manager's standpoint, five ırs' experience of the scheme, I am in a position to affirm that, any rate, so far as the Hartlepool Engine Works are con-·ned, and judging by the recorded results of Messrs. Clarke, Sunderland, and by Mr. Spence's paper and diagrams, all of ıich practically coincide with our own results shown in the ıgram (Plate XII.), the scheme is eminently successful, and is the present time doing good work.

The success or failure of the best scheme in the world depends very largely upon those who have to work it. As a nation we are possessed of a superabundance of innate conservatism and our respect for old things is only equalled by our contempt for new. We look with a friendly eye on the old plan and with suspicion on the new. The old plan is held on to, by a few, till the new has given it its last kick and its quietus.

The scheme which is a necessity will, if properly worked, be a certain success, and *vice versa*, when it becomes a success it is also a necessity. To the works manager and his staff in the Hartlepool Engine Works it has become a necessity and is therefore a permanent success. The scheme was formulated and first tried in the Hartlepool Engine Works five years ago. We were convinced from the outset that in it we should find much relief from those chronic worries inseparable from the management and control of large bodies of apprentices, and which, under the strain of present day workshop conditions, had become well nigh insupportable. Under the old system or negation of system, to be more proper, rewards, promotions and punishments were administered in an entirely promiscuous and irresponsible fashion. Apprenticeships were began and ended and the boys rarely ever came under the notice of the managers; influence was allowed to do its deadly work; mediocrity was hoisted into positions which should only be reached by merit; brilliant boys escaped reward and wasters escaped punishment.

The adoption of the Advancement Scheme has changed all this. It has raised the question of training of apprentices from a position of obscurity to one of great prominence since it has had, and will, I believe, have more, attention in the future, at the hands of this important Institution. The scheme compels attention from the works manager and his staff in their dealings with the apprentices, and one finds one's interest in each individual apprentice increasing, because both you and he are tacked on to this scheme, and one gets a closer acquaintance with them. All questions of discipline, promotion and punishment are settled in relation to the scheme, the management and the apprentice. Thus the scheme grows in strength and becomes daily more helpful. Under this scheme there is no escape for the waster; he gravitates under its operation towards the inevitable sack. Whilst, on the other hand, and this is one of the brightest and most cheering results, the door to every department in the works and office has been opened to the one who is anxious and determined to get on. These boys know by their position on the published list that they are entitled, in so far as vacancies occur, to a move into other departments and their applications are granted at once. Obscurity knows them no more; their names come before the highest members of the works and office staff and not infrequently they reach the managing director. The impersonal character of the scheme brings immense relief. Applications to be moved up, in works where there are such a large number of apprentices as ours, from boys and their parents are many and continuous. Many of you are acquainted with the difficulties of dealing with these matters and know how difficult it is to deal out evenhanded justice to all. One is granted something which has been withheld from another and so discontent, which cuts at the root of discipline, is engendered; trouble brews and breaks out, all of which make trouble and worry for the works manager. Now, under this scheme how easy all this is dealt with. Am I interviewed by a boy with a request for a move, the first question —Is your name on the list of successful apprentices?—settles the business. If the answer is in the negative they are told that if they succeed during the next twelve months and get their name amongst the successful boys, to come to me again, but in no case to come if their name is not on the list.

These decisions have always been taken by the boys in the best possible spirit; they appear to realise that it is not personal between themselves and their foremen or the management, and accept the responsibility which the scheme generally, and these decisions particularly, put upon them. So I say the influence of the scheme at this point is bound to be in the right direction.

Another important point which the scheme handles well and which also brings relief to the works management, is the part the parents are now compelled to take in the supervision of their boys in so far as their apprenticeship is concerned. Prior to the scheme they handed their boys over to us as they would hand them to a school master, to train them up. The fact that we were managing an industrial concern which could be kept going only so long as it made a profit never occurred to them. The scheme is forcing on them the idea that they and the boys are responsible partners in this business of training them up; that if they do not play the part they were engaged to play, the scheme, and not the foremen or works manager, automatically finds them out. The scheme finds the boys out, they and the parents take the blame—just as on the other hand, when a boy does well, the scheme only takes credit for discovering him. The boy and his parents take the rest.

Take again the question of the parents' opinion and wishes when they bring the boy along to the works for the first time. Some are very careful to enumerate all the departments they wish him put through, with the drawing office "to finish off with." Of course, to these people the works is nothing more than a school or a County Council technical college supported by rates. Well, the scheme settles this point in the most businesslike way. They will, in time (the scheme is educating them), realise that every boy entering a works does so as an industrial unit, and whether he ever becomes anything more depends on himself. All apprentices start off under exactly the same conditions, none are privileged from beginning to end of their time. I may state here, and it gives me much pleasure to do so, that though there have been several applications from influential persons, who were customers as well, to have their boys moved to the drawing office and though the applications reached the highest possible authority in the works, the fact that they had failed to win a place on the list debarred them. There has been no single instance, during the four years the scheme has been in operation in our works, of an apprentice having entered the drawing office except through the scheme.

We have many instances at present of boys who are striving with all their might, both in timekeeping and industry during work hours, and whose parents are equally anxious and helpful, to get their names on the list and to keep it there. There was some little difficulty at first to get the foremen to mark them up properly in the quarterly sheets, but this was quickly overcome and is being done now in quite a satisfactory way. I believe the disappointment at the results is due to the fact that so few secure a place in the list which entitles them to increased pay and promotion, and that so very few reach what we might call the high-water mark on the scheme. But surely this is due to a misconception of the objects of the scheme. If the object to be attained be properly focussed, it will be seen that the scheme is doing well all it is set out to do.

The object of the scheme is to evolve from the ruck the brilliant boys and to raise the standard of the rest who must, perforce, remain what nature intended them to be, namely, industrial units. It has been stated on high authority that the proportion of brilliant youths is about five per cent. The scheme does not, nor is it intended to, I maintain, produce this five per cent. of brilliant youths, *it discovers them,* and as soon as it does so we proceed to change the status of these youths from industrial units to students. Is that the object of the scheme or is it not? I maintain it is. And what kind of a scheme would it be which produced, say, seventy-five per cent. of students, leaving twenty-five per cent. of industrial units? It would be *primâ facie* a fraud.

I refer you to Mr. Spence's diagrams and to the one before you for proof as to whether the scheme is fulfilling its mission. If you set yourself to construct a diagram for the purpose of showing what were the ideal results to be sought for, you will produce this very diagram, which is a result of four years' actual experience.

Is the scheme discovering the youths who are best fitted to fill in the future the responsible positions in our industrial concerns, and is it raising the standard of those who must remain industrial units? I say it is.

Mr. Harold Thomson said—As one of those who was associated with the introduction of one of the three schemes that Mr. Kennedy has mentioned, I was extremely interested in seeing the results that Mr. Spence has put before us, and I was very glad that he took this opportunity of showing what practical result had been obtained from a practical attempt to put into operation the recommendations of the Educational Committee of this Institution. It is rather difficult for us, especially seeing that we have no information as to what was the state of affairs at the Neptune Engine Works before the scheme was introduced, to say definitely and conclusively what the effect has been on the apprentices as a body, and perhaps it is rather too early for us to expect as yet that the results have settled down into what they eventually will be, but I think there is no doubt some useful information has been obtained, and more could be obtained, if those three firms which are at present working schemes of this sort would tabulate their results on a common basis, or, possibly, agree to adopt a uniform scheme with similar markings. If that were done it would be possible to compare their results and also to compare them with similar results obtained from firms who have no scheme in operation, and this, I think, would show almost at a glance whether the firms who, as Mr. Morison said, have spent so much money on these schemes had any marked superiority, either in timekeeping or in class results. In any such comparison it would be necessary, I think, to take into account that conditions may vary in different places; the location of the works, or the personality of the foremen, might have a distinct effect on timekeeping, for instance, but one would suppose that on the average there would not be very much difference in similar works in similar districts. It would also be necessary to eliminate the marks awarded for conduct and ability, because these depend so largely on a purely personal feeling on the part of the foremen. In my own experience I have found these marks, at best, unsatisfactory. I have known cases where a foreman has given every apprentice in his department full marks, in spite of the fact that he occasionally had to punish some of them for infringement of regulations, or other defects. I think that, if possible, some system that would be automatic should be substituted. It is difficult to say what could be substituted, but possibly in the case of firms that work on the premium bonus system the premiums earned by the apprentice might be taken as a measure of his workshop ability. Personally, I think that these schemes are certainly valuable. Possibly my reasons are not quite the same as those mentioned by Mr. Kennedy, with whom, however, I very largely agree, but I think they are valuable for the following three principal reasons: First of all, they are a means, and a very good means, of selecting promising youths for promotion to the drawing office, or for other purposes, and for higher educational facilities. Secondly, I think they must have a tendency to improve the general timekeeping in the works; and, thirdly, because each apprentice at least once a quarter is brought under the personal notice of some responsible official, and the knowledge that his career, both in the works and at the evening classes, will be brought under the notice of his employer cannot but have a stimulating effect on an apprentice worth anything at all. Although I say that I consider these schemes valuable I must confess that the principal feeling uppermost in my mind when viewing the results obtained has been one of disappointment. I think Mr. Spence has possibly made things look worse than they really are, because he gives us no information as to the number of apprentices who attended evening classes, although they did not sit at the examinations. In the scheme to which I have referred a considerable number of apprentices made at least 80 per cent. of the possible attendances at evening classes. In our scheme we refunded to them the fees they paid provided they put in this percentage of the possible attendances. I have no figures now, but a considerable number made the necessary percentage and a boy cannot make 80 per cent. of the possible attendances at a class without getting some good from it, though he may not have passed an examination. Now, if we examine curve J in Mr. Spence's paper, we find that only about 15 per cent. of the apprentices gain any examination marks at all, and we must not forget that he neglects altogether the boilermaker apprentices, who, as a rule, do not attend any classes.

Professor WEIGHTON (interposing)—He also neglects the drawing office.

Mr. THOMSON—Is that so? Well, possibly the drawing office will to a certain extent compensate for the boilermakers. If you take into account the boilermaker apprentices, who are generally about as numerous as the engineer apprentices, the probability is that of the whole works only 7½ or 8 per cent. would gain any class marks at all. Seeing that no great amount of either ability or education is required to pass the elementary stages of the science and art examination, it seems to me that it is time we enquired very carefully into the reasons for this poor response on behalf of those for whom so much public and private money has been and is being expended. I am of opinion myself that one of the main factors tending to produce this result is that the great majority of these youths leave school when they are comparatively very young, and that they very readily forget most of what they have learned at school. In other words, a great deal of the trouble lies in the want of a thorough primary education. The consequence is, that when they attend science classes they are unable to follow the teaching of the professors, and they do not feel themselves able to go in for an examination. They know they would fail if they went in, and so they do not enter, and that accounts possibly to a great extent for the small number of apprentices who sit at the examinations. Some years ago, when I was a little more rash than I am now, I volunteered to teach an evening class. I have not forgotten it. I do not know whether or not it was my stupidity as an amateur teacher, but I came to the conclusion I had never met such a lot of duffers in my life. Seriously speaking, it was with the greatest difficulty that one got these boys to understand properly the simplest subject in science, and there were not more than two or three boys out of twenty or thirty who could answer a question properly in writing. So now we have to consider whether, with all this expenditure on technical education, we are spending money in a vain attempt to highly educate something which, from the nature of the conditions, cannot be highly educated, instead of concentrating our attention rather upon selected men chosen by some such methods as those we have under consideration. When all is said and done, for the largest proportion of the ordinary apprentices in an engineering works a very high degree of technical education is not an essential in their after life. Mr. Kennedy has referred to this, and puts it well when he says we are dealing with industrial units, and as industrial units the great majority of them will remain. There are only a small number of positions for men as managers, draughtsmen and foremen compared with the number of men who will eventually become mechanics, for whom technical education is not a necessity. Of course, it is an advantage, but it is not a necessity. I would not have it understood that I do not consider education for mechanics of any use. Quite the reverse. I believe it is the duty of every country to educate its people as far as possible, but I think it is of far more importance to devote our attention to training selected men who will be able to take their positions as leaders and uphold our position as an engineering and shipbuilding country. Some people have the idea that all you have to do to make a good engineer is to send him to a technical college and highly educate him. I disagree with that view. There are other qualifications besides education to make a successful engineer, and mere brilliance in passing examinations will never fit a man to take such positions as those I have mentioned. If we investigate into the careers of men who are now at the head of our works in this country we shall generally find that they are, in the first place, thoroughly practical men, and that they have obtained their positions by hard work—in other words—by character. It is this combination of ability with character that we wish to discover, and it is because these schemes are a means of selecting from a number of practical young men those who have also character and ability, and, besides that, a capacity for education, that I believe they cannot fail to be of advantage, in spite of the poor results obtained in examination passes. If this policy is pursued of selecting a few brilliant young men for higher educational advantages, I hope it will not be forgotten that our object should be not to produce learned professors and writers of books, who are recruited, in sufficient numbers from totally different channels, but rather to train practical men as practical engineers, and I hope provision will be made for them to obtain an extended practical knowledge in addition to the theoretical knowledge obtained at the college. I hope that, in spite of the conditions of which Mr. Morison has told us, we still hold a leading position in the engineering world. But although we do that we must not make the mistake of thinking we have not anything to learn from anybody else. That is a mistake often made in this country, and I think a certain amount of time spent by a few selected youths in studying the methods adopted in other countries cannot fail to have a good effect, and I feel sure that time so spent would have at least as high an educational value as the same time spent in the chase of an elusive X, Y or Z. We all know the wonderful progress made in recent years in engineering and shipbuilding by Germany, and by our friends and allies in Japan. How has it been done? I think very largely by sending their more brilliant young men to this and other countries. These men have been coming here for years and have studied our methods and put them into operation in their own countries, with the improvements which experience has taught. It is time we did something of the same sort with a few of our brilliant young men. I do not think it will do us any harm. I trust the apprentices themselves will endeavour to appreciate the spirit in which these schemes have been introduced, and take advantage of them in every possible way. The employers are now making it impossible for any apprentice who has merit to be overlooked, as no doubt often occurred in the past. Many of us must have known the feeling as apprentices that we were one in a great crowd and that nobody cared very much what we did, but under a scheme such as this it is impossible for a deserving boy to be overlooked, and if the results are used without favouritism for promotion in the works or to the drawing office the apprentice has only himself to blame if he does not get on in his profession. We will doubtless be told that the rewards offered are so small that they will not induce apprentices to work for them. My own feeling is that any apprentice worth his salt will work, not so much for the value of the reward, as because he knows that if successful he will advance himself in his profession and be brought under the notice of his employer. An apprentice who will not work for such a reason is not worth troubling about. In conclusion, I would say that it must not be forgotten that these schemes are not to be considered as an end in themselves, but rather as a means to an end, and we should see to it, or rather, those whom we make responsible for education in this country should see to it, that in their lavish expenditure on public education they do not overlook or neglect that which is best worth educating, and from which the country, in the end, would obtain most benefit.

The SECRETARY submitted the following communication on the subject:—

19, JAMES STREET, LIVERPOOL,
January 9th, 1908.

DEAR MR. DUCKITT,

I regret I cannot be at meeting when discussion is continued on Mr. Spence's paper but send enclosed note:—

I consider the engineers of this country owe a debt to Mr. Spence for the care and time given to tabulating the merits and demerits of the various apprentices in the works to which he refers. The tendency to fall off as mentioned may be expected, but any system that compels the foreman and his assistants to take note of what the apprentices are doing reacts on their own efficiency. Timekeeping is in almost all cases an index of the value of the apprentice as a future workman and therefore should be in my opinion more fully encouraged. It is very significant that only 20 per cent. show any results at all at classes and probably 5 per cent. or less will be all the really good material for further development in higher technical schools and colleges. This class it appears should come more under managers' supervision and cognizance and have their progress marked and kept in diagrams, while the 95 per cent. might be very well under the methods suggested, with benefit to boys and their employers. As Mr. Spence well says, it is not possible to polish the whole of the metal, yet the silver requires often a lower grade metal behind it and both need grading up. As in other connections, the survival of the fittest is spoken of, so the best apprentice is to be cared for, but at the same time, keeping the more modern idea in sight, that of producing the greatest number fit to survive, and there appears no better method than that outlined and experimented on here.

Yours faithfully,

AND. HAMILTON.

The following communication was sent to Mr. Spence:—

LANCASHIRE AND YORKSHIRE RAILWAY,
CHIEF MECHANICAL ENGINEER'S OFFICE,
HORWICH, S.O., LANCASHIRE,
January 13th, 1908.

MY DEAR SIR,

Further to my letter of the 3rd instant and yours of the 31st ultimo, in conjunction with the proof copy of your paper read at Newcastle on December 20th, 1907, as promised, I now send such comments as suggest themselves in connection with your paper and the technical education of apprentices employed in the engineering works of the Lancashire and Yorkshire Railway at Horwich.

Your graphical representation of individual apprentice's records (Plates VII. to X.); (A) Timekeeping; (B) conduct and industry in works; (C) evening study, with an indication of supplementary payment in wages as a resultant of the three foregoing diagrammatic curves.

The only absolute factors (as it appears to me) are (A) timekeeping and (C) evening study—if by that is meant progressive study, producing on examination a higher status, say, in 1907 than in 1906. The factor (B) has many possibilities of a thoughtful youth being apparently inattentive to his work, and of his mannerism largely entering into a foreman's report, that I give little weight to it. If a youth's conduct and industry is not satisfactory, it will or should be readily reported and dealt with from an administrative standpoint, but in my experience, a youth, earnest enough to be a good timekeeper, after successfully working at his evening classes, has seldom shown marked evidence of idleness or misconduct in the daily life of the workshop.

I do not like your proposal that youths doing well at their evening study should commence duty at 9 a.m. instead of 6 a.m. in the workshops. A youth may run well, but from personal or other causes, he is hindered, and a return to the 6 a.m. obligatory attendance is a disgrace, in some cases deserved, possibly in more cases not deserved, and I have therefore not adopted this arrangement as far as Horwich apprentices are concerned.

The exhibition of curve records is certainly a graphic and forcible way of emphasizing the individual progress of each student, and doubtless proves a very present and suggestive subject for discussion with all its pros and cons in the workshop.

With regard to the reward of successful students at examinations, the measure of such reward must be the need of the recipient and until pronounced ability in a specialized direction has been proved, little more than the future class fees and expenditure for particular technical text books are necessary but once having a youth of defined ability, and particularly in a workman's son with only an elementary school early training then the purse strings should be loosened and some bursarship exhibition or scholarship granted, commensurate with the need of the recipient and his qualification to return by increased educational fitness in riper years to the donor, whether an engineering institute or the County Council, the contribution to his technical training.

The course which I have adopted at Horwich is as follows:—The winter session of educational work begins in September and ends in May of each year, and in August about 30 apprentices are selected to attend classes in Graphic Statics, Mechanics and

Mechanism, Heat and Heat Engines, etc., specially arranged for them at the Horwich Railway Mechanics' Technical School, on two full afternoons weekly (Tuesday and Thursday), and whilst attending these classes, they each receive their ordinary wages. Their afternoon classes entail no class fees, and are supplementary to their ordinary evening classes, and each student is expected to attend classes on three evenings per week in accordance with a co-ordinate course of study which I have approved.

I do not think it possible in a week for a youth (however earnest he may be) to do his duty to his employer from 6 a.m. to 5·30 p.m. daily, attend technical classes from 7 p.m. to 9 p.m. for three nights per week, conscientiously do preparatory home work for his classes, and keep himself, mentally and physically, sound, and this has been my reason for arranging free afternoon technical education with ordinary rates of wages paid to each youth in preference to later commencement of work in the morning. During the apprenticeship term, it is a healthful disciplinary condition to every youth, whatever his position, to be on duty every day when the employees of the factory commence their work.

The selection of the thirty apprentices is based: (A) on record of examination reports of previous years (absence from class attendance from illness or other causes being duly considered); (B) timekeeping and workshop conduct (the mere fact of good timekeeping without any effort to gain technical evening instruction giving no distinct preference).

With regard to posting successes of each youth in the workshops, from an operative and educational standpoint, I think the course I adopt of showing to each parent, apprentice, foreman, and teacher, the individual attendance and progress of each successful student is efficient. To those concerned, the absence of the names of youths in whom they are interested will readily bring about personal and searching enquiries, as far as the technical classes are concerned, and the ordinary workshop discipline will keep the timekeeping question in its proper place.

Personally, what I am most deeply interested in is the question of the regular, sys na ly of our apprentices, namely, a co-ord and am working particularly in help-fully encouraged by generous donations of prizes for students who wisely take up the course laid down for their benefit. I enclose a copy of the current year's course of studies, which will show the direction in which it is hoped a full development will result.

Yours faithfully,

GEO. HUGHES.

CONDITIONS REGULATING ADMISSION TO CLASSES.

Engineering students are expected to follow the course of study recommended by the Institute Committee.

Junior Students who desire to enter Science or Technical Classes should qualify for admission to such classes by attending the Preliminary Technical Course recommended. The minimum requirement is that they attend a class in Arithmetic or Mathematics in their first session, and before entering classes in Machine Drawing, Building Construction, Metal Platework, or Practical Plane and Solid Geometry, they must attend a class in Practical Drawing.

To obtain admission to the Mechanical or Electrical Engineering classes, students must have passed in Workshop Mathematics or pass a test in Arithmetic to be set by the teachers; students proceeding to the second year's course must have passed in Mathematics or attend a Mathematics Class concurrently.

Students of Metallurgy must, either first or concurrently, attend classes in Inorganic Chemistry. No student will be admitted to the Practical course in either of these subjects unless he has taken the Theoretical course in the same stage previously, or takes it during the same session.

No student will be registered in the Second Stage of a Science subject unless he has passed in the First Stage, or gives satisfactory evidence of his ability to profit by such advanced instruction.

Regular and punctual attendance is strongly urged upon all students. In Science, Art, and Commercial Classes, students are expected to make at least 24 attendances during the session.

COURSE OF STUDY FOR ENGINEERING STUDENTS.

This suggestion for a continuous course of study is intended to enable engineering students to make the best use of the classes provided. No student must enter upon the second or any later year of the course who is not qualified by his progress in the work of the preceding year or by a corresponding standard of attainment.

PRELIMINARY TECHNICAL COURSE.

Those who are not sufficiently familiar with the subjects comprised in this introductory course should begin evening class work by attending the first or second year's Preliminary Technical Course, according to their attainments, and continue their studies in the order recommended.

1st Year ..	Practical Drawing ..	Mondays, 6·45 to 9·15.
	English Grammar	Tuesdays, 6·45 to 8·0 and 8·10 to 9·25.
	Workshop Arithmetic General Elementary Science	Thursdays, 6·45 to 8·0 and 8·10 to 9·25.
2nd Year ..	Practical Drawing and Mathematics	Tuesdays, 6·45 to 9·15.
	Experimental Mechanics and Physics English Composition	Thursdays, 6·45 to 8·0 and 8·10 to 9·25.

Mechanical Engineering Course.

1st Year.	
Machine Construction and Drawing (Elementary)	Wednesdays, 7·0 to 9·30.
Mechanical Engineering (Preparatory) .	Mondays, 6·45 to 8·15 and 8·25 to 9·40.
Practical Mathematics (Preparatory) ...	(same)
Practical Plane and Solid Geometry (Stage 1)	Fridays, 7·0 to 8·15.
2nd Year.	
Machine Construction and Drawing (Inter. or Advanced)	Thursdays or Tuesdays, 7·0 to 9·30.
Practical Mathematics (Intermediate) ...	Mondays, 6·45 to 8·15 and 8·25 to 9·55.
Mechanical Engineering (Intermediate) ..	Wednesdays, 7·0 to 9·30.
3rd Year.	
Practical Mathematics (Advanced) ...	Fridays, 7·0 to 9·0.
Mechanical Engineering (Advanced) ...	Tuesdays and Thursdays, 7·0 to 9·30.
4th Year.	
Machine Construction and Drawing (Advanced)	Tuesdays or Wednesdays, 7·0 to 9·30.
Electrical Engineering (1st Year's Course)	Fridays, 7·0 to 9·30.
Inorganic Chemistry — Theoretical and Practical (Stage 1)	Mondays, 7·0 to 9·30.
5th Year.	
Practical Draughtsmanship	Wednesdays, 7·0 to 9·30.
Practical Plane and Solid Geometry (Stage 2)	Fridays, 8·25 to 9·55.
Metallurgy—Theoretical and Practical (Stage 1)	Tuesdays, 7·20 to 9·50.

Electrical Engineering Course.

1st Year.	
Machine Construction and Drawing (Elementary)	Wednesdays, 7·0 to 9·30.
Mechanical Engineering (Preparatory) ...	Mondays, 6·45 to 8·15 and 8·25 to 9·40.
Practical Mathematics (Preparatory) ...	(same)
Practical Plane and Solid Geometry (Stage 1)	Fridays, 7·0 to 8·15.
2nd Year.	
Machine Construction and Drawing (Inter. or Advanced)	Thursdays or Tuesdays, 7·0 to 9 30.
Practical Mathematics (Intermediate) ...	Mondays, 6·45 to 8·15 or 8·25 to 9·55.
Electrical Engineering (1st Year's Course)	Fridays, 7·0 to 9·30.
3rd Year.	
Machine Construction and Drawing (Advanced)	Tuesdays or Wednesdays, 7·0 to 9·30.
Practical Mathematics (Advanced) ...	Fridays, 7·0 to 9·0.
Electrical Engineering (2nd Year's Course)	Mondays, 7·0 to 9·30.
4th Year.	
Electrical Engineering (Honours Course)	At Manchester, Salford, or Bolton.
Mechanical Engineering (Intermediate)...	Wednesdays, 7·0 to 9·30.
Inorganic Chemistry — Theoretical and Practical (Stage 1)	Mondays, 7·0 to 9·30.

The discussion was adjourned.

FLOATING DOCKS.

By HARRY R. JARVIS, Member.

[Read in Newcastle-upon-Tyne, on January 10th, 1908.]

Introduction.

For the inception of the floating dock, which, according to ition, occurred during the latter part of the sixteenth cen-, we are indebted to a Britisher, who while trading in the ic found it necessary to repair the underwater part of his . A dry dock or slipway not being available and the then l procedure of grounding the ship at high water and repair-her during the time the tide was down being impossible, g to the absence of tides in the Baltic, the captain purchased ld hulk, removed the beams and deck, fitted a gate to the ı end, and thus created a crude form of dock which served purpose.

No doubt this makeshift was improved upon during the next years or so, but no record appears to have been kept of the building of this period.

n more modern times the use of iron was adopted in the truction of floating docks. Several examples were built in sixties, some of which are still in existence and capable of ing ships, although perhaps deterioration of the material, ıgh neglect and lapse of time, has weakened the structures uch that only very light weights can be lifted as compared the original lifting power. A dock for the Turkish Govern-: for use at Constantinople, one for Alexandria, one for ıo in Peru, and one for Carthagena, were built about this d. Two of these have recently quietly sunk at their moor- and the others are not much use, excepting perhaps the ıagena dock, ordinary precautions to preserve the structures ng been neglected for many years.

Types of Dock.

It will be as well perhaps at this stage, and before proceeding with a description, to classify the various types of floating docks which, during the last forty years, have been designed by the only firm of floating dock specialists, namely, Messrs. Clark & Stanfield of London. These gentlemen, with whom the writer was associated for many years and from whom he has received much interesting data, have found it convenient to designate various types of non-"selfdocking" and "selfdocking" floating docks as follows:—The "box" type of floating dock is non-selfdocking. The "selfdocking" types include the "depositing," "off-shore," "sectional" pontoon, "Havana," and "bolted sectional" docks.

Description of Various Types.

The non-selfdocking "box" dock, which does not need any elaborate description, consists simply of a pontoon with two side walls forming one homogeneous whole. Being solidly built, this type is naturally the strongest form of floating dock which can be constructed. Whether "selfdocking" facilities in a floating dock are absolutely essential depends entirely upon its situation. It is generally found that marine growths, which are so detrimental to a ship on account of loss of speed, do not in any way interfere with the life of a floating dock, but rather tend to preserve the material. This statement is not based on theory but on actual experience over many years. It is not, however, the portion of the dock always entirely submerged which suffers most from corrosion but that portion between wind and water, about the normal waterline of the dock, which constantly varies with the amount of freeboard given to the floor of the pontoon. This part is very easy of access when the dock is not in use, for by pumping out the water and heeling the dock sideways or endways, it is always possible to clean and paint that portion as often as may be found convenient. Naturally, this operation is not so satisfactory as selfdocking the dock in a proper manner. H.M. Bermuda dock, built in the sixties and which is roughly U-shaped in section, was so designed that it could be careened by pumping up certain chambers in the side walls, and so enable the underwater parts to be reached. This operation, however, was found to be so dangerous when tried that it has never been repeated.

To enable the underwater parts of a floating dock to be examined, cleaned, painted, and if necessary renewed, with perfect safety and expedition, Messrs. Clark & Stanfield in 1877 designed and built for the Russian Government a single-sided outrigger dock which they designated a "depositing" dock. This dock which, in end elevation, is shaped like the letter L, is of peculiar construction, has a single side wall which contains the pumping machinery, and the pontoon is made up of a series of "fingers" with spaces between them as shown on

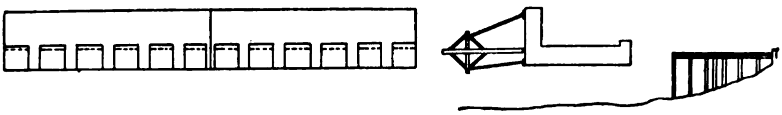


Fig. 1.

Fig. 1. The necessary stability to enable the pontoon to be lowered and raised is obtained by an outrigger which is connected to the side wall of the dock by a series of parallel booms hinged at each end. As the wall of the dock is divided into two equal lengths, it will be readily seen that to selfdock either portion of the dock it is merely necessary to separate the two halves and disconnect the booms from the portion to be dealt with; the remaining portion of the dock may then be docked in the usual manner (Fig. 2). This type of dock can not only

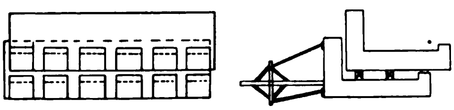


Fig. 2.

dock vessels but, owing to the peculiar construction of the pontoons, is enabled to "deposit" them on a grid, formed by groups of piles, shown on Fig. 1. It is obvious, therefore, that in certain situations, such as non-tidal harbours or rivers, comparatively cheap docking accommodation need only be limited by the number of grids provided. Several examples of this type of dock have been built, namely, for Vladivostok, Nicolaieff (now transferred to Sebastopol), Barrow-in-Furness, and more recently for Barcelona.

The "off-shore" dock (Fig. 3), which was designed and patented by Messrs. Clark & Stanfield in 1884, is a modification of the "depositing" dock. The pontoon is continuous and L-shaped in end view. Unlike the "depositing" dock, however, the "off-shore" dock is, as its name implies, attached to a series of shore girders or triangulations, by parallel booms, hinged at each extremity. The inner end of the top boom is not rigidly attached to the shore girder, but is suspended on a crank which allows the dock to take a small inclination in either direction. This movement is indicated in a simple manner to the man in charge of the dock, and enables him to correct, by manipulation of the valves, any tendency of the dock to go out of trim, and so avoid any undue strains on the shore girders or other parts of the structure. The "off-shore" dock is very simple in construction and is easily handled. It can be very profitably employed in suitable situations. When submerged to receive a vessel it is

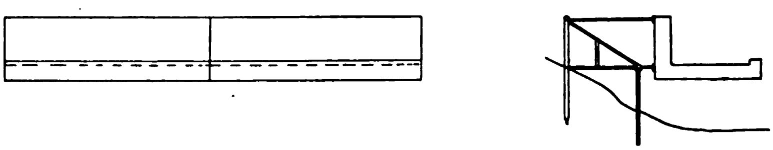


Fig. 3.

merely necessary to sheer the latter in sideways, or the vessel can enter the dock from either end. It is then rapidly centred by telescopic mechanical side shores. When properly centred the vessel is lifted in the usual way, and, without stopping the pumps, it is supported by mechanical bilge shores, which consist of strong timber booms hinged at their inner ends to the pontoon dock, and supported at their outer ends by a cast steel rack, which is raised or lowered by worm and pinion gear driven by suitable gearing from the deck of the side wall. The sound of a hammer need never be heard when docking a ship on an "off-shore" dock. Many examples of this type of dock have been constructed, all of which have given the greatest satisfaction. The first one completed was for the Reiherstieg Co., of Hamburg, and set to work in 1888. One of the latest, of 3,600 tons lifting power, for Messrs. S. P. Austin & Sons, Ltd., of Sunderland, has been constructed by Messrs. Swan Hunter & Wigham Richardson, Ltd., of Wallsend-on-Tyne.

Small "off-shore" docks of from 400 to 600 tons lifting power have been found to be very successful in dealing with large numbers of trawlers at Grimsby and Aberdeen.

The "sectional" pontoon dock is made up of a number of separate tanks or pontoons, which are held together by two side walls, as shown on Fig. 4. This type is very suitable for vessels of medium dimensions, and owing to its form can be very

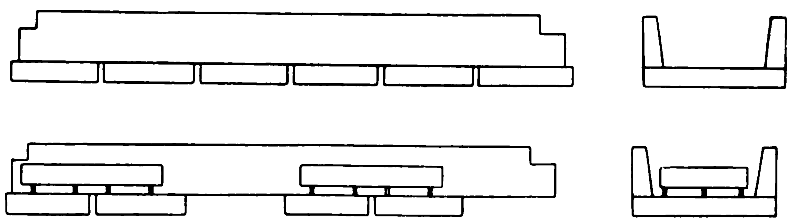


FIG. 4.

easily constructed in places where a dock of any other description would be practically impossible to complete. The separate sections of the pontoon can be easily erected and launched, after which the walls can be erected in place.

The "Havana" type of floating dock (Fig. 5), Mr. Lyonel E. Clark's patent, consists of two continuous side walls, between which are attached three or more (usually three) separate pontoons, two end sections and a central section. At intervals along the walls two tiers of lugs project from the face of the wall; corresponding lugs are built on to the side of the pontoons, the lower set of lugs being just above the light waterline and the top set in line with the top of the pontoon. The actual joint between the pontoon and wall is made by pairs of fishplates, secured by large

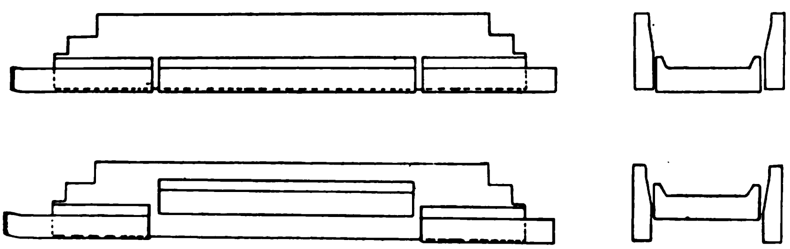


FIG. 5.

tapered screw bolts (see Fig. 6). Several examples of this type of dock have been constructed during recent years by Messrs. Swan, Hunter & Wigham Richardson, Ltd., but although the "Havana" type is a very strong and useful form of dock, the latest and undoubtedly the best and strongest form of self-docking floating dock is that known as the "bolted sectional" type, a recent design of Messrs. Clark & Stanfield's, two

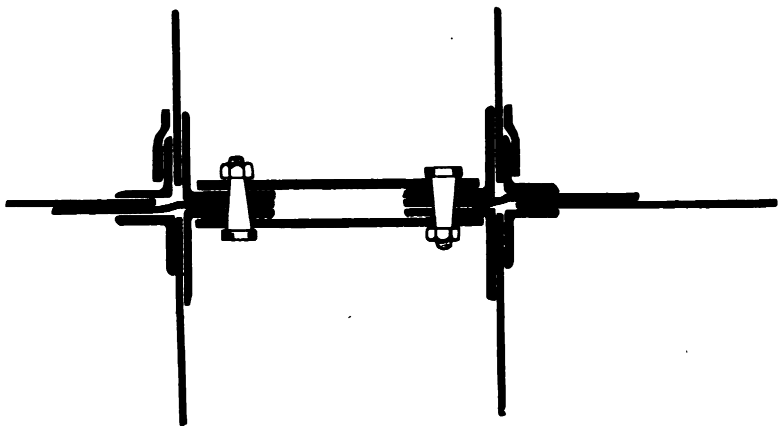


Fig. 6.

examples of which have lately been constructed at Wallsend, and a third, destined to be towed to Callao in Peru, is now in an advanced stage of construction at the Wallsend shipyard.

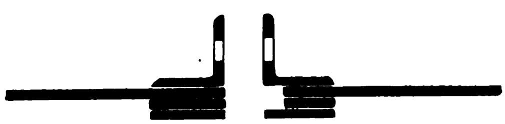


Fig. 7.

The "bolted sectional" dock is, generally speaking, a modified form of "box" dock, having the longitudinal strength of the latter, combined with the selfdocking facilities of the former. This type is built in three sections of approximately equal lengths (Fig. 8), the two end sections being symmetrical. The ends of the walls are stepped down, the lower step forming a docking land, when selfdocking the centre section. The joint between the three sections is usually a combination of butting angles bolted together for the underwater portion, and butt straps for the remainder (see Fig. 7). The end bulkheads of the various sections of the dock occur about two feet from the section ends. It therefore follows that when the sections are brought into position for coupling up, a chamber about four feet long is formed, from which the water may be removed and so allow the bolts in the joint angles across the bottom and up the outer sides of the pontoon to be inserted. The ends of the centre section are recessed, as shown on Fig. 7, and a compressible compound inserted to enable a tight joint to be made, so that the water may be removed from the joint chamber when making or breaking the connection between sections.

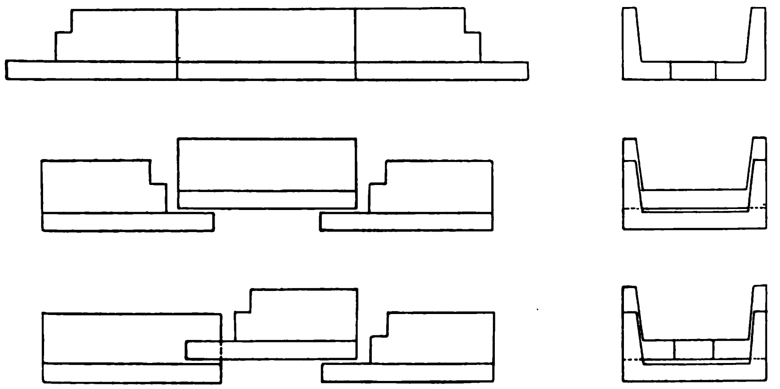


Fig. 8.

Facilities of Various Docks for Selfdocking.

With regard to the facilities for selfdocking possessed by the various types of floating docks as enumerated and described, the "bolted sectional," from actual experience, is as simple as any of the other, excepting, perhaps, the "off-shore." The "Havana" type certainly calls for very careful manipulation to enable all the tapered bolts to be withdrawn, and, moreover, the dock has to be heeled over sideways twice in each direction when selfdocking the centre section, or the two end sections, which are usually taken together. In the "sectional" type of dock, the pontoons are easily selfdocked. The bolts connecting the bottom flanges of the walls to the pontoon having been removed, water is let into the section to be selfdocked, to overcome its surplus buoyancy; it is then removed, the remainder of the dock sunk to the necessary draught and the free section docked between the walls in the usual manner. However, as long as proper precautions are taken to preserve the interior of the dock and the outer shell above light waterline by suitable protective composition, there is no necessity to selfdock at more frequent intervals than, say, from 10 to 15 years.

The principal points to be considered when determining the type of floating dock best suited for naval or mercantile purposes, are dimensions and lifting power, so that it may be adapted to economically accommodate all classes of vessels. It is well known that a floating dock is not restricted with regard to the length of vessel which it can accommodate, as the ends are open, neither is the normal docking draught arbitrarily fixed. In the case of a naval dock, it is an essential feature that it should be able to accommodate a damaged vessel, say one with a big list and perhaps partly waterlogged. As floating docks are usually designed to have a fair margin of freeboard when submerged to normal draught, it is a simple matter to give the dock a slightly greater draught and a similar list to that of a damaged ship. This is a common occurrence and can be accomplished to a certain extent even with single sided docks.

Messrs. Clark & Stanfield now have in hand designs for a naval dock of 20,000 tons lifting power, which will be able to accommodate vessels having a list of several degrees on a draught of 36 feet. With reference to longitudinal strength, it is essential that a floating dock should be able to accommodate within its lifting capacity and without appreciable deflection all classes of vessels. The dock should be capable of carrying its maximum load over, say, about three-fourths of its length, and this is usually the factor adopted when strength calculations are made. Single-sided docks, such as the "off-shore" or "depositing"; or double-sided docks of the "sectional" pontoon type, are certainly not in the same category, regarding strength, as the "Havana" or "bolted sectional" types. On H.M. Bermuda dock, 545 feet long, was lifted, as part of the contractors' trials, H.M.S. "Sans Pareil," displacing over 11,000 tons, the bearing length of whose keel was only a little over 300 feet. The dock was pumped practically dry without any appreciable deflection. On the other hand, the Barrow dock, several years ago, successfully lifted the s.s. "Empress of China," a vessel the length of which is nearly double that of the dock, far enough out of the water to enable the propellers to be adjusted, which was all that was required, therebv saving the delay and expense of a voyage to Liverpool for drydocking. These are exceptional cases, but numerous instances of a similar nature could be given to show the general usefulness of floating docks.

Class of Work which can be Performed on Floating Docks.

With reference to the general usefulness of floating docks, there is no class of repair work which cannot be satisfactorily completed on a floating dock. Very extensive bottom repairs are frequently made in these docks, even upon single-sided docks, which have a rocking joint in the centre of the pontoon and work in two sections usually, except when lashed together to accommodate a large vessel. Important ship lengthening contracts, to vessels of large dimensions, have been expeditiously and successfully accomplished. As an example, the Vulcan Co., of Stettin, several years ago contracted to lengthen the North German Lloyd steamers "Havel" and "Spree." The "Havel," however, was subsequently sold to the Spaniards during the Spanish-American war, but the "Spree" was docked and the bow end cut adrift and drawn out in less than three weeks from the time of docking.

Floating docks are exceedingly useful in the case of vessels touching the ground and requiring to be sighted to ascertain if damage has been sustained thereby. This docking and undocking is frequently done well within three hours on Smiths' off-shore docks at North Shields. For cleaning and painting, however, the floating dock is pre-eminent. The vessel stands high and dry out of the water, with plenty of air circulating around to dry the paint properly, so that the half of it does not come off, as is sometimes the case in ordinary dry docking.

Rapidity of Construction.

The fact that dry docking accommodation can be economically and expeditiously obtained is very often of supreme importance when the question of docking accommodation is under consideration. Numerous instances can be given of very rapid construction and delivery of docks of large dimensions and lifting power, and the writer proposes to give a few examples of creditable performances in this respect by Messrs. Swan, Hunter & Wigham Richardson, Ltd., at Wallsend. At the outset it should be stated that the Company are exceptionally situated for quick deliveries having special plant and a specially trained staff for dealing with this class of work. The "Havana" dock, with a lifting capacity of 10,000 tons, was built, launched and towed a distance of 6,500 miles, in a little under eleven months, and was ready for immediate service on arrival at Havana. The Stettin dock, similar in design to the Havana dock, was an even more remarkable performance. Just a little over ten years ago the Vulcan Company of Stettin were desirous of undertaking the very important ship-lengthening contract previously mentioned, but not having adequate docking accommodation they naturally hesitated to do so. However, the Company consulted Messrs. Swan & Hunter, and having satisfied themselves that a dock could be built soon enough to be of service, placed an order with them for a floating dock of the Havana type to lift 11,000 tons in 2½ hours, the dock to be delivered afloat at Stettin, and ready for work, in nine months. As a matter of fact the dock was delivered within seven-and-a-half months, and the first vessel docked within eight months of the time the dock was first contemplated. Another example of very rapid construction is the Port Said dock, which has lifting power up to 3,000 tons. This dock was built to the order of the Suez Canal Company for their own requirements at Port Said. The contract was signed in Paris on the 19th April, 1904, and on the 18th August following, that is, within four months, the dock successfully lifted its first ship.

Pumping Plant.

The pumping plant generally used in floating docks does not require any elaborate description. The amount of work done when lifting a ship is in direct proportion to the weight of vessel lifted; the larger and heavier the ship, the more water has to be removed from the dock within the limits of its lifting power. In most of the different types of floating dock, a main pipe of varying diameter runs from end to end of the dock at the bottom of the side walls. On this pipe the sea connections for the inlet valves and the branches for the distributing pipes are placed as may be required. To give the dock the requisite stability when working, the pontoons and walls are subdivided into a number of separate watertight divisions, each having its own flooding and draining pipe and air pipe. Flooding or draining goes on through the same pipe in each compartment, so that one set of pipes only is required for this purpose. The pumps are usually of the centrifugal vertical spindle type, and are seated directly on to the main drain, taking water from the under side and discharging it at their own level into the sea. The motors for driving the pumps may be either steam or electric, and are generally placed on the top deck of the side wall. The connection between the pump and motor is by vertical shafting, supported at intervals by plummer blocks attached to the internal framing of the dock's wall. The weight of the shafting and pump impeller is carried by a ball thrust bearing in the motor bedplate. The engaging clutch between the motor and shafting is made flexible, to deaden noise and shock.

In steam driven docks the engines are of the horizontal type with vertical crank shaft, simple high pressure engines for low powers, and right-angled or tandem compound engines for high powers. When cheap electric power is available, it is undoubtedly the best that can be adopted, especially for "off-shore" docks, thereby dispensing with the weight of boilers, etc., on the dock and also reducing the number of permanent staff required for the dock. In manipulating the dock, the various valves are controlled from one central station. From each compartment valve in the bottom of the wall, vertical rods are led up to, and attached by a knuckle joint, to one arm of a crank; the other arm of the crank is attached to a horizontal rod, which is suitably supported at intervals close under the top deck by guide rollers, and led to the centre of the dock, where it is attached to another crank. From this crank a rod terminating with a rack is led up into the valve house. This rack engages a pinion, which is actuated by an ordinary hand wheel with spokes, similar to a steering wheel. In some instances, where there are a large number of different compartments in a dock, it is found convenient to group several compartments together, so that the number of wheels in the valve house shall not be excessive.

Mobility.

One great advantage possessed by the floating dock is mobility. This is exemplified by the numerous long voyages which they have made with perfect safety and success. One of the usual conditions stipulated, when contracting for a floating dock, is that selfdocking trials, and the actual lifting of a ship of the maximum weight the dock can accommodate, shall be carried out by the builders before the dock is despatched to its destination. H.M. Bermuda dock is a notable example in this connection. The selfdocking trials of this dock could not be carried out at the builders' (Messrs. Swan & Hunter's) yard owing to insufficiency of water and space. The dock was therefore taken to temporary moorings at Jarrow Slake, and the selfdocking of the centre section, and one side wall, successfully accomplished. The dock was then towed round to the Medway and H.M.S. "Sans Pareil" docked as part of the builders' trials, to the complete satisfaction of everybody concerned, after which the dock was expeditiously towed to the Bermudas, where she has since been usefully employed. One of the largest jobs accomplished on this dock was the docking for temporary repairs of H.M.S. "Dominion" after stranding in the St. Lawrence River. The vessel in her waterlogged condition displaced, at the time of docking, nearly 17,000 tons. Another example of the value of mobility of docking accommodation is the Stettin dock. This dock usually occupies a berth dredged out from the land on the opposite side of the river to that on which the Vulcan Co.'s works are situated. When heavy repairs are being made to vessels in this dock, she is taken over to the other side of the river and moored alongside the Vulcan Company's yard. This arrangement naturally saves time in the transport of material and labour, which are serious items in a repairing establishment.

Cost.

The cost of a floating dock can be easily determined when once the particular requirements are known, but it depends, of course, entirely upon the cost of materials and labour and the time in which the dock is required to lift a vessel. A close estimate can always be made, however, when these particulars are known, by any ordinary shipbuilder. The cost of pumping plant, if a vessel of certain dimensions is required to be lifted in one hour, is naturally greater than it would be if the time were extended to two hours. The writer is of opinion that too much importance is given to rapid docking. A certain time is always needed for shoring the vessel, and it is better to extend the time for pumping over this period than to shore the vessel first and keep a powerful pumping plant idle in the meantime, to obtain similar results.

In conclusion, the writer purposely has made no reference to, or comparison with, the ordinary graving dock, this having been so ably demonstrated by Mr. Lyonel Clark in his papers read before the Institution of Naval Architects, and the Institution of Civil Engineers; but he has endeavoured to place before the members of this Institution a few simple particulars and facts about floating docks. For much valuable information and the use of the lantern slides the writer also expresses his thanks to Messrs. Clark & Standfield, and to Messrs. Swan, Hunter & Wigham Richardson, Ltd.

DISCUSSION.

Mr. George Renwick said—I have listened with very great interest to the paper which has just been read upon floating docks. For many years I have been intimately associated with these docks, and naturally take great interest in them; but I must say, before offering a few remarks in regard to them, that I am rather surprised that the writer of this paper has not referred to a gentleman who has unfortunately now passed away, but who took a very great interest in floating docks in this district—I mean the late Mr. Alexander Taylor. I notice in the paper that Messrs. Clark & Stanfield, of London, are referred to as the only floating dock specialists. I would like to say there are two floating docks on this river, owned by the firm of Swan, Hunter & Wigham-Richardson, and both were designed by Mr. Alexander Taylor without any assistance from any other specialist, and there are two similar docks on the Manchester Ship Canal, with which I am associated, which docks were also designed by Mr. Alexander Taylor. I think it is only just to our late fellow-citizen that I should mention these facts. I quite agree with nearly everything else that has been mentioned in the paper, and I am pleased to find that the writer of it acknowledges that the best dock is the box-sided dock, or a modification of it, and you who noticed the lantern illustrations would see that nearly all the docks that have been built to make voyages are of that type, which type, many years ago, we decided upon, on the advice of Mr. Alexander Taylor. I have often wondered why our Admiralty have not gone more in for this type of dock. I remember Mr. Taylor suggesting to me at the time the controversy was very strong regarding the new dry docks at Gibraltar. At that time a great difficulty was foreseen owing to the almost impossibility of a place being found at Gibraltar that was not likely to be subject to the fire from the sea and the land batteries. He suggested that a dock could be easily built that could have machinery placed in it to propel it at the rate of six or seven miles an hour, which machinery could be used for pumping, and a dock of that description could easily be moved, not, possibly, at Gibraltar, but where there was a river or other inlet, out of the range of fire; and not only that, but it could be taken to the assistance of a damaged ship, and possibly, in smooth water the ship could be brought upon the dock to a place where it was convenient to have the vessel repaired. That I thought a most excellent idea, and I think if there is any representative of the Admiralty here he might give the suggestion his consideration. There is no reason whatever why the dock should not sail at something like the speed I have mentioned. There is another consideration with regard to these docks we have to consider in regard to what we call lame ducks, or, damaged ships, and that is the difficulty of finding sufficient depth of water for them. I think the writer mentions they could easily deal with a vessel drawing 36 feet. I cannot say positively myself, but I think somewhere about 50 to 55 feet would be necessary to take a ship with 36 feet draft. Such a depth of water is available in very few ports. Perhaps the writer may give us some information on that point, but that, I think, is one of the difficulties in dealing with large docks of this type. There is also another point mentioned by the writer. He pointed out that the greatest deterioration took place at the point just between air and water. I do not think that that has quite been our experience. Our experience has been that the greatest deterioration takes place at the side of the dock where the sun plays upon it. There is naturally a considerable amount of sweating in the in-sides of the dock, and unless they are carefully watched where the sun beats upon them, owing to difference of temperature, a considerable amount of pitting and depreciation goes on. I also quite agree with the writer of the paper that floating docks do not suffer very much from the shells and other growths that are upon them in the same way that a ship does. We have had these docks floating in the Tyne and also in the Ship Canal for many years, and our experience is that it is not necessary to dock them more than once in about fifteen years. It is extraordinary the good state of preservation in which they have been found even in the water of the Ship Canal, after having been in it about fourteen years. The only other point I would like to mention in regard to the dry docking of these docks is that, where possible, I think it is better to build the dock without having it of a self-docking character, that is, where you can have a dry dock to put it in; and as far as I am concerned, both at Wallsend and on the Ship Canal, we have designed our dry docks large enough to take in the floating docks, and this gives you a dock of a more mobile character. They have their own pumping machinery and boilers on board and the mooring chains can be taken off and they can be towed away at half-an-hour's notice to any part of the river or harbour. I think the writer will agree with me that wherever it is possible to get them dry docked it is much better to make them entirely self-contained. They are more mobile and a better asset if you wish to sell them, and they are more easy to take away than any other type of dry dock, especially those which it is necessary to have attached more or less permanently to the shore. I have listened with much pleasure to the paper and I am much obliged to the writer for one or two hints he has given to me, and as already mentioned I thought it my duty to make a few remarks, especially to call to remembrance that my friend the late Mr. Alexander Taylor had so much to do with floating docks.

The discussion was adjourned.

The meeting then dispersed.

RTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWENTY-FOURTH SESSION, 1907-1908.

PROCEEDINGS.

FOURTH GENERAL MEETING OF THE SESSION WAS HELD IN THE LECTURE THEATRE OF THE LITERARY AND PHILOSOPHICAL SOCIETY, WESTGATE ROAD, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, JANUARY 24TH, 1908.

PROFESSOR R. L. WEIGHTON, VICE-PRESIDENT, IN THE CHAIR.

'he SECRETARY said—I am sorry to say our President is laid nwell, and he has asked me to convey to you his deep regret ing unable to be present to-night. Under the circumstances, essor R. L. Weighton, the senior Vice-President present, take the chair.

he SECRETARY read the minutes of the previous meeting, in Newcastle on Friday, January 10th, 1908, which were med by the members present and signed by the Chairman.

he CHAIRMAN appointed Mr. David Andrew and Colonel R. n White to examine the voting papers for new members, he following gentlemen were declared elected:—

MEMBERS.

nsworth, G., General Manager, Consett Iron Co., The Hall, Consett, County Durham.
rr, J. Lynn, Elec. Engineer, Parkside, Roker, Sunderland.
lne, J. J., Supt. Engineer, 31, Birken Allee, Stettin, Germany.

GRADUATES.

Aird, A., Engineer, Gosforth House, Roker, Sunderland.
Chisholm, J. P., Engineer, 48, Falmouth Road, Heaton, Newcastle-upon-Tyne.
Markham, M., Engineer, 9, Eldon Square, Newcastle-upon-Tyne.
Turner, S., Engineer, 4, Queen's Road, Monkseaton, Northumberland.
Winstanley, E. G., Shipbuilder, 5, Ash Place, Newcastle Road, Sunderland.

Mr. W. G. Spence replied to the discussion on his paper on "Notes from Four Years' Working of the Educational Committee's Recommendations."

The discussion on Mr. H. R. Jarvis' paper on "Floating Docks" was resumed.

Mr. J. Hamilton Gibson read a paper on "Torsion-Meters as applied to the Measurement of the Horsepower of Marine Steam Turbines."

MR. W. G. SPENCE'S REPLY TO THE DISCUSSION ON HIS PAPER ON "NOTES FROM FOUR YEARS' WORKING OF THE EDUCATIONAL COMMITTEE'S RECOMMENDATIONS."

Mr. W. G. Spence, in replying to the discussion, said—Allow me in the first place to thank the members for the kind reception they have given to this paper, and especially to thank all those who joined in the discussion or sent communications.

Professor Weighton draws attention to the fact that my paper deals with one section only of the Committee's report, namely, the section recommended with a view to increasing the efficiency of what may be termed the apprentice artizan, as distinguished from what may be termed the apprentice engineer or pupil. I am obliged to him for doing so, as persons outside the Institution and not familiar with the report might fall into the error of thinking the section I have dealt with was the whole scheme, whereas an entirely different scheme of training was recommended for "selected" young men who had shown they possessed the necessary character, ability and preliminary edu-cation to follow the higher course with advantage. With regard to the section dealt with by me, he advocates that an increased ratio of marks be given for evening study. The ratio of marks adopted for timekeeping, industry in works and evening study was fixed more or less as an experiment, there being no pre-vious experience for guidance. As a result of the four years' working, I think the amendment suggested by him would be an improvement.

I note with interest that the data submitted in my paper e confirmed by Mr. Hinchliffe's considerable practical experi-ce as a teacher of evening classes, and that he has found only small percentage of youths have the necessary qualifications higher work. This is the greatest argument for seeing that is small percentage is not lost in the crowd, but encouraged persevere. Mr. Hinchliffe takes some exception to the system awarding evening study marks on examination passes alone. is really raises the whole question of examination as a test of efficiency in anything. The system has its well-known deficiencies, but after considering several others the pass system was deemed the simpler and probably more effective. One reason for this was the wish to discover what is the amount and quality of work done by our apprentices at these evening classes, and the ability to pass the examination seemed the only definite measure available. We have now had four years' practical experience of the scheme, which, together with the opinions brought forward in this discussion, should enable us to more clearly understand the conditions, and improve on the present arrangement. With regard to overtime, the foremen have instructions to, as far as possible, avoid keeping boys who attend classes late in the works, and with the curve before them they should have no difficulty in knowing which boys to keep.

Mr. Harrison does not approve of the system of money awards adopted, and considers advancement in the works a sufficient inducement to offer. The Committee, in issuing their report, made it clear that while they recommended the general scheme, alterations in detail would probably be made by the various works adopting it. The report reads: "Promotion in the workshops will depend upon marks obtained," and this almost follows as a necessity. I see no reason why the system of marking recommended should not be used by anyone who considers the money awards unnecessary. The main advantage of the system of marks in my eyes is that it forms a definite scale on which you can measure each boy and tabulate the results for comparison and future reference. If these results are focussed by some such "graphic" method as adopted in this paper, both the management and everyone in the works can by inspection at once tell the relative position of each youth, and I know of no other system of which this can be said.

It must not be forgotten that with the exception of the portion of marks allocated by the foremen, the youth registers his own height on the diagram, timekeeping and evening study being entirely in his own hand.

The method of rewarding relative effort is quite distinct from the method of measuring it.

Mr. Harrison considers curve B (marks awarded by foremen) as unreliable and unnecessary, and that this should be abolished. Any order of merit awarded by human beings is nec sarily to some extent unreliable, and conduct marks awarded by foremen are not the only things to which this principle applies. This difficulty has been recognised all along, and was referred to in the paper. I think a better way of meeting it is that suggested by Mr. Henry Clark, namely, to reduce the ratio of marks under this head. It is distinctly a foreman's business to study his apprentices and promote them accordingly. Individual promotion in the various shops is mostly in their hands, and if they cannot give an approximate estimate as to the relative conduct and progress of each boy while at work, no one else can. At all events the system compels each foreman, once a quarter, to consider each boy under him and to publicly express his opinion, which I think is good.

Mr. Harrison considers that the yearly improvement shown on curve D may be due to the foreman's increasing anxiety to show his own department in a good position. An examination of the curves G, F and H, show that this improvement has been largely due to improved timekeeping.

Mr. Harrison draws attention to the poor results recorded for evening class work, and recommends compulsory class attendance as the only remedy. If intelligence and character could be put in with a spoon it would be possible, metaphorically speaking, to take a crowd of apprentices by the nose and administer the approved dose, but can it be done? I believe it is possible and wise to compel every child to learn the rudiments of reading, writing and arithmetic, and thus prevent him from becoming a public nuisance, but *to educate* is in my mind another matter and just what the derivation of the word implies, "to draw out," namely, the *drawing out* of what is *in*, which is exactly the reverse of cramming in. I believe it to be a sheer waste of time and money to attempt to compel many youths to acquire a scientific education; some are naturally adapted for it and some are not, just as some have a natural turn for music and some for drawing. An attempt to teach music or sketching to those without the natural instinct will fail, and I believe the same principle applies in science, the only true method being the selective principle, and this is what the Committee have aimed at in their scheme.

I note Mr. Harrison only accepts for apprenticeship boys who possess a satisfactory preliminary education. This must tend to improve the whole tone of the boys, and a wider application of the arrangement would be an advantage wherever the local conditions permit.

Mr. Harrison gives a list of the present positions occupied by his past apprentices. This list shows a post-apprenticeship interest in young men which is altogether admirable. I question if anyone else could show that they had taken the trouble to make an equally systematic record. The sole addition I would like to see to it would be an equally systematic method of recording their progress during apprenticeship, and this I hold he will obtain if he adopts some such system as has been dealt with in this paper.

I have heard Mr. Vardy's remarks with much interest. His results are, however, as he pointed out, from a shipyard, and as the conditions obtaining in a shipyard are necessarily different from those in an engine works, one must expect a different result. Two of the most necessary conditions in the formation of character are discipline and regular work. For several reasons the nature of a considerable portion of shipyard work makes discipline difficult, and the work irregular, and the youths in consequence grow up in an atmosphere which leaves much to be desired and which must affect them prejudicially. For this reason it is distinctly encouraging to note that he has found the system adopted tends to improve timekeeping, and that alone should justify its adoption.

I have to thank Mr. Henry Clark for his very complete summary of the results of the system as applied in his works, and his remarks thereon. Mr. Clark agrees generally with the deductions I have drawn, and his opinion is the result of three years' independent practical work. I quite agree with him that it would be advisable to reduce the ratio of marks awarded by foremen, as at present they form too great a percentage of the total. In the system adopted at the Neptune Works the apprentice is not credited with any overtime worked.

Mr. Jenkins also speaks of the system from practical experience, having been in the Neptune Works for several years during its operation. He is therefore able to speak of it from a strictly shop point of view. His suggestion for a graded series of courses of study would, I am afraid, be very difficult to work

It is, however, to some extent met in the courses adopted by Mr. Hughes, of the Lancashire and Yorkshire Railway, and described in his communication.

I have to thank Mr. Hamilton for his communication. I think his summation of the Committee's scheme both terse and correct, viz.: that while it is based on the principle of the survival of the fittest, it assists in producing the greatest number fit to survive.

The Institution is indebted to Mr. Morison for not only submitting the details of the scheme as in operation at the Hartlepool Engine Works, but for the fact that a similar scheme was adopted there as early as October, 1902, namely, previous to the issue of the Educational Committee's recommendations. It is a remarkable fact that each of the three works which has adopted the scheme, and every speaker who has had practical experience in its operation, has spoken favourably of it. It is interesting, also, to note that, broadly speaking, the results from all three works vary but little, viz.: that timekeeping and onduct have been improved, but that the results of evening lass work have been disappointing. The latter result is probbly no surprise to those who were familiar with such work, nd if the scheme brings to light the few who really struggle nd have ability, it will justify its adoption.

Mr. Kennedy has dealt with the subject very fully and very elingly. On the principle that an ounce of practice is worth pound of theory his opinion is important. His remarks deal ntirely with the operation of the scheme in regard to the actual ractical work of the apprentices while in the workshops, a art of the scheme which is in no way less important than that hich deals with evening study. I am so fully in accord with is remarks that it is difficult to add anything thereto. He has, wever, raised one important point which has not been dealt ith by any other speaker, and that is the part played by the rent in regard to the scheme. So far I have contented myself ith writing to the parents of the few at the bottom of the curve, ut I think the plan adopted at Hartlepool Engine Works of nding a copy of the yearly return to each parent or guardian valuable one.

Mr. Harold Thomson also speaks of the scheme from praccal experience, as he was connected with its inception at the

Southwick Engine Works, and was familiar with its working there. I should like to see his suggestion accepted for a uniform system for those works which have adopted the scheme. The experience gained during the past four years, combined with the results of this discussion, should make this quite practicable. Mr. Thomson draws special attention to the fact that under the scheme it is practically impossible for a youth to show marked ability and escape the notice of the managing staff. Can this be said of any other system? I think Mr. Thomson goes to the root of the whole matter when he points out that the most important duty of any scheme is to select and train men for positions of responsibility, and that the qualities required in these are a combination of character and ability. The main object of the scheme is to discover and help to the front youths with these characteristics, and I quite join with him in doubting if much of the public money expended on education has been directed in a way to assist this.

I am very much indebted to Mr. Hughes for his communication and the details of the courses of study he has arranged. I note the objections he points out to the arrangement of allowing the head boy to come in at 9 a.m. during the class session. I hope, however, should a youth secure this position one year and fail to secure it the next, that it will act on him as a further spur to exertion. I note that Mr. Hughes shows the result of each year's work to each parent, and I think this an important improvement. The copy of his "Conditions Regulating Admission to Classes" and his "Course of Study for Engineering Students" should be useful to all those who have to deal with engineer apprentices.

Before closing, I would like to sum up some of the points and practical suggestions brought forward in this discussion, as follows:—

(1) All those who have practical experience of the working of the scheme state their general approval thereof.

(2) The section of the scheme dealt with in this paper should now be reconsidered with a view to the amendment of details and the adoption of a uniform scale by firms employing it.

(3) The ratio of marks awarded for evening study should be increased.

(4) The system of awarding marks on examination passes should be reconsidered.

(5) The ratio of conduct marks awarded by foremen should be decreased.

(6) A copy of each year's results showing the marks gained and relative position of each apprentice should be sent yearly to each parent or guardian.

(7) The issue by this Institution of advice regarding the choice of classes and the arrangement of suitable courses of study for evening students.

(8) That some effort should be made to induce Educational Authorities to confine entrance to science classes to those only who can show satisfactory evidence that they possess the necessary preliminary education.

In conclusion, I wish to add that, judging from my own practical experience, and the opinions expressed in this discussion, I consider the Institution to be much indebted to its Educational Committee of 1903, which, under our then President, Mr. John Tweedy, formulated and recommended the general adoption of the scheme.

The CHAIRMAN (Prof. R. L. Weighton) said—Every contributor of a paper to our Institution lays us under a personal obligation to the writer, but I think this obligation is even increased in degree in the case of a paper such as the one which Mr. Spence has contributed. I do not know of any subject which is of greater importance than the proper training of the rising generation, whether they be engineers, or of any other profession or business. For the very great trouble Mr. Spence has taken in the preparation of his paper, and for the very full reply which he has given us to the discussion, which adds considerably to the value of the paper inasmuch as he sums up the general results of the discussion, I ask you to accord him a very cordial vote of thanks.

The motion was carried by acclamation.

RESUMED DISCUSSION ON MR. H. R. JARVIS'S PAPER ON "FLOATING DOCKS."

Mr. Edward Box said—In a paper read before this Institution in 1906 upon "Commercial Dry Docks," it was suggested by its author and concurred in during the discussion that there was ample room for a separate paper on the floating form of dry dock. The suggestion having matured, I think the Committee are to be congratulated upon having obtained a paper on the subject.

There are three accepted ways of recovering vessels from the water for purposes of cleaning and repairs; the standard method adopted in this country being by means of the graving dock. The other methods are the slipway and the floating dock. The slipway is not regarded with favour excepting in the case of very small vessels. The floating dock, the subject of the paper, has been adopted of recent years, mostly abroad. Much has been written by way of comparing the relative advantages of the graving and the floating docks. Generally, it may be said that those experienced with graving docks consider they are preferable to floating docks and *vice versa*. Experience in the use of floating docks in this country is, however, very limited. Whatever opinions may be held by those interested in the building or working of dry docks, there are many shipowners who give preference to the floating dock. It is true there are still a few who are prejudiced against this method of docking, but they are rapidly diminishing. I know it is contended by many that the upkeep of floating docks is much in excess of graving docks, but I do not think that contention can be borne out in this district, where much is spent annually upon repairs to graving docks. Concrete work has not been so certain in its nature as mild steel. It is quite feasible to put a steel structure together almost regardless of time, but in graving dock construction the material, when of concrete, is being made at the same time as the construction is going on, and the conditions are very different, especially during winter months.

The question has been much debated recently whether floating docks should be self-docking. Unless the locality where the dock is situated affords some method equivalent to docking the structure, such as beaching, then I am of opinion the dock should certainly be self-docking. If it were necessary to construct a graving dock, as has been suggested, so as to be able to dock the floating dock, then the graving dock would as a necessity require to be larger than the floating dock, and in addition to the floating dock losing its claim of independence, the graving dock in many cases would often be found to be impracticable. Again, the dock might receive serious damage, but in any case is sure to require docking sooner or later; the ability to do so should add materially to the life of the structure.

Coming to the question of design, there is a self-docking dock known as the "Hansson" type. I do not think any paper on the subject of floating docks complete without some reference to this design. A dock of this type was built quite recently in America for the Philippine Islands, and was fully described in a paper read before the American Society of Civil Engineers by Mr. Leonard M. Cox. In my contribution to the discussion upon that paper I made the following remarks: "There can be little doubt that the nearer we keep to the simple or what is called box form of floating dock the stronger it is possible to design. The design of the dock (which the author described) would appear to nearer solve the problem of a self-contained floating dock than most designs the writer has seen, but until auxiliary constructional works are entirely dispensed with the problem cannot be considered to have been entirely solved." In a paper read before the Institution of Naval Architects last year by Mr. Lyonel Clark (in which I was invited to take part), Mr. Clark admits "that the 'Hansson' design under certain and not unreasonable conditions may be considered as good a solution of the problem as there is." My own feeling is that it will be improved upon.

Of the types of floating docks shown by the author, I consider the off-shore the best dock for commercial purposes. It is not so strong structurally as a two-sided dock, especially when the latter has continuous side girders. For double-sided docks of limited proportions the sectional dock (Fig. 4, page 125), which is self-docking, is a very simple arrangement. The "Havana" type is too complicated in its self-docking arrangements. The bolted sectional dock is simple, but I should prefer a type which "breaks joint." I was hoping that the author would give a description of the method of constructing floating docks. Perhaps a few words on the subject would interest the Institution.

Although built in a shipyard as being the most suitable for launching, an entirely different system to shipbuilding is adopted. All dimensions are made to adapt themselves to a standard pitch of rivets and all frames and bulkheads are arranged to suit. The plates are punched in a multiple machine gauged by machinery. At Millwall Ironworks, where the early docks were built on this principle and the speaker received his early training, we had at that time a punching machine with a double head that punched six holes at a time, three on either edge, with a rack table to which the plates were fixed. We used also to punch the angles by rack. The racks were composed of $1'' \times 1'' \times \frac{1}{8}''$ angles cut with teeth and clipped on to the ends of the bars. This rack engaged with a pawl fixed to the head of the machine exactly opposite the punch. The result was very excellent work.

Although rapidity in floating dock construction must be credited to the Wallsend firm, the Smiths Dock Company were, I believe, the first on the Tyne to adopt the system of floating dock construction which I have described and which enables such rapid and excellent work being obtained. Their "off-shore" dock, known as their No. 7 dock, was the first Clark and Stanfield dock built on the Tyne and the first put to work in this country. The dock was built under my supervision on the site now occupied by another and larger dock of the same type. Not a template was marked off on the work but was made in the joiners' shop from drawings prepared in detail. For the plates we designed a rack table fixed opposite to an ordinary punching machine fitted with double punches. In this way the plates were punched to gauge. This dock was built of steel in 1891-1892, and was at once a success. It was in excellent condition when docked three years ago, and has successfully docked about 1,400 vessels.

There is not much information in the paper respecting design. A floating dock requires to have displacement to provide for (*a*) weight of the structure; (*b*) weight of the vessel; (*c*) freeboard; (*d*) contingencies such as drainage, water, etc., with some means of controlling the structure during operation. The strength of the structure must be such as to be capable of carrying the maximum weight to be lifted distributed on the keel blocks. This is very simple, if we regard the vessel as a distributed load throughout the entire length, but, in my opinion, a floating dock should be capable of utilizing its maximum lifting power to lift a loaded ship on not more than three-quarters its entire length. I am assuming that a reasonable draught is provided. You can then compare your floating and graving dock on the same basis. Then, again, the flexibility of the structures will require some consideration: you will probably find, with the usual margin of safety, that there is not much which requires attention, but this will greatly depend upon the design of dock, especially when self-docking.

The author might have added some useful information respecting the launching of floating docks. The early Russian docks built at Millwall were taken to pieces and shipped to their destinations. Those built at Grey's were built in a shallow basin, as was also the "Hansson" dock in America. The old Bermuda Government dock, built at Blackwall in 1869, was launched end on, as are also those built at Wallsend. The dock built at North Shields, already referred to, was launched sideways, half at a time. The launching weight was about 700 tons.

The declivity of the ways was 1 in 12 to 1 in 8.

By the courtesy of Messrs. Smith's Dock Company, I am able to show you a few slides which I think will be of interest, and which include amongst others: the dock being launched; docking the floating crane built for the "Mauretania"; and docking the floating hospital. Neither of these could be docked in a graving dock built for vessels of the capacity the dock was intended for.

I am sorry I cannot congratulate the author upon the exhaustive nature of his paper. The slides of the several docks, however, are very interesting. I should like, in conclusion, to ask the author the cost of the different types of docks he gives per ton of effective lifting power, ready for delivery.

The discussion was again adjourned.

TORSION-METERS, AS APPLIED TO THE MEASUREMENT OF THE HORSEPOWER OF MARINE STEAM TURBINES.

By J. HAMILTON GIBSON, Member.

[Read in Newcastle-upon-Tyne, on January 24th, 1908.]

When a revolving shaft transmits power it always twists slightly throughout its length. In other words, the end at which the power is applied moves slightly in advance of the end where the work is done, the amount of twist varying directly as its length, directly as the moment of the load applied, inversely as the rigidity of the material, and inversely as the fourth power of its diameter, the formula reading:—

$$\theta = \frac{10.2TL}{CD^4},$$

where θ is the angular displacement in radians, T = twisting moment in inch pounds, L = length of shaft in inches, C = the modulus of rigidity, and D = diameter of shaft in inches. The law holds good absolutely for all shafts which are not stressed beyond the elastic limit. As shafts are usually designed with a large factor of safety, it follows that the amount of twist, or the "torque," as we prefer to call it, is very small. In propeller shafting, for instance, the torque is rarely more than 1 degree for 10 feet of length, so that for a 12 inch shaft the circumferential displacement is only about ⅛ inch at full power.

Various methods and numerous instruments have been devised to enable an observer to read off the torque of revolving shafting, and such instruments are rightly termed "torsion-meters," or, if self-registering, "torsion-indicators." Many of these instruments are extremely ingenious, and it is proposed in this paper to briefly examine and describe some of them.

The rapidly growing adoption of steam turbines for ship propulsion has created a demand for some ready means of ascertaining their horsepower, and as the steam engine indicator is not suitable for this purpose, we are thrown back on a torsion-meter as the only known method by which such information can be obtained. The power of a steam turbine may be estimated approximately by calculating the amount of water passed by the feed pumps, or by measuring the number of heat units that pass through the turbines in a given time; but a co-efficient of efficiency must be first determined, and no account is taken of the revolutions in such estimates. As, however, "revolutions" is the very essence of power in dealing with the question of ship propulsion, that would be a very unsatisfactory method of reporting the power from a shipowner's point of view. How often do we hear the claim made that so-and-so's feed-heater, for instance, has given a liner an extra one or two revolutions on the same coal consumption as before? Observe there is no mention of power, because it is recognised that under similar conditions, the maintenance or improvement of the revolutions is the only thing that matters.

Now it is a well-known fact that a turbine, unlike a reciprocating engine, passes almost as much steam when standing as when revolving at full speed: and it has therefore become an almost imperative necessity, in fixing the responsibility as between the boiler and the turbine, to know what power the turbine is transmitting to the propeller under varying conditions. The power thus ascertained is called the "shaft horsepower," in contra-distinction to the term "indicated horsepower" which has come to be applied exclusively to the results obtained by "indicating" the mean pressures in the cylinders of a reciprocating engine. In this connection, "brake horsepower" and "shaft horsepower" are, of course, identical.

A small propeller working deeply immersed in smooth water is a fairly uniform brake, and the turning moment of a steam turbine is also very uniform. Consequently there is little, if any, fluctuation of the torsional stresses in the propeller shafting. If, then, we can ascertain the torque at only one point in each revolution, it may be assumed that, knowing the revolutions, we have all the information required to calculate the work done. It is very different, however, in the case of reciprocating engines. The turning moment is anything but uniform, there are several points of maximum and minimum torque in each revolution:

in fact, it is not an unknown experience to find that at one or more points in each revolution the torque is negative, that is, the propeller, acting as a flywheel, overruns the engine and actually pulls the engine round after it. In all cases of reciprocating engines therefore, it becomes necessary to read off the torque at several points in the revolution, the more points the better. The mean torque is then taken in making calculations of power. For a clear appreciation of the problem of torque measurement it is expedient to keep the foregoing facts well in mind, anl principally to remember that we are dealing with extremely minute angles: for it is no exaggeration to say that an error of a hair's breadth may mean a difference of several hundred horsepower in the result.

Before applying any form of torsion-meter to a shaft, we must know its "modulus of rigidity," that is, how much it will twist with a given static load applied at the end of a lever of known length. This can only be done satisfactorily in the workshop, preferably on a long rigid lathe bed (Plate XIII.). One end of the shaft is securely fixed and a twisting moment applied at the other end. To eliminate the effect of friction in the supporting bearing at the free end it is advisable to use two levers, one at either side, as shown in the illustration, and the loads are preferably applied by graduated spring balances. Two pointers independent of the load levers are secured to the shaft as far apart as practicable, and the difference in the angular movement of these two pointers gives the true twist for that length of shaft. If the pointers are made 57·3 inches long from the shaft axis, their ends will describe 1 inch of arc for 1 degree of twist, and a decimally-divided straight edge will then measure the twist to within $\frac{1}{100}$ of a degree, which is quite near enough for all practical purposes, and we can proceed to calculate the modulus of rigidity from the formula.

Observe that a propeller shaft is subject to two distinct stresses. Not only is it twisted as between the engine and the propeller, it is also compressed longitudinally by the propeller thrust, the compressive stress being sometimes as much as 20 per cent. of the shear stress at the surface of the shaft, produced by torsion alone. This compression augments the torque by an appreciable amount, which has been actually measured in numerous experiments, and may be taken roughly as 3 per cent. for hollow shafts and 1 per cent. for shafts which are solid. It might be considered sufficient to calibrate only one shaft in a multiple screw vessel; but it is found that similar shafts, with identical tensile and elongation tests, have different moduli of rigidity probably due to their varying elastic limits and some slight difference of homogenity in the material. The only way therefore to ensure accuracy is to calibrate each shaft separately; and we may then construct a power diagram, as shown in Plate XIX. for each.

Another point to bear in mind is that a working propeller shaft is "alive," and this condition must be imitated as far as possible during calibration by jarring the shaft with repeated blows of a mallet so as to keep the mass in a state of molecular vibration. Otherwise the phenomenon of mechanical hysteris, so marked in some static experiments, will obtrude itself and vitiate the results.

Having established the true modulus of rigidity for each shaft, we may proceed to build up our power diagrams based on the formula,

$$H = \frac{\theta D^4 N}{CL},$$

where H = shaft horsepower, θ = torque in degrees, D = diameter of shaft in inches, N = number of revolutions per minute, C = constant varying with the modulus of rigidity, and L = length of shaft in inches. In this formula we have all the elements for obtaining the shaft horsepower, and it only remains to ascertain the number of degrees of torque by means of a reliable and accurate torsion-meter. Naturally a mechanical engineer would employ mechanical means for the purpose, in the first instance at any rate, and we will describe two such means that have been tried with varying success.

Dr. Fottinger's apparatus (Plate XIV., Fig. 1) has been used on several German boats, and consists essentially of two stiff tubes encircling but free of the shaft, except at their remote ends, where they are rigidly secured to the shaft. The free ends of each tube are brought together and terminate in a pair of disks, the disks revolving with the shaft in parallel planes. Assuming the disks to be 2 feet diameter and the two points on the shaft to which the tubes are secured to be 10 feet apart, the edges of the disks will then have about ¼ inch movement relative to one another at full power. Means are introduced to multiply this movement by the employment of links and levers, and the torque is recorded by an indicator pencil moving round a fixed paper cylinder concentric with the shaft. When there is no torque the line drawn by the pencil is a continuous circle in the same plane, and this line represents the zero or base line from which the subsequent torque indications are measured. When the shaft transmits power "ahead" the indication for varying torque as in a reciprocating engine is a wavy line on one side of the base line. For "astern" power the indication is, of course, on the opposite side. The back lash of the link work is taken up by light springs to steady the pointer or pencil.

Several diagrams taken by a Fottinger meter are shown in Fig. 2 (Plate XIV.), which exhibit clearly the fluctuating torque of shafting driven by reciprocating engines, and at full power a negative torque is seen, as previously referred to, at that period of the revolution where the propeller overruns the engine.

Another form of mechanical torsion-meter is that of Mr. Collie's (Plate XV.). Instead of tubes encircling the shaft, which are limited in length by the distance between the couplings and the plummer block bearings, two light counter-shafts parallel to the main shaft and driven from it at their remote ends by sprocket wheels and chain gearing are carried overhead. Their free ends are screwed into each other, one of them forming the nut and having a limited longitudinal movement, whilst the other has none, merely revolving in a small thrust block. As one end of the main shaft revolves slightly in advance of the other, the countershafts screw themselves into or out of one another according to the direction of rotation of the main shaft by an amount depending on the power transmitted. The longitudinal movement is transferred to a pointer and rendered visible on a dial which is graduated on either side of the zero into so many degrees of torque "ahead" and "astern." The back lash of the gear is taken up by springs as in the Fottinger meter, and it is a simple matter to add a continuous recording apparatus if such be required.

As a variant on the concentric tube and countershaft methods of measuring the twist of a shaft by means of a parallel member not exposed to torque, several inventors have made use of the fact that some main shafts are hollow, and fit an inner shaft loosely fitting the bore (Plate XVI., Fig. 1). One end of the inner shaft is secured to the main shaft and to the other end is fitted a pointer or spider, the radial arms of which emerge through grooves cut in the face of a coupling between the coupling bolts. The spider shows the same movement as the remote fast end of the inner shaft, and moves relatively to the coupling at which it emerges. Various devices are adopted to show and record the relative movement which, of course, gives the torque of the main shaft for the length of the inner shaft.

The best known electrical torsion-meter is the Denny-Johnson apparatus (Plate XVI., Fig. 2), which has been frequently described in technical publications. Briefly, it is made up of two revolving armatures secured to the shaft as far apart as possible. Each armature had a pointed or chisel-shaped magnet which moves over but does not quite touch a finely wound coil. The coils are connected up in series through a Wheatstone bridge arrangement to a telephone receiver. When no power is being transmitted the relative positions of the revolving magnets and coils are identical at each revolution, and no sound is heard in the telephone receiver. But when the shaft twists, the armatures get "out of step," as it were, and a clicking sound is heard until the pointer in the recording box is moved by an amount equal to the number of windings in the coils, indicating that one magnet is ahead of or astern of the other, until silence again ensues, and thus the angle of torque is caught and measured.

Some time ago, Mr. Gardner, of Fleetwood, made an electrical torsion-meter based upon the varying amount of current permitted to flow through a wire connected up to an ordinary ammeter (Plate XVII., Fig. 1). Notched disks or interrupters are fitted to the shaft at a reasonable distance apart. The notches are filled with non-conducting material and so spaced that the conductor and non-conductor are the same length measured round the periphery of the disks. A brush lays lightly against the edge of each armature, the width of the brush tip being exactly equal to the length of a notch. When no torque is being transmitted, one brush is in full contact on one disk, and the other brush is adjusted so as to be just out of contact on the other disk. Therefore the circuit is interrupted, no current flows through the system and the ammeter stands at zero. Immediately the shaft twists, however, the relative positions of the disks and brushes are altered, and current flows through the system until a maximum is reached when both brushes simultaneously overlap the conductors by half their width. The width of the brushes and notches are pre-determined to register the full power torque of the shaft.

Recently, Messrs. Barr & Stroud, the makers of the artillery range-finder which bears their name, have brought out a torsion-meter which is apparently based on the same idea as that of the Gardner apparatus: but no details are as yet available.

Clever and ingenious as these mechanical and electrical instruments undoubtedly are, and manufactured with the greatest possible skill, they all leave something to be desired in the matter of accuracy when it comes to the measurement of power. Every link in the chain between the main shaft and the recording apparatus introduces a possible source of error, and, as has been pointed out, an error even of the proverbial hair's breadth means a fairly large percentage error in the horsepower result. In mechanical torsion-meters the multiplying gear necessarily involves a multiplication of whatever error there might be: whilst there are more insidious causes of error which creep in in an electrical apparatus such as variations due to battery resistance, temperature effects, slight dragging of the commutator sections and brush tips, metallic dust or damp on the contact surfaces, and so on.

We turn therefore to other methods, and proceed to describe those torsion-meters which depend on the action of a beam of light.

Herr Frahm, of Germany, and Professor Hopkinson, of Cambridge University, have been working for some time on the same lines and each has evolved an apparatus so similar that probably the same description will suffice for both (Plate XVII., Fig. 2). Starting with the concentric tubes and parallel disks of Fottinger's mechanical apparatus or their equivalent, the link work for recording purposes is dispensed with and a small plane mirror is used pivoted to the edge of one disk, and oscillated by a projection on the other disk. As the relative movement between the disks increases, so the plane of the mirror is altered. A beam of light from a fixed lamp is projected on to the edge of the disks, and at each revolution of the shaft it is caught on the mirror and reflected on to a graduated scale.

In a dark chamber such as a shaft tunnel the streak of light from the mirror on the rapidly revolving apparatus is almost continuous, and the graduations are read off with tolerable ease; but the almost inevitable spreading of the light beam adversely affects the accuracy of the reading.

Mention should be made of a neat torsion-meter device invented by Amsler of planimeter fame (Plate XVII., Fig. 3). A concentric sleeve is fitted on the shaft and the free end brought close up to a fixed collar. A short scale is engraved on the collar, and a pointer or vernier on the free end of the sleeve, something like the marks on a micrometer calliper gauge. As the shaft twists the pointer moves along the scale. The problem now is to read the scale as it is flying round with the shaft. Here advantage is taken of the instantaneous duration of an electric spark. Contacts are fitted on the shaft just in advance of the scale, and the spark throws a powerful light on to the polished scale once in each revolution: so that the scale, however, fast the shaft is revolving, appears to stand still, and thus the torque in degrees is read off directly.

The Bevis-Gibson flashlight torsion-meter (Plate XVIII.), has undergone searching tests during the last eighteen months. Starting with the well-known physical facts that the velocity of light is practically infinite, and that light rays travel in absolutely straight lines through air of even density, it was conceived that some simple means of applying these principles to a solution of the problem of shaft torque should be forthcoming. The usual trial and error work with which inventors are so painfully familiar followed, and eventually the flashlight torsion-meter was evolved and put into use. By a mental process of elimination it was decided at the outset that the less "gear" the better. The angles to be measured are so inconceivably minute, and in a rapidly revolving shaft the time intervals are so inconceivably short, that nothing but an absolutely direct reading can give a true result.

The method adopted can be best shown by a diagram (Plate XVIII.). Two blank disks are mounted on the shaft at a convenient distance apart. Each disk is pierced near its periphery by a small radial slot, and these two slots are in the same radial plane when no power is being transmitted and there is no twist on the shaft. Behind one disk is fixed a bright electric lamp masked, but having a slot cut in the mask directly opposite the slot in the disk. At every revolution of the shaft therefore a flash of light is projected along the shaft towards the other disk. Behind the other disk is fitted the torque-finder, an instrument fitted with an eyepiece and capable of slight circumferential adjustment. The end of the eyepiece next its disk is masked except for a slot similar and opposite to the slot in the disk. When the four slots are set in line, a flash of light is seen at the eyepiece every revolution, and if the shaft revolves quickly enough the light will appear to be continuous. This effect is apparent at anything over 100 revolutions per minute. At lower speeds the flash is seen to be intermittent, but this in nowise effects the accuracy and reliability of the result. At each end of the shaft therefore we have what is virtually an instantaneous shutter fixed, be it noted, directly to the shaft, and there is no connecting link or gear between the disks either mechanical or electrical, except the beam of light which flashes once in each revolution clear through the two shutters. Let us suppose now the shaft to be transmitting power. One disk lags behind the other by a definite amount, and although three of the slots are still in line, the fourth slot, namely, that in the lagging disk, effectually blanks the flash and no light is seen at the eyepiece.

This is where the function of the "torque-finder" (Fig. 11, page 160) comes in. To pick up the light again the eyepiece must be moved by an amount equal to the circumferential displacement of the lagging disk. This is accomplished by manipulating the micrometer spindle of the torque-finder, on which is a scale and vernier graduated in degrees. While the scale is fixed its vernier moves with the eyepiece, and the graduations are so marked that by the aid of a simple microscope conveniently hinged, differences of $\frac{1}{100}$ of a degree can be readily discerned. For shafts of ordinary size the scale is set at 14·325 inches radius from the centre of the shaft, so that the degrees are $\frac{1}{4}$ inch apart. One-hundredth of a degree therefore means $\frac{1}{100}$ of $\frac{1}{4}$ inch, or $\frac{1}{400}$ of one inch. As an ordinary shaft twists 1 degree in 10 feet at full power, it is therefore possible to get the shaft horsepower to within 1 per cent. of full power. But as it is frequently possible to fit the disks 40 or 50 feet apart, even this accuracy may be improved upon, and

FIG. 11.—TORQUE FINDER OF FLASH-LIGHT TORSION-METER (BEVIS

ɜ ascertained to within ¼ of 1 per cent. of full power. Users ordinary steam engine indicator will readily appreciate this means, for indicated horsepowers are frequently y erratic. When we consider that a steam engine cylinder n some thousands of times greater in area than the small tor piston, we get some faint notion of the effect of multion of error. Add to this the friction of the engine, the piston rod, the guides, and the connecting rod joints, e begin to realise how much more reliable is shaft horse- than indicated horsepower. For purposes of scientific especially in re- e to ship propul- the latter term no doubt soon ıe obsolete, and into the com- ve obscurity of al horsepower her like terms.

e slots in the ı-meter disks ecessarily of ap- ble width (Fig. ıd in moving the ı-finder over the is visible for distance along ale. The light

FIG. 12.—DIAGRAM OF SLOTS ILLUSTRATING METHOD OF USING THE EDGES TO GET FINE READINGS.

into view, attains a maximum amplitude and brightness ıdes away as the eyepiece moves along the scale. If it ossible to gauge the exact point where the light attains a ıum, that is the point that would be used. Failing this, er, use is made of one edge of the slot. The finder is always in the same direction in taking readings, and d at the exact point where the light is cut off. So delicate sense of sight that a movement of $\frac{1}{100}$ of a degree is suffio mark the difference between light and darkness. A zero g is taken when the shaft is revolving idly, if possible near full speed, and this reading forms a base and is subl from any subsequent power readings.

Let us see how this works in practice by employing a mechanical lantern slide. First, suppose the shaft to be revolving idly. The finder is moved over until the light is just disappearing, and the vernier is seen to be standing at ·53 degree. Now, suppose the shaft to be transmitting power. The disks have twisted relatively to one another, and no light is seen until the torque finder is moved the same amount. Having picked up the light the finder is worked gently over until the light is just disappearing again. The reading is now 2·39 degrees. Subtract from this the zero reading of ·53 degree and we get the true torque, namely, 1·86 degrees. Now, to apply our shaft horsepower diagram (Plate XIX.) referred to in the earlier portion of this paper. We will suppose that the revolutions are 475 per minute. The torque is 1·86 degrees, and finding the intersection of the lines on the diagram the power is seen to be 3,620.

It is perhaps scarcely necessary to point out that the whole operation takes much less time than its description. Indeed, it is possible to produce the shaft horsepower on a trial trip immediately on the termination of each measured mile run, and to hand a slip to the officer in charge similar to that shown in the following table, containing all the information, in plenty of time for him to make any necessary adjustments before coming back on the straight for the next mile.

FLASHLIGHT TORSION-METER RESULTS.

Engines, No. 1215.

Vessel, H.M.S. "Indispensable." Date, 31st November, 1907.
Trial, Official Full Power. At Clyde.

Shaft.		Run.	Steam at H.P. Recvr.	Revs. per Minute.	Reading.	Degrees Torque.	Shaft Horse Power.
Stard.	Wing ...	IV.	180 lbs. □″	710	5·90	1·26	8,300
	Centre ...			680	6·02	1·20	7,480
Port	Centre ...			687	4·64	1·21	7,520
	Wing ...			707	5·74	1·23	8,270
Mean revolutions				696	TOTAL ...		31,570

For reciprocating engines a simple modification of the flashlight torsion-meter enables the operator to take several readings—usually twelve—in one revolution of the shaft. The disks are perforated with 12 slots arranged in the form of a spiral—one at each 30 degrees of the circumference (Plate XVIII.). The light and torque-finder must be moved radially from the shaft, so as to bring them into line with each corresponding pair of slots in the disks. By spotting the readings on a sheet of squared paper and sketching in the curve (Plate XX., Fig. 1), we get an actual twisting moment diagram from which the mean torque is readily obtained. The mean torque with the revolutions is then referred to the power diagram and the shaft horse-power read off as before.

This modification of the apparatus is only required in the case of shafting driven by reciprocating engines. In a recent vessel an interesting comparison in this connection was made (Plate XX., Fig. 2). A crank-effort diagram was built up in the usual way from the indicator diagrams, due allowance being made for the effect of the inertia of the moving parts, and the torsion-meter twisting moment diagram drawn down to the same scale. The latter curve corresponds closely with the crank-effort diagram, but the variation from the mean is greater in the shaft torque diagram, due probably to the action of the propeller and the torsional oscillations thus set up. It will be noticed that the dotted shaft diagram is consistently below the crank-effort diagram, the mean difference being about 10 per cent. This difference corresponds almost exactly with the result obtained by steaming and indicating the engines disconnected from the propeller in the wet basin before the underway trials, and forms a striking check and corroboration of the two curves.

Cases sometimes occur, especially in modern warships, where a long length of shafting is not available for torsion-meter purposes, and recourse must be had to a special form of apparatus. To meet this contingency, another modification of the flash-light torsion-meter is used, in which the beam of light, instead of flashing axially along the shaft, is made to flash radially through slots in concentric drums, and is caught by a torque-finder at some distance from the shaft axis (Plate XXI.). The drums are fixed to the shaft only two or three feet apart, and the relative movement due to shaft torque is naturally very much less than that of the disks in the axial form of torsion-meter. A masked lamp is fitted inside the smaller drum next the shaft, and so close to the drum that when the shutter opens the source of light is exactly at the shutter. The outer drum is made as large in diameter as can be conveniently arranged, the radial distance between the drums, as compared with the distance of the torque finder from the source of light, giving by direct proportion the required multiplication of effect, and enabling the torque as before to be read off with extreme accuracy, considering the short length of shaft available. The light in this case is cut off by three knife edges—one at the lamp, one at the inner drum, and one at the outer drum, the eyepiece being fitted with a diaphragm pierced by a minute pin-hole in the centre. The extreme sensitiveness of the apparatus is almost incredible. The angle of the flashing beam proceeding radially from the shaft can be measured to $\frac{1}{1000}$ of a degree, so that although only three feet of shafting may be available the result is as good as if a 30 feet length had been used with an axial-ray apparatus.

Radial flash torsion-meters are not quite so simple in construction as the axial-flash type: but there are certain obvious advantages besides its applicability to a short length of shafting. For instance, the flash might be led vertically upwards through a tube in a deck immediately overhead and the readings taken at will in the seclusion that a cabin grants, instead of in the engine room or tunnel.

In the practical application of the flashlight torsion-meter to various vessels fitted with steam turbine installations some very interesting results have been forthcoming, which are set out in tabular form in the table on page 165. Attention is specially directed to the immense range of the apparatus. Some of the low powers recorded are less than half of 1 per cent. of the full power. If indicated horsepowers of such small amount were required to be taken from a piston engine, the indicator spring would have to be changed for a very weak one to get a reasonably accurate card: but no such change is required in the apparatus we are considering.

Then again the distribution of power in a turbine installation can only be approximately estimated. The steam is turned into the high pressure turbine and left to follow its own devious course through the successive turbines on its way to the condenser. At low powers it is sometimes found that the high

"TURBINE STEAMER"

FLASH-LIGHT TORSION METER.

ACTUAL READINGS & CORRESPONDING HORSE POWERS TAKEN DURING TRIAL TRIPS UNDER VARYING CONDITIONS OF DISPLACEMENT & PROPELLERS.

TURBINE SHAFT		DEGREES TORQUE	REVS. PER MIN.	SHAFT HORSE POWER	S.H.P. TOTAL
STARBOARD	L.P.	1·43	482·9	2775	
CENTRE	H.P.	1·69	461·2	2600	7975
PORT	L.P.	1·37	472·8	2600	
STARBOARD	L.P.	1·32	461·2	2410	
CENTRE	H.P.	1·65	426·8	2330	6940
PORT	L.P.	1·24	457·3	2200	
STARBOARD	L.P.	1·15	426·4	1970	
CENTRE	H.P.	1·52	417·6	2080	5960
PORT	L.P.	1·13	418·9	1910	
STARBOARD	L.P.	1·05	418·4	1765	
CENTRE	H.P.	1·52	422·3	2120	5555
PORT	L.P.	1·02	415·5	1670	
STARBOARD	L.P.	·21	198·6	162	
CENTRE	H.P.	·27	206·3	185	495
PORT	L.P.	·19	183·5	148	
STARBOARD	L.P.	·22	146·7	88	
CENTRE	H.P.	·21	171·4	87	257
PORT	L.P.	·13	144·8	82	
STARBOARD	L.P.	·07	46·3	13	
CENTRE	H.P.	·05	86·1	15	37·2
PORT	L.P.	·01	24·4	9·2	

pressure turbine shows the most power, whilst for overloads the lower pressure turbines have the advantage. In Plate XXII. the percentage distribution of power is shown by three sets of figures—for a three-shaft turbine installation, including high pressure and intermediate cruising turbines. Set A shows the estimated or designed distribution, Set B the calculated distribution from the pressure gauge readings at the terminals of each turbine, and Set C shows the actual distribution of power over the three shafts as ascertained by flashlight torsion-meter readings. On the basis of heat units recorded the starboard propellers should be doing the most work; but the torsion-meter shows the greater power in the port shaft. A clear case for investigation.

Referring again to the table on page 165, it will be seen that the starboard low pressure turbine shows throughout the series more power than the port. Investigation showed that the blade tip clearances of the two turbines differed slightly, and a further comparison proved that the percentage difference of clearance was just sufficient to account for the differences of shaft horsepower recorded.

In a recent progressive trial of a vessel fitted with triple expansion engines, flashlight torsion-meter readings were taken at varying speeds, as shown in Plate XXIII. Plotting these results in the manner before described, we notice an almost alarming fluctuation of torque as the power increases, and at one point, namely, where the intermediate crank is at right angles coming up, and the low pressure has just opened full to steam on the down stroke, the high pressure being just past cut-off, the propeller overruns the engine and the torque is negative.

Other observations and comparisons might be made: but enough has been said to indicate the advantages and possibilities of shaft horsepower results, and we must conclude that whichever type of torsion-meter comes into general use on the inexorable principle of "the survival of the fittest," the torsion-meter in some form or other has come to stay.

A working model of a torsion-meter was exhibited by the writer of the paper, and was at the close examined by many of the members with much interest.

The discussion was adjourned and the meeting dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWENTY-FOURTH SESSION, 1907-1908.

PROCEEDINGS.

THE FIFTH GENERAL MEETING OF THE SESSION WAS HELD IN THE LECTURE THEATRE OF THE LITERARY AND PHILOSOPHICAL SOCIETY, WESTGATE ROAD, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, FEBRUARY 21ST, 1908.

THE PRESIDENT, W. H. DUGDALE, ESQ., M.INST.C.E., IN THE CHAIR.

The SECRETARY read the minutes of the previous meeting held in Newcastle on Friday, January 24th, which were confirmed by the members present, and signed by the President.

The PRESIDENT appointed Mr. G. J. Carter and Mr. D. R. MacDonald to examine the voting papers for new members, and the following gentlemen were declared elected:—

MEMBERS.

Bayliss, Wilfrid, Engineer, 14, Wentworth Place, Newcastle-upon-Tyne.
Clegg, William George, Engineer, 13, Simonside Terrace, Heaton, Newcastle-upon-Tyne.
Selby, Christopher H., Engineer, 26, Cobbam Road, Westcliff-on-Sea, Essex.

ASSOCIATE.

Gillie, John Wilson, Nautical Instrument Maker, New Quay, North Shields.

GRADUATES.

Mountney, Chas. F., Engineer Draughtsman, 7, Caroline Street, Jarrow-on-Tyne.
Pellow, Ernest John, Engineer, 3, St. Bede's Terrace, Sunderland Road, Gateshead-on-Tyne.

THE INSTITUTION SCHOLARSHIP.

The PRESIDENT said—Before commencing our ordinary business I would like to mention that the Council has decided to grant a scholarship to pupils or apprentices biennially to the extent of £50 per annum. The first examination will take place in the rooms of the Institution, on September 15th of this year, and will embrace the following subjects:—

English: Grammar and composition.
Arithmetic: Algebra, up to and including the Binomial Theorem.
Geometry: The first six books of Euclid, or their equivalent.
Trigonometry: Up to and including the solution of plane triangles.

The rules and regulations have been already forwarded to the Graduate Section, because it is arranged that only those who are Graduates of the Institution are eligible to compete, but I mention this to-night to the members, so that they may tell some of their younger friends to induce them to become Graduate members, and therefore become eligible for this scholarship.

The reply of Mr. H. R. Jarvis to the discussion on his paper on "Floating Docks" was postponed.

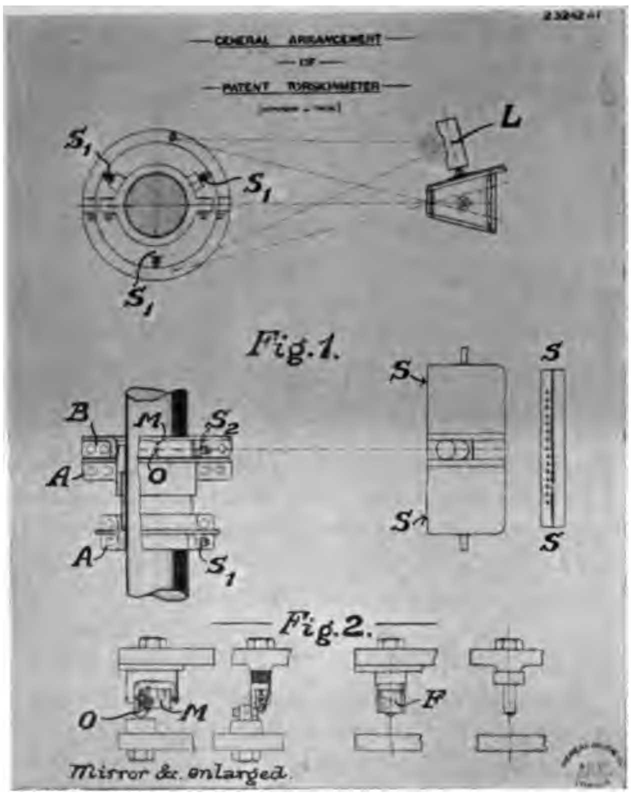
The discussion on Mr. J. Hamilton Gibson's paper on "Torsion-Meters, as applied to the Measurement of the Horse-power of Marine Steam Turbines" was resumed.

Mr. A. E. LONG submitted a paper on "Notes on the Form of High-speed Ships."

RESUMED DISCUSSION ON MR. J. HAMILTON GIBSON'S PAPER ON "TORSION-METERS, AS APPLIED TO THE MEASUREMENT OF THE HORSEPOWER OF MARINE STEAM TURBINES."

The PRESIDENT said—Professor Hopkinson wrote and said he would like to speak on the subject, but he is unable to come. However, Mr. Thring, who has been associated with him in the invention of a torsion-meter, will act in his place.

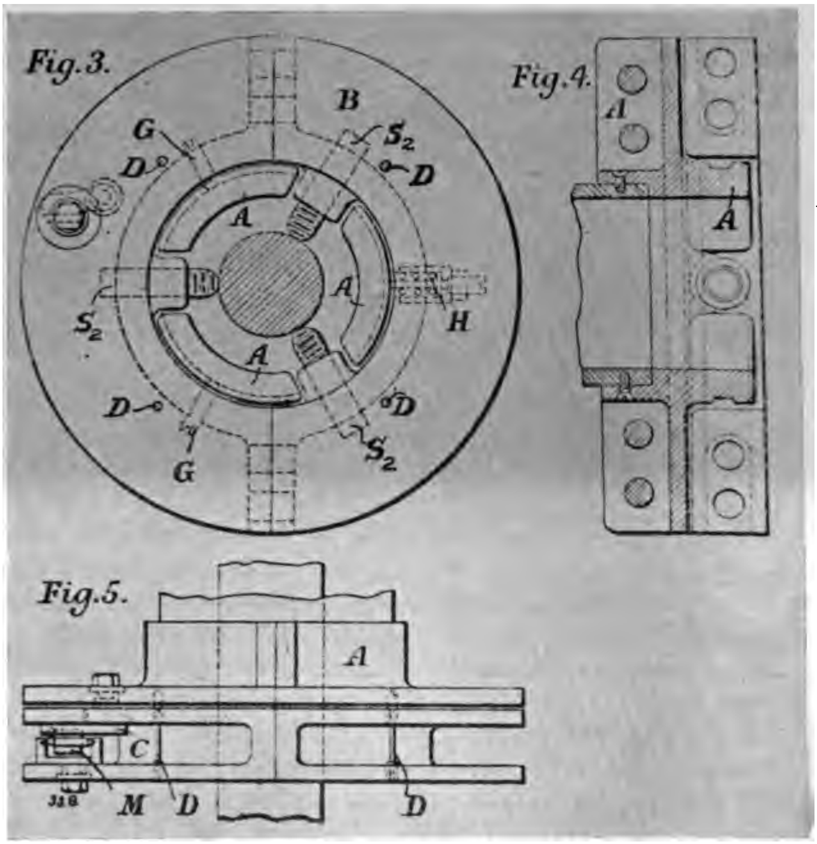
Mr. LEONARD G. P. THRING said—The Hopkinson-Thring torsion-meter, in common with all other meters depending for their action on the elasticity of a shaft, is designed to make visible the relative angular displacement that occurs between two sections of a shaft when it is subjected to torque. The authors have endeavoured to produce a reliable instrument which can be used on shorter lengths of shaft than have hitherto been required by this class of meter, in order to make it available for use in situations where only a foot or two of shaft is available for fixing an instrument. Such cases are of frequent occurrence, especially in destroyers and other small vessels. Since the angle of shear measured at the surface of a shaft is only about $\frac{1}{2000}$ when working under normal conditions at full load, it follows that the relative displacement of two points on the surface 12 inches apart will be $\frac{12}{2000}$ or ·006 inch, and an instrument for use on this length of shaft must be capable of accurately recording such a motion in a manner that can be easily observed. It will be seen that the first part of the problem to be solved consists in finding suitable means of recording the very small motion produced by the twist on a sufficiently magnified scale, and the second, and equally important part, consists in ensuring that the record shall be a true one unaffected either by vibration, bending of the shaft, or by the alterations in length that occur owing to the thrust of the propeller, and changes of temperature. The solution adopted by the authors, which represents in all essential features the meters now manufactured under their patent by Messrs. Siemens Brothers, is illustrated in the accompanying diagrams. Fig. 1 shows the general arrangement of a meter mounted on a shaft. It consists of a sleeve, A, clamped to the shaft by the three radial screws, S_1S_1, and a collar, B, similarly clamped by the three screws, S_2S_2. The collar, B, and the adjacent end of the sleeve, A, are each provided with deep flanges that serve to stiffen the instrument and to support a concave mirror, M, and a stop, O, respectively, by means of



which the relative angular motion of the two flanges is recorde[d]. The mirror is attached to a spindle mounted radially on t[he] flange, B, and is provided with a short arm ending in a harden[ed] steel ball, which is kept in contact with the plane surface of t[he] stop, O, by means of a spring.

When the shaft is twisted, the flange A will rotate relativel[y] to the flange B by an amount proportional to the twist, causin[g] the stop, O, to move the ball and thus tilt the mirror. The angular movement of the mirror is shown by placing an incandescent lamp, L, opposite the instrument and allowing the vertical filament of the lamp to be reflected by the mirror and focussed on a scale, SS. The beam of light reflected on the scale is deflected through twice the angle turned by the mirror and crosses the scale once in each revolution of the shaft, appearing as a bright vertical line. By adjusting the length of the mirror arm, any required degree of sensitiveness can be obtained. In practice it is found convenient to adjust the latter so that the beam of light reflected on the scale may turn through an angle 200 times as great as the angle of shear occurring in the material at the surface of the shaft. If the angle of shear is $\frac{1}{2000}$, corresponding to a maximum shearing stress of from 5,000 to 6,000 lbs. per square inch, then the angle turned through by the beam of light will be $\frac{200}{2000}$ or 1-10th. With the scale placed 50 inches from the mirror, this corresponds to a deflection of $\frac{50}{10}$ inches = 5 inches. The scale has 20 graduations per inch, giving 100 graduations in the above length.

The width of the line of light seen crossing the scale is about $\frac{1}{30}$ inch, so that its position can be easily noted with an error of less than half one division. This method of measuring the twist by means of a mirror and scale has the advantage of enabling every variation in the torque to be measured, and, since the torque is constantly varying through a range of several per cent. owing to torsional oscillations in the shaft, changes in the immersion of the propellers, and the like, the authors are of opinion that a better mean reading can be arrived at by this method than by systems employing any form of searcher. Observations obtained by the latter methods take account only of those revolutions where the torque coincides with the position for which the searcher is set, while momentary variations remain unrecorded. To secure that no other causes except the small relative rotations of the sleeve and collar about the axis of the shaft shall produce deflection of the mirror, it is necessary to so couple the two parts together that any motions occurring between them may leave the direction of the centre line of the mirror arm unchanged. The method adopted for insuring this is shown in Figs. 3-5. Fig. 3 shows an end view of the collar clamped to the shaft by three radial screws, S_2S_2. AA represent three projections at the end of the sleeve, two of which engage with the rounded points of two screws, GG, passing through the collar, the engagement being definitely secured by means of the spring, H, which passes through the opposite side of the collar and presses against the third projection on the sleeve. The effect of this coupling is to prevent any motion occurring in its own plane between the sleeve and collar, except that due to



rotation about the axis of the shaft. It will be seen that all other possible motions which may occur between the sleeve and collar can be reduced into one of sliding in the direction of the axis of the shaft, which always occurs when its temperature changes or the thrust of the propeller alters, and one of bending about an axis in the plane, GGH.

By fixing the stop, O, on the sleeve so that its surface is perpendicular to the plane, GGH, it is obvious that the sliding merely causes the ball of the mirror to move over the surface of the stop, O, without giving the mirror any rotational motion about its axis. By selecting a suitable position along the axis of the shaft for the plane of the coupling, GGH, relative to the clamping planes, S_1S_1 and S_2S_2, and the parallel plane passing through the axis of the mirror, it is possible to insure that the bending also, while it may cause motion to occur between the ball and the stop over the surface of the latter, shall not produce any rotation of the mirror about its axis. In the example illustrated, the three planes, GGH, S_2S_2, and that containing the axis of the mirror, coincide, which is the simplest but not the only arrangement that satisfies the required conditions.

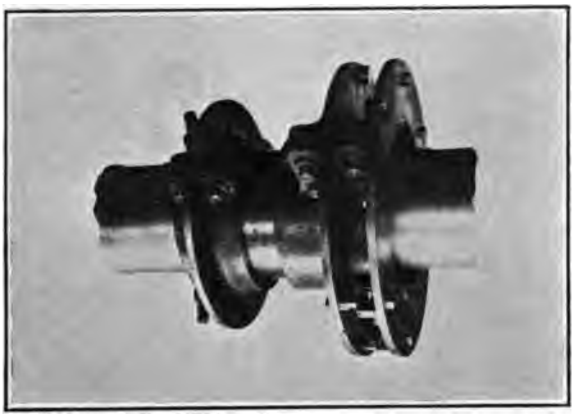


FIG. 6.

In addition to the working mirror that registers the torque, a fixed mirror, F (Fig. 2), is provided clamped to the flange of the sleeve. The latter gives a constant reading on the scale, unaffected by torsion of the shaft, and is used to correct errors that may occur through alterations in the relative positions of the lamp, scale, and meter. Any displacement of this kind will cause the readings from the fixed mirror and working mirror to alter by the same quantity, so that the scale can be readjusted by moving it lengthways to its former position opposite the fixed mirror. It is convenient to adjust the latter so that the reflection from it coincides with that from the working mirror in its zero position.

The flexible steady pins, DD (Figs. 3 and 5), are for the purpose of holding the two parts of the instrument together in their correct positions when the meter is being clamped on the shaft. The instrument is made in two halves so that this can easily be done, and the centreing is readily effected by means of the radial screws.

Figs. 6 and 7 show one of three meters recently used on the 8-inch shafts of a destroyer during her trials with satisfactory results. Twelve inches of shaft were available in this case, and these instruments are about 14½ inches long over all. At full power the deflection was about 70 scale divisions. The image vibrated over about four divisions in consequence of the

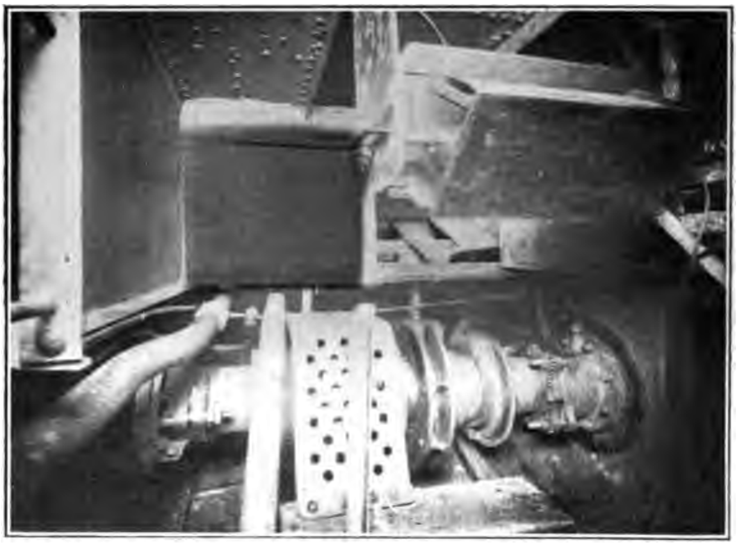


FIG. 7.

changes of torque referred to above, but it was easy to estimate its mean position within one division. The zero of the instrument remained constant, and there can be no doubt that the estimate of mean torque was correct within 3 per cent.

Mr. E. M. SPEAKMAN said—It is now some time since I heard about the flash-light meter Mr. Gibson has described in his paper and am glad to note the development that has taken place in the same. The diagram he refers to on Plate XXIII. shows a series of curves taken by the flash-light instrument, and these indicate a curious feature that is occasionally obtained from reciprocating engines, and that is, negative torque. Whether this is a genuine phenomenon and the propeller is really dragging the engine round at a certain point in each revolution, it is very hard to say. Other investigators, such as Herr Frahm, of Hamburg, and Dr. Fottinger, of the Vulcan Company, have found the same thing when measuring German vessels with other types of meter. It seems to me that there is a possibility that the inaccurate measurement of the indicated horsepower may account for an inaccurate shape of curve at such points, and that the torsional oscillation of the shaft is not really sufficiently great to permit the propeller to advance in front of the engine. It is noticeable, however, that Mr. Gibson has found the same phenomenon as other investigators and it will be very interesting to have more information on this point. All the gentlemen who are making torsion-meters and reading papers about them, appear to accept this instrument as absolutely accurate. It seems rather a curious thing to me that nobody, except Dr. Fottinger, as far as I know, has tried one of these instruments against a water brake. It will be rather interesting to know how the results would compare, because the accuracy of torsion-meters deserves a good deal of attention. It may be that the indications of negative torque are due to inaccurate torsion-meter readings as much as to inaccurate indicator readings, though I think the balance is very considerably in favour of the accuracy of the torsion-meter. In any case one would only get this violent torsional oscillation in badly balanced engines. Diagrams have been taken on the Fottinger meter—as a matter of fact, they were taken on a size of paper composed of two indicator cards gummed together—during the progressive trials of the "Kaiser Wilhelm II." At low powers the fluctuation in torque was very slight, but at high powers there was a distinct wave in the diagram, but in no case was there anything so marked as there is in Mr. Gibson's diagram, or in the case of the German cruiser "Hamburg," which he quotes as an example of the work of the Fottinger meter. Mr. Gibson hardly refers to the question in this paper, but it is similar in general lines to one that he read before the Institution of Naval Architects, when he spoke of propeller efficiency. The best way to obtain this is, of course, to determine brake horsepower and tank horsepower, but to do so accurately is no easy matter. Although it is now possible to get brake horsepower with a very small margin of error, the tank horsepower is not so easily obtained, so that the propeller efficiency remains as indeterminable as ever. On page 152, Mr. Gibson says: "A turbine, unlike reciprocating engines, passes almost as much steam when standing as when revolving at full speed." I do not think that is quite the case except when the shaft is prevented from revolving, which I suppose the writer of the paper understood. It should also be noted that the pressure plays an important part in that, and Mr. Gibson's sentence in its present form might be misleading. On page 153, he remarks that the compressive stress is sometimes as large as 20 per cent. of the shear stress at the surface of the shaft produced by torsional lowering. After getting this paper, I worked out some examples, and I seldom found more than 13 per cent., so that I think that Mr. Gibson's is rather a high estimate. The probable explanation lies in the fact that Mr. Gibson has assumed a considerably higher propeller efficiency than I have taken.

I beg to thank Mr. Gibson for his extremely interesting paper.

Mr. Harold Thomson said—I have read, and I am sure we must all have read, this paper with a great deal of interest, because it gives us some definite information upon a subject which is of very great importance at the present time, seeing that we are now introducing turbines very rapidly for the propulsion of ships both in our navy and our mercantile marine. We have had a good deal of information, both from Mr. Gibso and Mr. Thring, and I am not able to add anything to tha information, but in the few remarks I have to make I propose t emulate Oliver Twist, and ask for more. Perhaps the autho will excuse me if I say that some portions of the paper, especiall on page 152, do not appear to me to be so clear as they might b I do not quite follow the clause concerning revolutions, and appears to me to be somewhat ambiguous. My experience that shipowners do not care a button about revolutions; the principal care is coal consumption in relation to speed. It is o the ground of decreased coal consumption that most make of feed heaters, etc., advocate their wares and not on the groun of increased revolutions. In fact it is always a marvel to m when reading these advertisements, that there should be a necessity for coal bunkers in a ship at all. I give our President this suggestion for what it is worth, that in the next economical coal carrier he builds, she should have so many of these coal-saving devices that she should positively coin coal and so be able to start from port with nothing at all and arrive at her destination full of coal. That is the tendency, according to the advertisements. As Mr. Speakman has already said, I think the author's meaning regarding the steam consumption of the turbine when standing is not clear, and it might lead the lay reader to suppose that a turbine always used the same quantity of steam, whether standing or running fast or slow. I take it that Mr. Gibson means that if a turbine was prevented from rotating, and the full steam pressure put upon it, it would then pass the same quantity of steam as when running with the same initial pressure.

Mr. Gibson lays stress upon the extreme accuracy which is necessary if correct results are to be obtained from these torsion-meters, and it is obvious that the whole method is dependent upon an extremely careful calibration of the shafts. The question in my mind is whether the calibration of the shaft can be accurate for any length of time. We know that a shaft in constant use and subject to vibration for a long period seems to change its molecular structure. This is shown by the crystalline fracture which is seen when the process is carried to an abnormal development. I take it that this change, or any change of this nature, will affect the modulus of rigidity of the shaft, and as it is a gradual and not a sudden process, I would like to ask Mr. Gibson at what intervals a shaft ought to be recalibrated. If we take the case of a fast running vessel on a long voyage, would the readings at the start and at the end be equally accurate? Mr. Gibson also tells us of the extreme accuracy with which results can be read off the torsion-meters. Has he tried two different makes of torsion-meter on the same shaft? If so, were the results identical and not merely approximately so? I would also like to ask him whether he has tested a torsion-meter by a brake, to see how the shaft horsepower corresponds with the brake horsepower. In his paper, read before the Institution of Naval Architects last year, Mr. Gibson explained the effects of varying thrust upon the torque obtained on a shaft; in the data he has given us he does not tell us whether he has made allowance for this varying thrust at different speeds. As regards the results given in the table on page 165, it is stated that they were obtained under varying conditions of displacement and with various propellers. I would like to know where these varying conditions come in. The paper does not say what changes were made in the propeller, or which runs are made with the same propeller. What I would like to know is this: suppose we consider the first item given, we see that the starboard shaft ran at 482·9 revolutions per minute, and gave a torque of 1·43 degrees with a corresponding horsepower of 2,773. Now, suppose this propeller is changed and a larger one fitted, with heavier pitch or surface, and that with the same steam pressure in the turbine the revolutions are reduced to 450. In practice as opposed to theory, what is the effect on the shaft horsepower and the torque of the shaft, neglecting any small difference that there may be in the efficiency due to the altered revolutions? Does he find that practically the shaft horsepower remains constant, or, in other words, that within a moderate range the torque increases as the revolutions decrease? As regards the comparison which Mr. Gibson gives between shaft horsepower and indicated horsepower, I notice in the diagram that the ratio of these two quantities varies from 88·4 per cent. to 95 per cent. in this particular engine at various speeds. These figures are corroborated by those given by Mr. Denny before the Institution of Naval Architects, where, on the engine on which he experimented, the figures worked out at 94 per cent. I think it unlikely that these figures would cover all the different ratios that might be obtained from all classes of engine. For instance, in the case of vessels whose engines run at a very high speed, such as torpedo boats, it is no uncommon thing to obtain a high propulsive co-efficient which may be largely fictitious, due to the fact that the correct indicated horsepower is not being ascertained by the indicator. I should like to know whether Mr. Gibson has ever come across a case where the shaft horsepower was actually in excess of the indicated horsepower.

I am sure we are all very pleased to have read this paper, and in thanking the author I would express the hope that other members will follow Mr. Gibson's example in giving us special information which they may have at their disposal. The future of this Institution is entirely in our own hands, and if we wish to maintain its position and status the way to do so is to come forward with papers like this so as to ensure that our *Transactions* shall be second to none of those of similar institutions in this country.

Mr. James Thomson said—I have read the paper with great interest, but it is a subject that I have not had any practical experience of, although I have known for many years the great importance of it. I have only one criticism to make—a verbal one, namely, that the author uses the word "torque" in a wrong sense. He says, "the amount of twist, or the torque, as we prefer to call it, is very small." Now, the word torque was introduced by my father in Glasgow University, to denote a system of forces which produces a twist and not the twist itself. I think it would be better to retain the word torque for the meaning originally proposed.

The Secretary submitted the following communications which had been received on the subject:—

Leven Ship Yard, Dumbarton,
January 28th, 1908.

Dear Mr. Duckitt,

Referring to Mr. J. Hamilton Gibson's paper upon Torsion-meters, I have to thank him for the kindly reference he makes to the torsion-meter invented by myself and Mr. Johnson. It may be interesting for the members to know that this instrument has proved itself quite suitable in practical use. One crucial trial was in the case of the "Carmania;" the instrument was left on board for the first two voyages and the after sector and magnet were more or less submerged in water almost the whole voyage, but continued to work perfectly well, as it was quite watertight. The great advantage that I claim for this instrument is that the observations are made clear of the tunnel, the recording apparatus being usually located in a quiet cabin where the observer is quite undisturbed by the noise and traffic in the tunnel.

In this cabin is also fitted the time-recording instrument, to which I referred in my paper read before the Institution of Naval Architects, so that the observer has under his immediate observation not only the torsional measure of the shaft, but also the revolutions, and the time of entering and leaving the measured distance. Mr. Johnson and I are gratified to know that our instrument has been adopted by our own and several foreign Governments, and has been proved by them in actual working.

I wish to congratulate Mr. Gibson upon the extreme ingenuity of his instrument and the delicacy of his measurements, and agree with him that any of the well-constructed torsion-meters at present available, even those that are least accurate, are much more accurate than the steam indicators, upon which we have been accustomed to base our information.

Mr. Edgecombe, of my firm, and myself have constructed a torsion-meter, using an independent side shaft geared to the shaft to be measured, by means of toothed wheels, somewhat on the lines of Mr. Collie's mechanical torsion-meter, but so arranged that the torsion is recorded by a moving pen upon a paper cylinder. This instrument has been used in a factory for ascertaining the torque of a species of rolling mill. It only takes ten seconds for the material to pass through the mill, the time is therefore so short that it would be impossible to get any measurement of the power required otherwise than by torsion. This we have been successful in doing, and I enclose you two diagrams showing the appearance of the records (Plates XXIV., XXV.), as also a photograph (Plate XXVI.) of the torsion-meter itself.

After my paper had been read at the Institution of Naval Architects in the spring of last year, Dr. Elgar received a communication from the Rev. F. J. Jervis Smith, Professor in Mechanics at Oxford University, who seemed surprised that I had not been aware of the work he had done upon the recording of torsion of shafts in the years 1894 to 1898, and which work had been recorded in the *Transactions* of the Royal Society. Mr. Smith sent me his papers, from which I found that he had anticipated my original plan of rubbing contacts and a telephone receiver, also Mr. Collie's separate shaft arrangement, and had also designed a very similar arrangement to Amsler's, of which I was not aware until I saw Mr. Gibson's paper. I have therefore taken the liberty of sending Mr. Gibson's paper to Mr. Smith, and suggested to him that it would be of value to your members if he would communicate with you as to the work he had done.

Yours faithfully,

A. Denny.

CAMMELL, LAIRD & CO., LIMITED,
BIRKENHEAD,
February 12th, 1908.

DEAR MR. DUCKITT,

I thank you for the copy of Mr. Gibson's paper on Torsion-meters and your invitation for some remarks on same. I have taken a keen interest in the problem of finding a satisfactory method of registering the amount of torque in running shafting, having tried mechanical, electrical, and light systems, and have come to the conclusion that as the movements are so small, and in most cases the length of shafting available is so short, that either of the two latter methods is the only way to give reliable results.

The first instrument I designed was of the mechanical type and has been illustrated by Mr. Gibson (Plate XV.). This gave some very interesting results showing the varying torque at different periods of starting, stopping, and reversing, and was, I think, the first instrument to show exactly what stresses were taking place in turbine shafting during these periods. It showed that the maximum torque was when the shaft was transmitting full power, and not during the periods of stopping and reversing. Owing to the necessary gearing required, it was difficult to get steady readings; there also appeared to be a considerable amount of torsional oscillation, probably due to propeller action. It seems to me that, in taking readings, this oscillation should be considered, and that it is necessary to either get a meter to give a continuous reading, or to be able to take the mean of these oscillations, otherwise only the peaks are taken and consequently the results are too high.

In my latest instrument, one form of which Mr. Gibson has also illustrated (Fig. 1, Plate XVI.), I have also employed light, but unlike his, in that mine is a radial beam of continuous light, the length of which varies with the torque. Two discs are brought close together, and attached by sleeves to the points of shafting to be measured. There are two radial slots in the discs, which when there is no torque are blanked, but as soon as torque begins, and the discs move relatively to each other, the slots overlap; a very small circumferential movement giving a long radial slot of light, which, owing to the speed of rotation, is visible when a light is placed behind the discs. I thus get a large multiplying effect without any form of gearing. I do not think it is advisable to take less than 3 feet of shafting if accurate results are to be obtained, as it is very probable that the steel has not all the same degree of flexibility, and in short lengths the error due to uncertainty of knowing the exact point of attachment may be considerable.

Hoping these few remarks may be of some interest,

I remain,

Yours faithfully,

J. H. Collie.

Leven Ship Yard, Dumbarton,
February 19*th*, 1908.

Dear Mr. Duckitt,

Mr. Gibson having kindly invited me to take part in the discussion on his very interesting paper, I very much regret that pressure of business prevents my being present in person, but I desire to avail myself of the privilege of sending a few written remarks on same. I notice that in referring generally to torsion-meters other than the flashlight, the author makes the following statement, namely: "Every link in the chain between the main shaft and the recording apparatus introduces a possible source of error," and that "the multiplying gear involves a multiplication of whatever error there might be." To at least one of the instruments mentioned, namely, the Denny-Johnson torsion-meter, these remarks do not apply, for in it there are no intermediate links which can possibly cause errors, as the deflections are not multiplied up at all but are simply transferred in their entirety from the noisy shaft tunnel in which they are obtained to any convenient cabin or saloon, where they are read off with a degree of accuracy and comfort difficult to obtain in any shaft alley.

With further reference to "intermediate links," I might point out that the "radial" flashlight torsion-meter for which the author claims such extremely accurate results—even more accurate than with the "axial" type, I believe—employs the very multiplying links which he himself condemns. He starts off with an actual deflection so small as to be scarcely measurable, and of which a very large portion might easily be due to slip at the sleeve keyways and therefore is not torque at all, and multiplies this up by means of a long beam of light proceeding direct from the shaft and caught some feet away at the torque-

r. Now, if the shaft and that portion of the hull to which orque-finder is attached chance to vibrate in unison, fairly ate results may be obtained, but as the period and direction oration are almost certainly different, the multiplication of vibration by the long beam of light, and the vibration of edestal to which the torque-finder is fixed combine to form termediate link the effect of which on the accuracy of the ngs may be very serious, and amply justify the author's con-ation of such contrivances.

ı his remarks on electrical torsion-meters, the Denny-son being mentioned by him as a well-known example of class, the author states, "that there are more insidious s of error which creep in," such as (1) variations due to ry resistance, (2) temperature effects, (3) dragging of the ıutator sections and brush tips, (4) metallic dust or damp on ontact surfaces, and so on. These remarks may be very in such cases as they apply to, but surely the author is that the Denny-Johnson torsion-meter, which is electrical nd-out, does not suffer from any of these troubles.

) We use no battery, so can have no error from this cause; emperature has no effect whatever on it; (3) we employ er commutator nor brushes, so can have no error from these s; (4) any contact surfaces we have are not on or near the but in a recording box situated in some secluded place, and anged that metallic dust or water deliberately emptied over ld not possibly affect the accuracy of the results obtained or y way affect the working of the apparatus. In this con-ɔn I may state that the Denny-Johnson torsion-meters, ı were fitted on the "Carmania" during her first voyage the Atlantic, were frequently working under some inches ge water and the results were in no way affected.

regard to the flashlight forms of torsion-meters, I notice he author makes reference to the fact that light rays travel solutely straight lines through air of even density. It is st unsafe to reckon on air of even density in a shaft alley, t there must always be streams of hot and cold air in such e, which are apt to cause trouble by bending the rays of The magnification of any slight distortion is so enor-—owing to the great length of the beam—that the errors such causes may be very serious indeed.

My experience, now extending over a good many years, of the difficulties of dealing with magnification and recording of very small deflections on board a vibrating ship, leads me to suspect that Mr. Gibson is perhaps rather too sanguine with reference to the particular method he at present favours, and which has yet to stand the test of all sorts of ship conditions.

Yours faithfully,
CHARLES H. JOHNSON.

CHADBURN'S (SHIP) TELEGRAPH COMPANY, LIMITED,
TELEGRAPH WORKS, CYPRUS ROAD,
BOOTLE, LANCASHIRE,
February 20th, 1908.

DEAR MR. DUCKITT,

I beg to thank you for your letter of the 19th inst., enclosing particulars of the next General Meeting. I regret extremely that a business engagement elsewhere prevents my attendance at this interesting discussion, and particularly as I have on several occasions seen Mr. Gibson's torsion-meter in actual use. I also was connected with the experiment on Mr. Collie's mechanical torsion-meter, which was first tried on a small vessel on the Clyde. At first we were very hopeful as to the prospects of this instrument, but it was subsequently found that the amount of running gear, and the high rate of revolutions of the counter shafts (almost three times that of the main shaft) required too much attention for practical use, particularly as it is impossible to arrange a satisfactory disconnecting gear which would throw the two sprocket wheels in and out of gear at precisely the same instant.

The simplicity of Mr. Gibson's apparatus is one of its great advantages, I think, and although I confess to having been a little doubtful of its accuracy at first, I was subsequently convinced by the fact that three different and independent observers all got the same readings to within one-hundredth of a degree. The actual point of eclipse of the flash is apparently very definite, as one is distinctly conscious of the faintest flickering glimmer of light when the finder is moved a minute distance back into the arc in which the ray is visible. This is true during a large range of speed, as the brightness of the light ray appears greater at low speeds, although one is receiving a fewer number of impressions on the retina per second. It is for this reason that I believe the radial form of the apparatus may prove successful, although so far it has not been actually properly tried. Its form would prove a great convenience where there is little room available.

Yours faithfully,
A. J. Grant.

The discussion was adjourned.

NOTES ON THE FORM OF HIGH-SPEED SHIPS.

By A. E. LONG, M.A., Member.

[Read in Newcastle-upon-Tyne on February 21st, 1908.]

The following notes upon some of the different forms which
ay be used for high-speed ships are mainly intended to pro-
ote discussion upon a subject which is of interest to all
esigners, even if they have not had the good or evil fortune
be engaged in the design of such vessels themselves. In
is connection it is also well to remember that the freak of
-day may perhaps be the orthodox vessel of to-morrow. As the
bject in its entirety is much too large for a single paper, it
ll be well to commence by stating the limitations to the scope
these notes. The length and displacement are supposed to
already determined upon; also in a general way the curve
sectional areas; our enquiry is therefore limited to the study
the form into which the leading elements already fixed can be
it. "High speed" is taken as high relative to the length of the
essel, not merely absolute speed; thus from this point of
iew a "Mauretania" is a slow vessel, and vessels of less than
alf her speed are very fast. The lower limit of speed fixed
pon is $2\sqrt{L}$, and even this is much too low to bring out the true
haracteristics of some of the types. Elementary straight line
gures of fixed length and displacement are herein used for a
omparison of type, because the types are clearly differentiated,
nd overlapping is avoided.

In actual practice it is sometimes difficult to classify a ship
s belonging definitely to one type, as vessels are in nearly all
ases—except perhaps racing motor boats—a compromise between
speed and other necessary requirements. The vessel as built is
rarely the designer's ideal of a speed form pure and simple, and
is in many cases far from it. Sometimes we meet with a vessel
whose designer has obviously set out with very definite ideas as

to type, but in the course of his labours his heart has failed him, and relicts of older ideas appear which are incongruous with the ideal, and really detrimental to it.

In some of the compromises of type which are frequently met with, the designer has annexed much more of the defects of the two types that he has amalgamated than their virtues. A secondary advantage of these simple figures is that we can deal with the forms in the abstract, without any troublesome enquiries as to whether this is, or is not, someone's favourite design disguised.

The five forms chosen, A, B, C, D, E, are shown in Figs. 1, 2, 3, 4, 5 (Plate XXVII.), and their leading elements are given in the Appendix. For simplicity the forms are shown in quasi-perspective, and the part above water omitted.

Type A.—This comes first on our list for many reasons, amongst others that it is practically the only type in use for vessels of less speed than our limit, and is the only one recognised by many people as a speed form at all. Another claim is its great antiquity, as we see it in the beautiful form of the Viking ships dug up in recent times. Its intrinsic merits are also great, and it is much to be regretted that for the very high speeds with which we are dealing it is practically impossible to use it. The merits of the form, besides the value of the great experience which we have had of its use, are fairly obvious. First, it is a very easy seaboat, on account of the well balanced wedges of immersion and emersion, both in a longitudinal and a transverse direction. Secondly, the transverse sections being deep at the ends, and in practice generally sharp, there is an absence of the violent thumping shocks which occur under certain circumstances in some of the other forms. Thirdly, the wetted surface is small.

The defects are: Firstly, the longitudinal and transverse stability are relatively small; secondly, the change of trim when driven at speeds much beyond that economical for the length is so excessive as to be prohibitive. This change of trim, moreover, is more nearly what is ordinarily known as such, namely, an actual depression of the stem and elevation of the bow, than what occurs in some of the other types where the change of trim relative to the horizon is very largely a lifting of the fore body and a reduction in the total displacement. In small vessels which are not intended to be always run at the maximum speed it may be possible to correct this defect by fitting a movable fin at each side of the after end, set at a slight angle to the horizontal; so as to act as a hydroplane. These fins might either be arranged to hinge up against the side when not in use, or could be fitted to slide in and out after the manner of a sailing vessel's centreboard. Some Canadian steam yachts are fitted with contrivances of this nature, known as squatboards, but they are placed horizontally and are fixtures. The effect is said to be very marked, but from a seagoing point of view such a structure, if fixed, could have no advantage over an ordinary flat form of hull.

Type B.—In this type, which is practically that of all modern torpedo boats, destroyers, etc., we have the same fore body as in A, but a horizontal wedge is substituted for the original vertical one for the after body. The area of the water line is increased 50 per cent. and there is a corresponding increase in the stability, both longitudinal and transverse. The wetted surface is 13 per cent. greater, but at high speeds it is probable that this is not really the case, owing to the vertical lift of the ship; the wave making aft is also so flat that there is less increase of surface there in contact with the water than in A under similar conditions.

The advantages are: Firstly, the great increase in longitudinal and transverse stability, the latter being in small single-screw vessels a matter of vital importance owing to the great torque of the propeller. Secondly, great reduction in the change of trim, and the fact that it is more due to a lift of the whole body than to a tipping action as in A. Thirdly, the angle of delivery is much reduced with the same volume of after body. Fourthly, the area available for accommodation is greater, and aft is of a more suitable shape for arrangement than in A.

The defects are: Firstly, the wedges of immersion and emersion are badly balanced, and the necessary result is a somewhat uneasy twisting motion in a seaway. Secondly, the flat form of the after-body is subject to more or less violent slamming in rough weather; in the extreme case where the sections are absolutely flat this may cause serious results, unless the structure is abnormally heavy. Thirdly, variations in draught may cause considerable differences in the resistance, apart from the actual addition or reduction of displacement, as this form of after body is really designed for one draught only.

Type C.—We now come to a type which seemingly violates all experience acquired in the past, and to most people appears to be quite new; indeed, in a paper read before the Institution of Naval Architects in 1906, it is clearly stated to be so. A little investigation of the work of the older writers on naval architecture shows that there is really nothing new in this form; it probably originated in prehistoric times from the skimming stone with which we have all been acquainted from our earliest youth. Chapman devotes part of a chapter to a discussion of the merits of two forms which are our A and C, and comes to the conclusion that C is excellent for smooth water speed, but impracticable for seagoing purposes; his summary is given in the appendix. More than half a century later, Lord R. Montague, in a very interesting little treatise on naval architecture, follows on Chapman's lines and comes to very much the same conclusions.

To yacht designers the form is well known, but with them its speed virtues are quite masked by the facilities which it presents for evading a length on the water-line measurement. The form itself has great merits, also great defects, and is probably one of the most interesting forms in actual use. The advantages are: First, maximum stability, both in a transverse and longitudinal direction. This merit, of course, appealed to Chapman even more than it does to us. Secondly, very fine angle for both entrance and delivery. Thirdly, maximum room on the lower deck, and of a shape well adapted for arrangement of cabins, etc.

The disadvantages are: Firstly, great change of apparent trim; but this is quite different from the case of A, as it is chiefly a bodily lift of the vessel, not merely a tipping about the centre as in ordinary ships. Secondly, the slamming action in a seaway at both ends may be very violent, and a vessel of this type will require to have scantlings much in excess of those calculated in the usual way. Thirdly, the wetted surface, as will be seen in the table, is 26 per cent. larger than that of A, but this is really of little importance for high speeds, as, owing to the bodily lift, the surface is actually considerably less than that given for the still-water condition. As regards the angles given, there is also in actual work a great difference from the "at rest" condition; forward the angle will be greater, but a very large portion of the body there is above water; aft the surface of the bottom will be nearly or quite horizontal, giving practically no angle, merely frictional resistance.

Some years ago, Mr. Yarrow made a series of very interesting experiments on full-sized models for international cup racers, and some of these results are available for the general good. Mr. Yarrow's conclusion seems to have been that type C was the best, but he modified it by cutting off the corners of the fore end, giving a somewhat uncouth resemblance to the bow of an ordinary vessel. Looking at the lines of this vessel as given in Mr. Smith's paper, read before the Institution of Naval Architects in 1906, and numerous photographs of her when running at full speed, some curious questions arise which are worth careful consideration. Roughly, about two-thirds of the forward wedge is in the air, where it is of no further use for speed, and, in fact, is detrimental, as it presents a large area for wind and waves to act upon. Mr. Yarrow has cut away about one quarter of this; query, could he not have cut away a good deal more and utilized the length saved for elongating the after body, as the total length was limited to forty feet?

Mr. Yarrow's experiments, and the actual performance of the vessel in a very moderate seaway, completely bear out Chapman's conclusions come to more than a century before, so that we have here another proof, if one were needed, of the great grasp of his subject which Chapman possessed.

Type D.—We have here another curious form which at first sight appears to be of very recent invention, but, as in the case of C, the origin is probably old. An instance of it in a fairly pronounced form is seen in the North-East Coast coble. Yachtsmen have also been familiar with it for many years in the well known "raking midship section;" in fact this is the raking section carried to its logical conclusion. In this type in the table the breadth has been increased, also the draught at centre, as if the breadth had been retained the draught required would have been too great. As shown in the table, the co-efficients also differ, the block being less and the prismatic more. The curve of sectional areas is a common parabola, being thus rather fuller than is generally found in ordinary forms. In practice, the curve would probably be rather finer at the ends, as the fore foot would be somewhat rounded off and the keel line right-aft slightly hollowed, coupled with a possible rounding off of the corners of the waterline. As this type is really a further development of B, its merits and defects are much the same in character, but accentuated. As to accommodation, the fore end is too fine to be of much use, and the after end inconvenient in shape. The wetted surface is not quite so large as that of C, but when running at high speeds it is probably larger as this is a type not intended to lift much forward. The transverse and longitudinal stability are not satisfactory considering the large increase of breadth.

In a seaway such a vessel would almost certainly be very wet and uncomfortable, and in some conditions dangerous. The case of the coble, however, shows that, modified, a good sea boat may result, at least in small sizes; whether a large coble would be a desirable vessel is open to question. The great difficulty in docking a large craft having such a profile, unless she had considerable additions in the way of deadwood, etc., is obvious. The French motor boats of this type seem to behave fairly well in the rather mild type of sea in which they have recently been tried, being superior to the rival type C in this respect.

Type E.—This is one of the forms of hydroplane which has been so much before the public in the last few years. Curiously enough the sketch would do equally well as representing some of the most recent designs published, or the model submitted to the Admiralty nearly forty years ago by the Rev. C. M. Ramus, so that there does not seem to have been much progress made in this direction as far as form goes. The power to drive it is, of course, another question. The late Mr. W. Froude's report upon the trials of this, and a revised model of his own, and the articles which were written on the subject in *Naval Science* and *The Annual of the School of Naval Architecture*, afford very interesting reading. They are wholly condemnatory, but the idea still lives on, so that perhaps the reverend gentleman was nearer to the mark than his critics imagined. Some extracts from these papers are given in the Appendix.

It is very difficult to compare this form with the other four, as they are more or less accomplished facts, whereas this is still in a very nebulous state. Startling stories are abroad as to what can be done with one of these craft of amazingly small dimensions, but there is a painful absence of reliable facts and figures. The first thing that will strike anyone looking at the published drawings is that even if a great bodily lift took place, there would still be a very serious eddy making behind the ends of the planes. Possibly this can be got over in time, but at present it seems to be a grave defect. As a seaboat there does not appear to be much hope of improvement. Mr. Froude gave a startling description of what would happen to a semi-flying Atlantic liner amongst waves. Some mechanical genius may come forward who can deal with the shocks to the structure from such usage, without taking excessive weight; and it must be remembered that light weight for the dimensions is an essential feature of the problem. I have not had the pleasure of making this gentleman's acquaintance, but if I do so during the discussion, my trouble in writing this paper will be amply repaid.

In concluding this part of the subject, the relative value of the five forms for very high speeds, so far as they have yet been tried, may be briefly noted. A may be summarily struck out both on theoretical and practical grounds. B is the form in general use for torpedo boat destroyers, torpedo boats, and many small craft in which high speed is not the only object sought; it is, in fact, the only one of the five which as yet meets the usual requirements, and has been thoroughly tested practically. C and D are the rival forms for motor boats; which may be taken as possible models for the ships of the future, when we can get the power to drive them. In practice, D seems to have rather the advantage over C in ordinary working conditions of weather. Under what may be called tank conditions their respective merits are still very doubtful. E is not yet in a sufficiently practicable condition to judge of its ultimate success or failure.

In all the forms dealt with, when driven at very high speeds, some curious phenomena occur. We see a vessel in a position not momentary, but for hours together, where the centre of gravity is many feet ahead of her nominal centre of buoyancy, and if of one of the flat-tailed types, she has also considerably less displacement than her total weight. In the case of E, and also, though in a less degree, of C, this latter feature is intentional, and we are met with the difficult problem as to whether it is better to use a considerable part of our available power in lifting the vessel, or to use it for driving through the water in the ordinary manner as aimed at in D. That we cannot get the lift without expenditure of power is fairly obvious. If the lift causes a considerable change of trim, there must also be a corresponding loss in power, owing to the angle of the shaft with the horizontal being increased, and as the shafts of all, or nearly all, high-speed vessels are already at a considerable angle, this loss alone may be serious. In E there is supposed to be no change of trim; in fact, this is one of the chief objects of using two or more inclined planes, but this advantage involves serious disadvantages, at least in the crude shapes which have yet been tried. Whether or no this form can ever come into even limited use is still very doubtful.

Form of the Midship Section.

As the shape of the midship section generally governs the form of the other sections for a considerable portion of the vessel's length, the consideration of it is important, and the following notes may be useful for discussion. In the previous part of this paper the mid section was taken as being in all cases a rectangle, whereas there is really a very large number of suitable forms to select from, particularly if the dimensions may be varied while keeping the given area. Even with the rectangle itself the wetted perimeter may be greatly altered by varying the ratio of breadth to depth. Fig. 6 (Plate XXVIII.) illustrates this. The areas of the sections are all alike, but the perimeter changes from 13 feet at one end to 8 feet at the other, the curve shows the wetted perimeter to a scale half that of the sections themselves. From the surface point of view the very shallow section is considerably better than the very deep one, but the minimum is found in a moderate proportion. If, however, we also consider the wave making resistance, we know from Rota's and other experiments that within the limits of the experiments the deeper sections yield less resistance, so much so as to overbalance the greater frictional resistance; this difference will naturally increase as we increase the speed, but there will possibly come a speed where the shallow section will, owing to its skimming action, give a less resistance than the deep.

Fig. 7 (Plate XXVIII.) shows some of the forms which have been adopted, or proposed, all being of the same area. Section F does not seem to have any advantages to compensate for its large relative girth, unless there are reasons for strictly limiting the dimensions; when something approaching a rectangle may allow us to use a curve of sectional areas which would otherwise be impossible. G is merely the ultimate development of the rising floor which has been a favourite feature in design in many countries and many ages. It has considerably less girth than the rectangle, but is not an economical section from the surface point of view. It involves large dimensions and in many cases an undesirable draught. In America this is a favourite type, as will be found by a study of the many published designs, but the reason for the preference is not very clear. The resulting water, ribbon and buttock lines are very clean, easy curves, and the vertical sections of the vessel forward being sharp, there is not so much hammering in a seaway as in the flatter-bottomed types. H is a true semi-ellipse, which has the great advantage of having a small girth for the given area, and compact dimensions, and it lends itself very well to development into any of our forms A, B, C, etc. For example, in a form of D type, by using the elliptical sections we can gradually merge from a vertical line forward to a horizontal line right aft without abrupt changes in the horizontal lines. An objection which may be made to the true semi-ellipse is that to many people's eyes it is too lean under the bilge, and too full about the centre line. Perhaps for this reason the true curve is not often met with; a very good example of its use will, however, be found in the launch "Lotus," the lines of which appear in the *Yachtsman* of December 19th, 1907. K is a modified section which gets over this objection, but the girth has to be made somewhat greater. The section shown is constructed by describing a circular arc with a radius of one-quarter the breadth of the vessel for the bilge, and striking a tangent in from this to the centre line to enclose the required area. It is not suggested that this construction has any particular merits; it is merely given as fairly representing many sections in general use. J, called in America the sharpie or dory type, has been introduced here, as it crops up from time to time as having some more or less occult virtues. It yields a moderately small girth, and lends itself fairly well for use in all the forms.

L is a very interesting section, patented by the great French designer, the late M. Normand, from whose specification it will be seen that the object sought is twofold—a reduction of breadth for the same metacentric height, and a lowering of the machinery—single screw—so as to get the shaft horizontal. The girth is large, but as the lower part of the section is merely a sort of crank-pit not more than half the vessel's length, the end sections are relatively more cut away than in the other types. A somewhat similar section is found in the very curious design "Napier," given in Mr. J. A. Smith's paper read before the Institution of Naval Architects in 1906. In this an attempt seems to have been made to combine type A with a flat stern. The main body of the vessel is a pure type A with very fine water lines, the length being about three-fourths of the total. On the after part of this is superimposed a flat bottomed body of very little depth which projects far enough aft to make up the total length, 40 feet. The vessel does not seem to have been very successful, but this may be due to other causes than the peculiar form of hull. M is formed of two semi-parabolas base to base. Very much the same remarks apply to this as to the semi-ellipse. The curve is a pleasing one, and well adapted for use with such of our types as have deep forebodies. Sections G, H, and M, have the common disadvantage in that they are rather cramped for room in way of the wing shafts in multiple screw vessels, and the shafts may be an inconvenient length out board. A good deal might be written about the relative strength of these forms of midship section, but we have here dealt with them from a speed point only. Figs. 8 and 9 (Plate XXIX.) are given to show how, with a fixed length, displacement, curve of sectional areas and form of load water line, we may greatly vary the cross sectional shape. Fig. 8 is of the triangular section form known in America as the Dolphin type. Fig. 9 has true semi-elliptical sections all fore and aft.

The sections like those given which are mechanically constructed, such as the rectangle, triangle ellipse, parabola, etc., are not suggested as necessarily superior to curves drawn in the usual way to suit the eye, but there is some advantage in using a constant type of curve right fore and aft, as it insures an amount of harmony between the sections which is not always found in forms constructed without it, even with good curves of sectional areas. Abrupt changes in sectional shape are common features in poor designs and should be avoided where possible.

In conclusion, the writer wishes again to state that these notes upon the forms possible for high-speed vessels have been mainly written to promote discussion upon a subject which has not previously been before the Institution. The forms shown are at present of very limited application, such as to torpedo craft and racing motor boats, but unless the dimensions of ships can keep pace with the increased demand for speed, some such forms as these must ultimately be adopted instead of our present big ship type. Possibly in the course of the discussion our attention may be drawn to some form which is superior to any of those shown, and if that is so, then the writer will have done the Institution a good service.

TABLE OF ELEMENTS.

	A	B	C	D	E
Length on water-line	50·00	50·00	50·00	50·00	50·00
Breadth moulded	5·00	5·00	5·00	6·00	5·00
Draught at centre of length ...	1·20	1·20	1·20	1·50	1·20
Draught, maximum	1·20	1·20	1·20	3·00	1·20
Displacement in cubic feet ...	150	150	150	150	150
Centre of buoyancy below water-line	0·60	0·50	0·40	0·75	0·40
Transverse metacentre above centre of buoyancy B.M.	0·87	2·17	3·46	1·50	3·46
Longitudinal metacentre above centre of buoyancy L.M.	87·15	178·68	347·22	140·54	347·22
Area of water-line	125·00	187·50	250·00	150·00	250·00
Area of wetted surface—sides ..	120·57	90·28	60·00	150·26	72·00
Area of wetted surface—bottom ..	125·00	187·60	250·20	150·26	250·20
Area of wetted surface—total ...	245·57	277·88	310·20	300·52	322·20
Area of wetted midship section	6·00	6·00	6·00	4·50	—
Angle of entrance	11° 30′	11° 30′	2° 45′	6° 52′	2° 45′
Angle of delivery	11° 30′	2° 45′	2° 45′	3° 26′	2° 55′
Excess area of wetted surface over A	0	13 %	26 %	22 %	31 %
Block coefficient, using depth at centre	·500	·500	·500	·333	—
Prismatic coefficient ...	·500	·500	·500	·666	—
Breadth to give the same BM as B	6·78	5·00	4·27	6·78	4·27

APPENDIX.

Type C.—The whole of chapter vi., paragraph 24, of the *Treatise on the Construction of Vessels*, of Chapman, is devoted to a consideration of the relative merits of two possible forms for speed; these are practically our A and C, except that the midship section of the first is before the centre of length. The following is from the French translation by Clairbois, 1781 (Fig. 30 is our C):—

"La forme de la figure 30 serait bonne par rapport à la direction de l'eau, et au plein de la flottaison dans la navigation au plus près, s'il était possible que la mer fût tranquille. Mais comme un vaisseau ne peut, sans vent, aller de l'avant au moyen des voiles, et que le vent fait élever la lame donnant à un vaisseau une proue d'une telle forme, il éprouverait, dans la route au plus près, un choc trop considérable de la part des vagues, ce choc se trouvant dans une opposition directe avec la proue. La vitesse en serait fort retardée; c'est pourquoi, au lieu de donner à la partie de l'avant du plan de flottaison la figure d'un rectangle il faut qu'elle soit arrondie ou un peu en pointe. Cela diminuera bien quelque chose du moment de stabilité, mais l'effet des vagues en sera considérablement moindre. Quant à la partie d'arrière, il n'y aurait pas de difficulté à lui donner une figure rectangulaire, relativement à l'effet des vagues; mais par les raisons qu'on a vues dans le paragraph 12, il convient d'y faire quelque changement."

As Lord Robert Montague's *Naval Architecture* (1852) is not very generally known, and has been long out of print, the following notes may be of interest. The main object of the book is to advocate the use of normal or, as he calls them, "dividing lines," for designing purposes, instead of the system of water lines then generally in use. The method adopted was to design a main dividing line in the half breadth and sheer plans, and project it on to the body plan: the sections were then drawn so as to cut this line at right angles: other dividing lines followed, and then the ordinary water lines, buttocks, etc., were used for fairing purposes only. A good deal of the book is devoted to the consideration of resistance, and draws largely upon Chapman, although having a great deal of original ideas of the author's own. The whole book is so full of methods of thought quite contrary to the then accepted theories, that it is a pity it is not better known.

Type D.—In 1860 the late Mr. Maudsley read a paper before the Institute of Naval Architects, advocating a rake of midship section of from 30 to 35 degrees. Later on, in 1875, this form exaggerated was patented, and a paper read upon it at the ıte of Naval Architects. The lines of a yacht by the ee will also be found in the *Hunt's Yachting Magazine* 1876.

curious application of the raking midship section, which cally amounts to our form D, is to be found illustrated in *Science*, 1875, in an article upon the exhibits at the a Exhibition, 1873. In this design for a merchant steamer de Carvalho, the vertical sections right forward are rect- with the lower corner rounded off. These sections are narrow, giving fine forward water lines. Going aft, there apidly increasing rise of floor, which in connection with eatest breadth being carried very far aft, gives very flat k lines and rounded water lines. As the usual straight orm aft is largely made up of mere dead wood, we have ype D in almost its entirety. Vessels appear to have been from this design, but I have not found any particulars of performance. Many years ago I came across a surprisingly ittle model yacht which was an even more pronounced ple, as the buttock lines ran in nearly straight lines from ad of the counter down to the forefoot. The boat was lingly fast when fairly upright, but was very wild on her when much pressed, as might be expected from the nature inclined wedges. The model was then an old one, and bly dated back to about 1850-60.

ype E.—An article in *Naval Science*, 1874, giving a very ete account of the Admiralty experiments upon the Rev. Ramus' proposal, should be read by everyone interested lroplanes. The model designed by Mr. Ramus represented el 360′ × 50′ × 7′ draught, 2,500 tons displacement. The ıes given in *Naval Science* show a double wedge sheer plan, nearly rectangular deck line, practically the same as Fig. te XXVII.). Mr. Froude afterwards tried a three-wedge gement, the forward plane being in front of the other two etween them, the arrangement being nearly an equilateral le. The Ramus model was tried against one of the same ısions and displacement, but of ordinary type. No sketch s is given. The conclusion come to was that at speeds up 0 knots the resistance of the Ramus model was avagantly large" compared with the ordinary model. The ıs was tried up to 130 knots speed, but for some reason not the highest given for the other model is 52 knots.

The net horsepowers are given as follows :—

10	knots	=	1,000
20	,,	=	14,000
30	,,	=	44,000
40	,,	=	83,000
50	,,	=	124,000
60	,,	=	172,000
90	,,	=	308,000
130	,,	=	455,000

Mr. Froude goes on to state: "The danger of using such extravagant speeds at sea has been alluded to. But in contemplating the supreme advantages which such speeds would in some respects confer, it might be hastily thought that precautions could be adopted which would obviate such risks. It is therefore, necessary to show that these risks are inherently and incurably fatal. The hope of the successful employment of such speeds usually rests on the assumed principle of what is called the "duck and drake" action of a flat stone skimming along the water, or of the ricochet of a cannon shot from it. But these exhibitions of the action show also its inevitable danger, for on meeting the slightest undulation the stone or shot is glanced upwards into the air, and returns to the water with a plunging descent. It is a matter of very simple and certain calculation that if a ship, when skimming along the surface of the water at a speed not more immoderate than 60 knots, were to meet a wave of, say, twice her own length and having 10 degrees of a maximum slope (no extravagant supposition), she would be launched upward at that angle, and would take a flight of nearly 100 feet before she again reached the water, and the upward impulse would involve the communication of some rational motion which would inevitably add to the destructive effect of the shock she would experience on meeting the water; with a double speed the flight would be quadrupled."

In the *Annual of the School of Naval Architecture*, 1875, there is an article signed "W." dealing in the first place with the general problem, and afterwards with the Ramus experiments, although strangely enough Mr. Ramus is not mentioned. The writer takes as an example a vessel 250′ × 50′ × 7′ mean draught, 2,500 tons displacement, and 16 knots speed. The bottom is assumed to be a plane of 12,500 square feet, inclined 10 feet in the whole length. He then calculates the reduction of displacement which would take place, assuming the impossible condition that no change of trim occurred, by the formula:

$$\frac{3Av^2 \sin\theta \cos\theta}{2240} = \text{tons},$$

A being the area of the plane in square feet, v the speed in knots and θ the angle of the plane. The result is given as 171 tons. To modern eyes the speed 16 knots is, of course, absurdly small to expect to get any important results from, especially as the Ramus experiments went up to 130 knots. If we substitute, say, 35 knots for 16 knots, leaving the rest unchanged, we will get a reduction of about 818 tons, or nearly one-third of the whole displacement.

"W." does not discuss the question as to whether the double wedge would or would not give as great a reduction as his single plane.

Neither of the writers make any comment upon the possibilities or otherwise of so arranging a single plane as to avoid any considerable change of trim; or whether variations in the proportion of length to breadth would much affect the result. As regards the latter, in aeroplanes we find the lifting area arranged transversely, the plane or planes being relatively very short in fore and aft direction, like a bird's wing.

DISCUSSION.

Mr. ARCHIBALD HOGG said—I feel rather timid to make any remarks upon this paper, because I have not had the good fortune to be engaged in the design of vessels of such very high speeds. I do not know why Mr. Long should say the "evil" fortune, unless it is that they are rather tricky things to deal with. He says "the freak of to-day may perhaps be the orthodox vessel of to-morrow." I do not think any such "freak" as, say, type E for instance, can be an orthodox vessel of to-morrow. It should be noted that this paper has in view high speeds of a certain type—that is, speeds such as obtain in torpedo boats and destroyers, there is no reference to high speeds relative to "form." It is just as difficult to drive a cargo boat 20 knots as to drive some of these boats 40 knots. The paper has only relation to special high speeds relative to length, and, if one thinks about speed in relation to form, the absurdity of trying to introduce "freak forms" is more apparent because you cannot usefully use freaks in full formed steamers. The figures, illustrating types of forms, are shown by means of straight lines, and, while it is about the best he could do in a certain sense, you have to be careful in looking at ships' forms as shown by straight lines, because they come a long way short of telling you what like the form really is. It looks as if some of the things Mr. Long says arise through looking at the straight-line forms as being true indications. He starts by giving five types of boats, and in describing them he lays down pretty correctly what are the essential elements to get a good form for high-speed ships. These essential elements are something like this: She must be a good sea boat, and as free as possible from shocks, and, of course, she must have transverse stability. She must also be easy of propulsion at varying mean draughts, and there should be a clear entrance and a clear run, and the change of trim at high speed should be as small as possible. Mr. Long adds one about the cabin accommodation which I do not think is important. In type A, Mr. Long says, "it is to be regretted, that for the very high speeds with which we are dealing it is practically impossible to use it." He says also that "the change of trim when driven at speeds much beyond that economical for the length is so excessive as to be prohibitive;" and at the end of the same paragraph he talks about fins being added. This is where the use of straight lines is rather misleading. I would say that instead of five there are only three types. A, B, and D (Plate XXVII.) are practically the same type of boat. At present, for vessels of not nearly so great speed as these, we have a form that takes such variations as are indicated by Mr. Long's straight lines. We can have a boat with the centre of buoyancy well forward, or the same with the centre well aft of amidships, and the model of the one with the centre forward or with the centre aft can be made to look, at either end, pretty much like that indicated at the fore end, of any of the types shown. So these three types A, B, and D, are really the one type which is now in general use for ordinary steamers. The filling out of the water line at the aft quarters is the only device that can be used "to attempt" to prevent the excessive change of trim. In describing type B, Mr. Long says the area of the water line is increased 50 per cent. and in the table which he gives he keeps the same length and the same beam for both types A and B. I would suggest whether it would not be worth while taking advantage of the extra stability to reduce the beam of type B. At the end of the first paragraph (p. 187) describing type B he says "the wave making aft is also so flat that there is less increase of surface there in contact with the water than in A." Now I should think it does not matter whether the ship at the aft end is flat or more of V shape. The height of water at the aft end would mainly depend on the speed in relation to length of entrance and to breadth of beam. In the next paragraph describing type B, he says, "the latter being in small 'single '-screw vessels." I rather think a ship of that type would have twin or triple screws. As for type C (Plate XXVII.) with very flat ends, I would not consider that at all as a type for a sea boat, and the same with type E; because of its flat bow. Mr. Long says that A type may be summarily struck out both on theoretical and practical grounds. If you make a list of the advantages and disadvantages as given by Mr. Long, you will find that type A has every one of these advantages with, it may be, the exception of one, and that is the change of trim, a condition which is perhaps impossible to be stopped, so I do not see why he should strike it out. In fact, he is only proving in his paper that there is only one form after all, and that form is one which has a clean entrance and a clear run, and designed so as to overcome as far as possible the change of trim due to the high speed, and at the same time giving it a clear run, which must be done if you want to attain anything of a good result. Mr. Long says that types C and D (Plate XXVII.) are boats for the future, when we can get power to drive them. I should say it is quite objectless and needless to attempt to put power into such a boat. Then he says at these high speeds the actual fact is that the boat is lifted up out of the water, and in the next paragraph he discusses the form of midship section. I should think the mere fact, "if it is a fact," that the boat is raising itself out of the water should tell you what type of midship section you should use for boats of high speeds. Mr. Long says some such form must ultimately be adopted instead of our present "big" ship form. I would not like to go across to America at 40 or 50 miles an hour in any such small freaks, I think the big form is yet much more preferable. Mr. Long says something about wet surface, now at these high speeds the wet surface forms a small fraction of the resistance and too much attention can be given to this. Mr. Long says the paper is mainly written to promote discussion, as if the only value of the paper is expected to be in the information given in the discussion, but I think Mr. Long is to be thanked for giving himself the trouble in writing this interesting paper and it is to be hoped that those who can will come forward with a discussion that will add to its interest and value.

The discussion was adjourned and the meeting dissolved.

.TH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWENTY-FOURTH SESSION, 1907-1908.

PROCEEDINGS.

IXTH GENERAL MEETING OF THE SESSION WAS HELD IN 'HE LECTURE THEATRE OF THE LITERARY AND PHILO-OPHICAL SOCIETY, WESTGATE ROAD, NEWCASTLE-UPON-'YNE, ON FRIDAY EVENING, MARCH 20TH, 1908.

OL. R. SAXTON WHITE, MEMBER OF COUNCIL, IN THE CHAIR.

e SECRETARY announced that, owing to the President [. Dugdale, Esq.) having been called away from home, he nable to be present.

e SECRETARY read the minutes of the previous meeting ı Newcastle-upon-Tyne on Friday evening, February 21st, which were confirmed by the members present and signed Chairman.

e CHAIRMAN appointed Mr. Alfred Harrison and Mr. J. L. lell to examine the voting papers for new members, and lowing gentlemen were declared elected :—

MEMBERS.

nall, Richard S., Engineer, The Groves, Winlaton, County Durham.
b, Maurice S., Engineer, Central Marine Engine Work, West Hartlepool.

ASSOCIATE.

rrie, J. J., Shipowner, 49, Meadowside, Dundee, N.B.

GRADUATES.

Coates, John, E. Apprentice, 15, Park Place E., Sunderland.
Huggins, Walter, E. Apprentice, 27, Mundella Terrace, Heaton, Newcastle-upon-Tyne.
Taylor, Hugh Lamport, E. Apprentice, 2 Prior's Terrace, Tynemouth.

Mr. H. R. JARVIS's reply to the discussion on his paper on "Floating Docks" was taken as read.

The discussion on Mr. J. H. Gibson's paper on "Torsion-meters" was resumed and closed.

The discussion on Mr. A. E. Long's paper on "Notes on the Form of High-speed Ships" was resumed.

Prof. R. L. WEIGHTON read a paper on "Piston Speed and Steam Engine Economy."

RESUMED DISCUSSION ON MR. H. R. JARVIS'S PAPER ON "FLOATING DOCKS."

The SECRETARY read the following communication on Mr. H. R. Jarvis's paper on "Floating Docks":—

WINDSOR CRESCENT,
WHITLEY BAY,
March 20th, 1908.

DEAR MR. DUCKITT,

As I now find that it will not be possible for me to be present this evening in order to take part in the discussion on Mr. Jarvis's very interesting and instructive paper on "Floating Docks," I think that perhaps the following experiences may be of interest to the members, if forwarded in the form of a communication.

To my mind, they show how far superior a floating dock can be to a dry dock, in the manner of overcoming what would otherwise prove to be great, if not altogether insurmountable, difficulties. Owing to the large dry dock in Kiel being unavailable through damage, the German Admiralty decided to entrust the work of repairing the very extensive damage done to the large cruiser "Scharnhorst," to the firm of Blohm and Voss in Hamburg, and this was carried out by them in one of their floating docks in the following manner:—As there was not a sufficient depth of water at the ordinary position of their No. 4 dock to allow of its being lowered to suit a vessel of the draft of the "Scharnhorst," it was towed by means of six tugs to the deeper site previously occupied by No. 3 dock. This No. 3 dock was at the time occupied by the North German Lloyd liner "Kaiser Wilhelm der Grosse," and dock and vessel were therefore towed over and safely moored alongside the South Quay. This manœuvre took place during a strong wind and heavy snowstorm, and was a brilliant demonstration of the mobility of the floating dock.

The two large docks with their contents, together representing a capital of not less than two million sterling, were now *both* away from their normal positions, yet the repair work on both vessels was carried out with the greatest facility and precision.

The foregoing also recalls to mind a somewhat similar experience the writer had at the same yard some years earlier, when carrying out extensive repairs to the Hamburg-American liner "Deutschland," which vessel, by the way, had also, as in the case of the previously mentioned "Kaiser Wilhelm der Grosse," lost her rudder at sea, together with a part of the stern frame. The vessel was docked on the No. 3 dock while in its normal situation, then dock and vessel were towed under the 150-ton crane, and this readily allowed of the old stern frame being removed and the new one placed into position, together with the new rudder. In removing and replacing the stern frame of the "Kaiser Wilhelm der Grosse," a different method was adopted to the foregoing. One section of a small dock was fitted with suitable ways and then placed end on to the large dock, and by continuing the ways up to the vessel, it was an easy matter to move the old stern frame to the small dock section. This was then moved under the 150-ton crane and the frame lifted on shore. In replacing the new 80-ton stern frame the same method was employed, but, of course, in the reverse direction.

All this, as experienced by the writer, points to the superiority of the floating dock, both in mobility and accessibility, when handling heavy weights and carrying out extensive repairs.

Yours faithfully,

H. E. Rea.

MR. H. R. JARVIS' REPLY.

Mr. H. R. Jarvis said:—I am extremely obliged to Mr. George Renwick for reminding me of the late Mr. Alexander Taylor, and regret that I had not the pleasure of his personal acquaintance. I am, however, well acquainted with the two pontoon docks owned by Messrs. Swan, Hunter and Company, which were designed by Mr. Taylor, and which no doubt have been of much service. They are, however, inferior in a few respects to other floating docks which were constructed about the same time, and the form of the side towers precludes any possibility of fitting mechanical side shores, which are a very essential adjunct to a successful floating dock. They are also weaker longitudinally than other designs, owing to the large openings between the side towers. Many people have designed and built floating docks, *e.g.*, Mr. G. B. Rennie, who designed the first sectional pontoon which is described in the paper, and also, I believe, by Mr. James Campbell and others, but that does not establish them as specialists. Messrs. Clark and Standfield, however, are floating dock specialists, and the only firm of that description that I am aware of in existence.

I agree with Mr. Renwick that our Admiralty are slow in adopting the floating form of dry dock, there being so many places where they could be usefully employed, well sheltered and secure from torpedo attack. It is not a new suggestion to instal machinery into a floating dock to be able to propel it at moderate speeds. It has been under the consideration of experts for many years. The power required, however, would be proportionately very great to propel a dock at a speed of even four miles an hour. Moreover, serious practical difficulties arise in getting the propellers deep enough into the water to be of service, and the propelling machinery would, together with the bunkers, occupy so much space and extra displacement that the idea of a self-propelling floating dock seems to be almost impracticable. Steering is also a very difficult matter to overcome. Some idea of the power required may be gathered from the following particulars:—A dock 320 feet in length by 86 feet in width, and a draught of 4 feet 6 inches, when towed at the rate of 5½ knots per hour, was found to require an effective horsepower of 462. When towing at 6¾ knots per hour the E.H.P. required was 790; when towing at 7½ knots the E.H.P. was 935. This dock, it will be observed, was a comparatively small one, with a lifting power of 4,000 tons, and the indicated horsepower of the pumping machinery in the dock was only about 150.

With reference to the draught of water required to take a vessel drawing 36 feet, and with perhaps a list, this would probably require to be about 10 fathoms, and the difficulty has been experienced that too much depth of water has been available. In the case of the Bermuda dock, which is an example of how a dock could be sent to meet a damaged ship, having been sent from the Tyne to the Medway to dock a battleship as part of the official trials, the depth of water available at the place where the dock was temporarily moored was no less than 15 fathoms. The working depth of water normally required to dock a ship of 27 feet draft on this dock is 46 feet, which gives a freeboard of 10 feet to the dock. The dock was sunk to a draft of a little over 33 feet over the keelblocks, leaving only 4 feet of the side walls above the water.

Of course, it is not essential that the dock should be moored at a place where she can be dropped on to the bottom, but naturally it is a safeguard to be able to do so, in the remote event of a total failure of the pumping plant.

With reference to the parts most likely to deteriorate in floating docks, I agree with Mr. Renwick that the side on which the sun shines wastes quicker than the sheltered side, owing to the sweating which takes place on the inside of the dock. This was particularly exemplified in the case of a dock at a Mediterranean port, upon which a survey was made recently, with a view to extensive repairs. The surfaces exposed to the sun were found to have wasted away from an original thickness of $\frac{7}{16}$ of an inch and $\frac{1}{2}$ an inch to from $\frac{1}{16}$ of an inch to $\frac{3}{16}$ of an inch. However, there is no reason why such excessive corrosion should take place, as proper ventilation of the interior of the dock, and cleaning and painting at intervals, should make the structure last indefinitely, more especially if the steel work is coated with bituminous products.

Mr. Renwick is, I am afraid, mistaken with regard to the inadvisability of making a floating dock self-docking, and I agree with Mr. Box that it would be a difficult and costly work to construct a graving dock with sufficient width of entrance to take in a very ordinary sized pontoon, of, say, from 6,000 tons to 8,000 tons lifting power. Such a floating dock would have an overall width of from 85 feet to 95 feet, and a graving dock with an entrance of sufficient width to accommodate vessels of such beam is a very costly affair, and, moreover, a firm having, say, one or two pontoons and one graving dock of sufficient dimensions to dry dock the pontoons, would find themselves badly handicapped by possibly having to refuse work owing to their having two docks occupied in such a manner. It has been demonstrated and proved, as described in the paper, that the bolted sectional type of dock is, undoubtedly, the best that can be devised as a self-docking dock. It has the advantages of mobility and strength, which are such important factors.

In reply to Mr. Box, I can only express my regret that he did not fall in with the suggestion made during the discussion of Mr. Moncrieff's paper on "Commercial Dry Docks," and himself contribute a description of floating docks to this Institution. The paper was not intended to describe the various means of recovering vessels from the water for any purpose, and, moreover, any comparison between the floating dock and other types, the paper clearly stated was purposely avoided, it having been dealt with so exhaustively in various contributions to the proceedings of the Institution of Civil Engineers and the Institution of Naval Architects.

With reference to the question of design, I am unacquainted with any dock known as the "Hannson" type, but perhaps Mr. Box means the one named the "Dewey," which was towed from the east coast of America to Subic in the Philippine Islands a year or two ago. If this is the dock which Mr. Box described, it was built from the designs, and under the superintendence, of Mr. Sven Anderson and Mr. Cunningham of the Maryland Steel Company. This dock certainly has the merit of simplicity in self-docking, but only at the cost of an enormous expenditure of material as compared with the bolted sectional type; and, moreover, the end sections when disconnected for self-docking, must have special pumping apparatus which is coupled to the main boilers of the dock by objectionable flexible steam pipes, whereas each section of the bolted sectional type is self-contained, and when coupled together, any single unit of the machinery can pump out the whole of the dock.

The "Dewey" dock must of necessity terminate at each end rectangular in plan, and in consequence has excessive lifting power in proportion to its length. It is also only suitable as a comparatively short and broad dock suitable for naval purposes, and for such, as a matter of fact, it was specially designed.

The end sections must be of sufficient length to enable them to have the requisite lifting power, and, what is equally important, initial stability, when being manœuvred for lifting the main portion of the dock. This means that the dock must have an excessive beam to enable the main portion of the dock to lift the two end sections.

The bolted sectional dock, however, is entirely independent of such considerations; it is not extravagant with material, as the dock in plan has pointed ends and the ends of the side walls are also stepped down, thereby saving weight and also avoiding excessive lifting power at the ends of the dock. It is an advantage sometimes to curtail the length of the buoyant portion of the pontoon and extend the working length by light lattice platforms.

Floating docks which break joint have been designed and patented in this country and in America, but they have precisely the same objections as the "Dewey" dock.

With reference to the method of constructing floating docks to which Mr. Box refers, the matter is very simple. The exact position of every rivet hole is, on account of the rivet pitches in either direction being multiples of each other, exactly determined before the work is commenced, and the accuracy of the work depends almost entirely upon the reliability of the drawing office staff. The plates, as Mr. Box described, are punched on a multiple punching machine, and the majority of them do not require any further manipulation other than shearing or countersinking after leaving that machine. For the angle work, however, the rack arrangement described is only suitable for comparatively small work.

The writer had subsequent experience to Mr. Box at Gray's, Essex, and also introduced the system in the Wallsend yard, but it was found to be unsuitable to North Country methods. It is found that excellent work can be made with the ordinary template when care is taken in punching.

With reference to design, it is obvious that a floating dock of any type to lift a vessel of a certain weight must also be able to support its own displacement with a margin for freeboard and contingencies. The method of controlling the dock is fully described in the paper under the heading of pumping plant.

The question of strength also was considered in the paper, and the statement made that the docks were usually designed to carry their maximum load over three-quarters of their length, without excessive deflection.

With regard to the launching of floating docks to which Mr. Box refers, this does not entail any greater risk than the launching of a ship, if as much; the methods adopted are precisely the same in both cases, and therefore quite familiar to the members of this Institution.

It is an advantage, however, if launching can be avoided, and the dock built in a basin, which was the practice at Gray's, and with the "Dewey" dock, and also more recently at Pola. The blocks are laid on the level, and consequently simplify the fairing of the work.

To go exhaustively into the question of floating docks and various methods of construction would not only take up too much time, but would probably not be interesting to all the members, neither was it the writer's intention to do so, but simply to place a few simple facts and particulars of the various designs before the members of this Institution.

With regard to the cost per ton of lifting power of the various types of docks described, to which Mr. Box refers, this is quite outside the scope of the paper, and the writer cannot for obvious reasons give any information; it, of course, varies very much with the cost of materials and labour.

The Chairman said—I beg to propose that a hearty vote of thanks be given to Mr. Jarvis for the paper he has contributed.

The proposition was carried by acclamation.

RESUMED DISCUSSION ON MR. J. HAMILTON GIBSON'S PAPER ON "TORSION-METERS, AS APPLIED TO THE MEASUREMENT OF THE HORSEPOWER OF MARINE STEAM TURBINES."

The SECRETARY read the two following communications on Mr. J. Hamilton Gibson's paper on "Torsion-Meters":—

THE HOLLIES, WESTFIELD AVENUE,
GOSFORTH, NEWCASTLE-ON-TYNE,
March 19*th*, 1908.

DEAR MR. DUCKITT,

I regret it is not possible for me to be at the Institution meeting on Friday next, and as I am desirous of making a few remarks upon the paper of my late colleague, Mr. Gibson, perhaps you will be good enough to put these before the meeting.

No doubt others have commented on the admirable summary which Mr. Gibson has given, descriptive of the several torsion-meters designed to date, but the chief interest will probably centre in the description of the flashlight torsion-meter worked out by the author of the paper in conjunction with Mr. Bevis. Having been familiar with the design in its early stages, and knowing that, as Mr. Gibson says, a difference of reading equal to the thickness of a hair would make a very appreciable difference in the result, I was somewhat doubtful whether readings of such small quantities could be taken with sufficient accuracy under the conditions of actual practice. I took, therefore, an early opportunity of testing this for myself on one of the first vessels fitted with turbines by Messrs. Cammell, Laird and Company. With the vessel going at full speed, I experienced no difficulty in ascertaining a definite position where the beam of light of the torsion-meter was just shut off, and on reading the torque I found it to exactly agree with that just previously recorded for the same shaft by the expert in charge of the instrument. I can thus confirm what Mr. Gibson says on page 161 as to the fineness of adjustment which is possible.

The diagram given on Plate XXIII. is a specimen of what is needed to increase confidence in the accuracy of torsion-meter results generally, namely, a comparison between simultaneous readings for indicated and shaft horsepower of reciprocating engines. That diagram shows one result I was not prepared to see, the efficiency of the engine—judged by the ratio between shaft and indicated horsepowers—being least at the highest powers and greatest for the lowest powers recorded, whereas one expects the reverse to be the case, remembering the relatively greater importance of dead load friction at low powers. I have noticed the same tendency in published comparative results in connection with other types of torsion-meters, and perhaps Mr. Gibson will be good enough to explain this—unless, indeed, we are to accept the statement in the body of the paper, that indicator results cannot be relied upon within 10 per cent. or so, in explanation.

It goes without saying that, in view of the increasing use of the turbine, it is most necessary to have a reliable instrument for measuring the power delivered to the screw, in order that trial trip results may be properly analysed and questions of propeller efficiency, etc., adequately dealt with. The flashlight torsion-meter has already proved its value for such purposes, and I think, therefore, that instruments of this type—possibly modified as further experience suggests—must come into extended use.

Yours faithfully,

J. J. Welch.

Greenock,

March 18*th*, 1908.

Dear Mr. Duckitt,

As I am unable to be present at the meeting on Friday evening, I shall be pleased if you will submit the following remarks on Mr. Hamilton Gibson's paper.

On page 152, Mr. Gibson says: "A small propeller working deeply immersed in smooth water is a fairly uniform brake." It would be interesting to know whether any experiments have been made to determine the extent of the variability of torque during the revolution, due to variability of wake, and the effect of successive propeller blades passing through the water nearest to the skin of the ship. In a turbine vessel this could easily be done by arranging the torsion-meter discs with two slots, one opposite a propeller blade and one opposite a space between two blades. By this means we would be able to measure the maximum torque and the minimum torque, and see the possible extent of error involved in measuring at only one point.

On comparing the shaft and indicated powers given in Fig. 2, Plate XX., it will be found that the mechanical efficiency is very high, about 92 per cent.

Perhaps Mr. Gibson will be able to offer some explanation why such a high figure should have been attained in such a small engine.

On page 163, Mr. Gibson says that the difference between shaft and indicated horsepowers corresponds with the result obtained by steaming with the engines disconnected, but it should be noted that the power found by this method is less than the frictional horsepower of the engine, due to the absence of load on the bearings. Whilst this may be negligible in the case of the engine bearings, yet at the thrust block the additional load must always result in an increased loss of power.

Again, from Fig. 2, it appears that the thrust was measured. It would be interesting to know the method adopted in the measurement of thrust, whether by hydraulic rams, spring balances, or strain indicators, and also whether the thrust was measured when running at sea or with the ship moored in dock. If a comparison be made between thrusts when running and when moored in dock, it will be found that for constant speed of revolution, the thrust in dock is very much greater than at sea; this is because the real slip at which the propeller is working is greater. Therefore, if we wish to obtain the apparent propeller efficiency it will be necessary to measure the thrust when running at sea. For a determination of the real propeller efficiency a knowledge of the wake and thrust deduction factors must be obtained, for which the experimental tank seems to be the only method available.

The whole problem is one of very great interest, and I must thank Mr. Gibson for a very valuable contribution to its solution.

Yours faithfully,

JOHN NEILL.

The discussion was closed.

ꞮESUMED DISCUSSION ON MR. A. E. LONG'S PAPER ON "NOTES ON THE FORM OF HIGH-SPEED SHIPS."

Mr. F. H. ALEXANDER said—Those of us who hoped from the itle of the paper that Mr. Long was going to let us into the ecret of some of the success of the destroyers built by the firm ıe is connected with, may perhaps feel somewhat disappointed; ›ut that does not prevent the paper being a very interesting nd instructive one. It is doubtless to our benefit to look beyond he class of work with which this district is particularly associted, to the tendencies which are showing themselves in the esign of small boats of relatively very high speed, whose speed-ength ratio is greater even that that of destroyers.

Mr. Long says that the design of any vessel involves a comromise between speed and other requirements; and there is no oubt that this will always be so, and particularly in the cases f vessels intended to move among waves; many considerations re modified where we can depend upon smooth water.

In using the straight line forms, and in omitting the part bove water, Mr. Long is following out the methods of repreentation suggested by Mr. A. C. Kirk, whose analysis of lengths nd angles of entrance and run is so well known. By so doing, e has simplified the classification of types, but there are two oints in connection with the method which I may refer to. think that, as the under-water form to some extent domintes that of the parts above water, the omission of the latter ıay obscure the adverse windage effects which would be felt n the exposed parts of some of the types; and in the case of ne type at least, an objectionable overhang of the ends would robably result unless the top sides were out of all harmony ·ith the under-water part; and if such overhangs existed, would ot that mean that we were really dealing with a larger and ›nger vessel than those described by the other type forms. gain, I would point out that Mr. Long's method of measuring ıe angles of entrance and run has been the subject of difference f opinion. In some cases it is measured by the intersection f lines in a vertical plane, and in other cases these lines are hosen in a horizontal plane, the choice apparently being made so as to give the least angle; it would be perhaps more consistent if a definite method were adopted throughout if such were possible, but, of course, in that case some of the angles might become right angles, and the meaning of the term be quite obscured. I prefer, therefore, the Normand system of determining angles of entrance and run, in which neither the breadth nor the draft of the midship section is directly used, but the square root of the immersed area of that section. The length of this line, divided by the length of the entrance, gives the tangent of the angle of entrance.

In reference to the boat built by Messrs. Yarrow, I would like to ask Mr. Long to tell us how he would form the above water part of the bow, if he shortened it back as suggested; would not the wind resistance be increased to an undesirable extent?

It must interest us in this part of the world to know that the form which is being most generally adopted for these high speed boats so closely resembles that of our local "cobles." Those of our members who have seen the three papers on motor boats read last November at the meetings of the American Society of Naval Architects and Marine Engineers, cannot fail to be struck with this resemblance as shown in the illustrations of the boats described. The greatest beam is quite near the aft end and the greatest draft near the fore end. The same typical features appear in most recent British and Continental designs.

Coming now to the "hydroplane" or type E, which is at present in the stage of a toy rather than of practical use, I agree with Mr. Long's remark that this type is of very old conception; but it has another remarkable feature, and that is, that it is invented afresh every year, if not every month, according to the illustrations one may see in the patent columns of the technical journals. Obviously its success, even in smooth water, and even in the case of a light small vessel, depends on the power being sufficient to raise the main part of the hull well clear of the water; and this accounts for our having to wait for success until the recent production of a motor sufficiently powerful in relation to its own weight. It is to be noted, however, that once the vessel is so raised, the power needed for increased speeds does not increase as rapidly as it does in the case of an ordinary ship; and that may be proved by the test of the ordinary Admiralty constant. Suppose we take as an example the Italian boat recently tried. An account of this is given in the current issue of the *International Marine Engineering* for March, 1908 (Vol. XIII., No. 147, page 127). The boat is 26 feet 3 inches long, and its displacement at rest with two men on board is about 1½ tons. Its highest speed (attained apparently in still air, if one may judge from an illustration) is stated to have been 70 kilometres per hour, or about 37·8 knots per hour, with a motor rated at 80 to 100 horsepower, turning twin air propellers at about 1,200 revolutions per minute. At this speed the hull was about 18 inches above the surface of the water, and the hydroplane supports were nearly on the surface. Now, of course, it is obvious that considerations involved in the use of the Admiralty constant cannot apply to a case like this, but if we were able to drive an ordinary boat of that displacement at that speed, with that power, the Admiralty constant would be 708! It is interesting to note that Mr. Froude's estimated powers for the Ramus ship confirm this high value at about the same speed-length ratio; though here again this ratio can hardly be strictly applicable if it enters the question at all. But, as Mr. Long says, the vital objection to the hydroplane boat of excessive speed is its inability to cope with waves without disastrous results.

I think it is not impossible, however, that new principles may yet be made use of which may enable us to reach higher speeds than we do at present and even with lower powers, at any rate in smooth water; although it is probable that rough seas and winds will always prove an obstacle to sustained high speeds at sea.

Mr. Long's paper will, I hope, induce some of our younger members to take an interest in the development of the small high-speed craft, even though these are not much in direct evidence in this district; for, as he says, " it is well to remember that the freak of to-day may be the orthodox vessel of to-morrow."

Mr. R. Hinchliffe said—Mr. Long has contributed some very excellent papers to our *Transactions*, all of an interesting and instructive nature. Further papers by him are therefore looked forward to with no small amount of interest, and the announcement that he was to give us a paper on the subject of high-speed forms raised, I should say, not a few pleasant anticipations. Candidly, however, I must confess to a certain feeling of disappointment on reading his paper—not that the paper falls any way short of Mr. Long's high standard, but rather with that portion of the subject which Mr. Long has seen fit to deal. He says: "The lower limit of speed fixed upon is twice the square root of the length, and even this is much too low to bring out the true characteristics of some of the types." Most of us, I fear, are inclined to look upon a speed which is much in excess of once the square root of the length as a "high" speed, and would be inclined to call Mr. Long's speeds "excessive." The "Mauretania" would have to attain a speed of 55 knots and the "Lord Nelson" a speed of 43 knots before they would enter Mr. Long's class. Indeed, it is only to a limited class of vessels, comprising torpedo boats, torpedo boat destroyers, and motor boats that the forms Mr. Long discusses apply. Since only these high-speed forms are considered, Mr. Long quite logically deletes type A as unsuitable. Yet that is the type in which the majority of us are most interested. Furthermore, it is a type regarding which we are not yet familiar with all the characteristics, as witness the recent controversy regarding the value of straight and hollow water-lines in the *Transactions* of the Institute of Naval Architects. What is more, type A is a form about which I feel sure Mr. Long could have given us a lot of valuable information based on his own experience had he chosen so to do. We can only hope he is keeping the material for a subsequent paper. In one part of his paper Mr. Long comments upon forms which seem to suggest that the naval architect has hesitated half-way, and has lacked the courage to carry out his convictions. I venture to protest that this is not always the reason for certain modified forms we see. There are probably few naval architects who have not, at one time or other, designed a form which they thought would be conducive to high speed, only to be told when he has submitted his "spaces" to engineers that the boilers in the forward boiler room project 3 inches through the shell of the ship, or, on the other hand, that the space between the condenser and the shell was so small as to render it impossible to clean and paint. It is troubles like these that spoil the ideal forms that all naval architects are longing to produce, and which make naval architects old before their years. A naval architect, as Mr. Long points out, has to consider other matters beside that of speed in deciding upon a vessel's form. In criticising the disadvantages of form B, Mr. Long points out this form is apt to produce slamming in a seaway owing to the flat section. This view is borne out by the experience of Lieutenant L. H. Chandler, of the United States Navy, who was in command of some torpedo destroyers proceeding from the United States to Manila. Writing in a paper read before the Society of Naval Architects and Marine Engineers of the United States, he comments on it as follows:—"The worst feature that I have seen in their behaviour is the pounding of the flat stern that comes in driving into a head sea, or when at very low headway in a short steep sea. I have felt the ship when it seemed as if she must surely be pounding on a reef, and have more than once run from my cabin to the deck because of this pounding when some reason compelled slowing down, fearing that we were aground. This pounding tends to loosen rivets and generally disintegrate the hull structure, especially aft, and I have some fear that, under certain conditions of sea, a breakdown of the engine might result in so much hammering as to break up the afterbody of the ship. I am of opinion, for these reasons, that in new construction some modifications of this stern must be made." I believe that similar trouble has been experienced in connection with certain British boats, and it is not improbable that in subsequent designs some modifications to the after-body of these boats will have to be made, even at the expense of a more resistful form. Mr. Long concludes his paper with some remarks to the effect that the forms under discussion apply to only a very limited number of ships, but that it is possible with our great advance in speed the forms he discusses may have to be adopted in the near future. Whilst we all look forward to progress, I fear, unless some startling change is made in the methods of marine propulsion, very few of the present generation will see speeds advanced to such an extent as to necessitate these forms being used on large sized ships. Our advance in speed is more apparent than real. The "Mauretania" is no faster a vessel than the

"Paris." The "Dreadnought" is little faster than the "Centurion," built about fourteen years ago. The new "Invincible" class, if they attain their designed speed of 25 knots, fall a long way short of the Tyne-built "Piemonte," while the 33-knot destroyers of the present day are little in advance of the "Lightning," built, I think, in 1877. So that really, I fear, we are not going along quite so fast as Mr. Long's remarks might lead us to imagine. Nevertheless, Mr. Long's is an interesting paper and contains much that is instructive, and when added to our *Transactions* will be an addition to the literature on this subject; but, I venture to think, it will be more appreciated by future generations than by the present.

The discussion was adjourned.

PISTON SPEED AND STEAM ENGINE ECONOMY.

By Prof. R. L. WEIGHTON, M.A., Vice-President.

[Read in Newcastle-upon-Tyne on March 20th, 1908.]

Some time ago a series of revolution trials were carried out on the experimental engines in the Engineering Laboratory at Armstrong College, Newcastle-upon-Tyne. Stress of other work at the time prevented the present writer from giving that consideration to the analysis of the results which he would have liked, nor has he even yet been able to complete to his own satisfaction the important line of investigation opened up by such trials. He thinks, however, that at this stage it may be desirable and not uninteresting if the results be put on record in the *Transactions* of the Institution, along with such comments and deductions as they obviously suggest. The complete and adequate interpretation of such results is, however, a most intricate and somewhat arduous undertaking, requiring more study than the writer has been able to give to it as yet. Moreover, to thoroughly elucidate the subject, further trials will probably be necessary with cylinders having different proportions of steam ports, and the writer would therefore have the present contribution looked upon as being of a more or less introductory or preliminary character, and not by any means as a complete solution of the problems raised.

Object of Trials.

(1) In general terms, the primary object was to ascertain by careful experiment the exact effect upon the steam consumption per brake horsepower of running engines of ordinary design and proportions—such, for instance, as are usual in marine practice—at varying speeds of revolution, ranging from the lowest up to the highest practicable, nothing being altered throughout the series except the resistance against which the engines were working.

(2) A second object was to discover, if possible, the maximum permissible speeds of steam and exhaust in such engines, with due regard to economy. This last with a view to the determination of the minimum sectional dimensions of the steam and exhaust ports, openings, and passages, for adoption in proposed engines of this type, without entailing sacrifice of economy in working.

Other objects might be mentioned, *e.g.*, the determination of the effect of speed of revolution upon mechanical efficiency, and upon total power developed; but all such may be regarded as subsidiary to the two objects just stated, these latter being of a character calculated to have a direct and important bearing upon practice.

Obviously the only true power of an engine is the brake power, this representing the power available for the performance of the useful work, to do which the engine was built. We are all aware that revolution trials have frequently been made, and the results worked out in terms of indicated horsepower. The classic tests carried out by the late Mr. Peter Willans on his central valve engine are a wellknown—and deservedly well-known—case in point. These trials threw light upon several previously ill-understood points, and might be said to have marked an epoch in the question of the economic utilization of steam. The brake horsepower, however, does not seem to have been recorded, nor were the revolutions carried to such a degree as to reach minimum steam consumpt per horsepower, the object of the trials not calling for this. And further, the engines experimented upon were of a quite unusual type, the results from which could scarcely foreshadow what might be expected from engines of more normal design.

Conditions under which the Trials were made.

Two separate sets of trials were carried out, one with the engines arranged as quadruple, and the other as triple expansion; otherwise the conditions were as nearly as practicable identical for both sets, as follows:—

Quadruples: Cylinders, 7″, 10½″, 15½″, and 23″ diameter; 18″ stroke.

Triples: Cylinders, 10½″, 15½″ and 23″ diameter; 18″ stroke.

Steam pressure in high pressure chest, 138 lbs. per square inch, absolute; vacuum in condenser (barometer 30″), 24½ inches of mercury. Jacket steam shut off and jacket drains open. Receivers continuously drained by hand into hotwell. Amount of lubrication of steam and of bearings the same on both trials. Steam cut off in quadruples at 12½″, 10½″, 10½″, and 10½″ respectively; steam cut off in triples at 6″, 10½″, and 10½″ respectively. Engines in both cases linked up very slightly and to exactly the same amount in every trial.

In all the trials great care was taken to secure uniformity in the quality of the steam entering the first cylinder, by resorting to hand drainage of the high pressure steam chest, the water from which was, of course, not included in that debited against the engines. The steam pressure is low for use in quadruples, but it was purposely chosen so in order that there might be no doubt about the ability of the boiler to maintain the pressure constant at the higher piston speeds. The vacuum also was kept low in the interests of economy of condensing water. So far as the writer can see, neither the degree of steam pressure nor the vacuum can, within limits, materially influence the comparative or qualitative nature of the results. Quantitatively both of these factors would, of course, have an important influence.

The variation in speed of revolution was brought about by adjustment of the dynamometer, the lowest speed in each case being that which resulted when the dynamometer was adjusted for maximum resistance. Care must, of course, be taken not to confuse this condition with quite a different condition under which engines may be worked. In prosecuting research it is often necessary to introduce arbitrary and artificial conditions and adjustments not met with in ordinary industrial working practice. In the case before us, it was desired to try the effects of change in speed of revolution alone, without the complication of any other disturbing cause whatever, and hence change in speed was brought about solely by change in resistance. This is quite a different case from that met with, say, in the ordinary everyday working of marine engines, where change of speed is occasioned by change in initial steam pressure, or in some cases by change in expansions, or by both of these causes combined. The aggregate resulting effects are in such cases due not to change in speed of revolution alone, but are complicated with those due to change in pressure or expansions or both, and hence the particular share which speed of revolution has had in the combined result is not clearly ascertainable. In order to elucidate the precise effect of any given cause, that cause alone must be changed. For our present purpose we change revolutions alone and keep all the other causes or conditions as constant as we possibly can, and then, of course, the results which follow are attributable entirely and completely to the change made in the revolutions.

The economic effect of working at various steam pressures or at various expansions and *at constant revolutions* are, of course, well known. The trials here dealt with show the effects of working given engines at *various revolutions* and at constant steam pressures and expansions.

Seeing that a description of the engines and dynamometer, etc., has been already published* nothing further need be added in that direction here.

Results of Trials.

These are given in the diagrams; I. and II., Plates XXX.-XXXI., referring to the quadruple, and III. and IV., Plates XXXII.-XXXIII., to the triple expansion, conditions.

Diagrams I. and III. contain the actual recorded observations set out in the graphic form, the actual spots being shown in Diagram I. but omitted in Diagram III. for the sake of simplicity. The spots are given simply to illustrate the degree of consistency with which they range themselves along the lines drawn through the mean of them.

The final results are given in Diagrams II. and IV.

Remarks on the Results.

The factors primarily involved and the values of which have to be ascertained by observation on each trial are:—

Revolutions per minute = R.

Pounds of steam used per hour = W.

Indicated mean pressure reduced to low pressure cylinder (lbs. per square inch) = I.M.P.

Load sustained at the end of brake levers (total pounds) = L.

From these observed factors all the other quantities are computed, *i.e.*:—

Brake load reduced to equivalent mean pressure in low pressure

$$\text{Cylinder} = \text{B.M.P.} = \frac{L \times 2\pi 6}{412{\cdot}5 \times 3} = \frac{L}{32{\cdot}8} \quad . \quad . \quad . \quad . \quad (1)$$

* *Transactions of the Institution* for year 1896-1897, vol. xiii., page 73.

Indicated horsepower $= \text{I.H.P.} = \dfrac{412{\cdot}5 \times \text{I.M.P.} \times 3\text{R}}{33{,}000} = \dfrac{\text{I.M.P} \times \text{R}}{26{\cdot}7}$ (2)

Brake horsepower $= \text{B.H.P.} = \dfrac{412{\cdot}5 \times \text{B.M.P.} \times 3\text{R}}{33{,}000} = \dfrac{\text{B.M.P.} \times \text{R}}{26{\cdot}7}$ (3)

Pounds steam used per I.H.P. per hour $= \dfrac{\text{W}}{\text{I.H.P.}}$.

" " " B.H.P. " $= \dfrac{\text{W}}{\text{B.H.P.}}$.

Mechanical efficiency of the engines $= \text{M.E.} = \dfrac{\text{B.H.P.}}{\text{I.H.P.}}$ or $= \dfrac{\text{B.M.P.}}{\text{I.M.P.}}$

Steam used per revolution (pounds) $= \omega = \dfrac{\text{W}}{60\text{R}}$.

Revolutions being the only causal condition which is changed from trial to trial, they will be the determining factor, direct and indirect, of whatever variations take place in the other factors, and we therefore use revolutions as a base upon which to plot the other quantities.

(1) *Relation between Steam used and Revolutions.*—It will be seen from Diagrams I. and III. that within the range of the trial revolutions, the line connecting W with revolutions is a straight line. The law of variation of W with R is, therefore, susceptible of very simple expression, thus:

For quadruples $\text{W} = 6{\cdot}1\text{R} + 439$ . . . . . . (4)

For triples $\text{W} = 7{\cdot}16\text{R} + 678$ . . . . (5)

According to these equations the steam used per hour varies as the revolutions plus a constant. The value of the constant will obviously depend on the type and characteristics of the engines, and also to some extent on the conditions in which they are worked, and is much higher for the triple than for the quadruple type. One interpretation of the equation would be that the added constant represents the steam consumption at zero revolutions, being the equivalent of initial condensation, back pressure, friction, piston and valve leakage, and other losses, the steam or heat-cost of which must first be met before any motion of the mechanism can take place.

From the above it follows that as revolutions increase, the weight of steam used per revolution diminishes, thus:

For quadruples $\omega = \dfrac{\text{W}}{60\text{R}} = \dfrac{6{\cdot}1\text{R} + 439}{60\text{R}} = {\cdot}102 + \dfrac{7{\cdot}32}{\text{R}}$ . . . (6)

For triples $\omega = \dfrac{\text{W}}{60\text{R}} = \dfrac{7{\cdot}16\text{R} + 678}{60\text{R}} = {\cdot}119 + \dfrac{11{\cdot}3}{\text{R}}$. . . (7)

A curve showing the rate of this diminution is given on Diagrams I. and III. (Plates XXX.-XXXII.)

The physical explanation of the fact that the weight of steam used per revolution falls as revolutions rise, would seem to be found in the shorter duration of the high pressure admission period at the higher revolutions. This shorter duration may be expected not only to admit less weight of steam per stroke, but also to some extent to lead to a diminished amount of initial condensation in the high pressure cylinder. From these causes combined, the steam used per revolution will be lessened as revolutions increase.

(2) *Relation between I.M.P. and Revolutions.*—From Diagrams I. and III. it is seen from the curve of I.M.P. that the value of I.M.P. falls as revolutions rise, the rate of fall increasing with the revolutions. The causes of this fall would seem to be, first, the diminishing consumption of steam per revolution, as shown by equations (6) and (7); and second the increase in resistances encountered by the steam during its passage through the several cylinders due to the higher speeds at which it must travel on entering and leaving the cylinders as revolutions increase. This last source of resistance shows itself in the shape of increasing gaps between the expanded indicator cards—the back pressure on each piston is increased and the forward pressure diminished as revolutions increase. The fall in I.M.P. takes place in spite of the fact that the time-element will beneficially affect condensation within the cylinders.

Obviously, this source of loss might be lessened by an increase in the sectional areas of the ports and openings by the valves. And if we imagine the hypothetical case in which these areas increase in proportion to the revolutions, the line of I.M.P. would be approximately horizontal and a nearly *constant* I.M.P. would result. But it must not be overlooked that this imaginary condition of matters would entail—amongst many other disadvantages—larger valves, or longer valve-travel, or both; and this would mean greater friction losses and therefore enhanced rate of fall of B.M.P. as revolutions increased, with doubtful benefit in the final result.

(3) *Relation between B.M.P. and I.M.P., and therefore between B.M.P. and R.*—The curve of useful mean pressure (B.M.P.) falls faster than that representing I.M.P., which indicates increasing frictional resistances throughout the engine

›chanism as revolutions increase. The vertical distance at ven R between these two curves shows the resistance due to ction of the engine mechanism and air-pump resistance. This, the case of the quadruples, is approximately proportioned to R̄, between R=100 and R=220. In the triples the rate of in- ›ase is considerably lower than this.

(4) *Relation between Power and Revolutions.*—The power is pro- rtional to the product of the mean pressure and the revolutions [uations (2) and (3)]. The diagrams show that as revolutions :rease mean pressure decreases. So long as revolutions rise at greater rate than mean pressure falls, the power will increase th the revolutions. Within the limits of the trials this is the ›e with I.H.P. for both sets of trials. Up to the highest ·olutions at which the engines were run, I.H.P. does not attain ximum value, but owing to the decidedly downward tendency the I.M.P. curve it is clear that were the revolutions carried a ;le higher, the maximum height of the I.H.P. curve would n be reached. When the rate of decrease of the mean pressure ıals the rate of increase of the revolutions the power will have ained its highest limit in the circumstances. This limit is ched for brake power—see Diagrams II. and IV.—in the case ¡uadruples at 212 revolutions per minute, and in the triples at ⟩ revolutions per minute. When the engines are allowed to :eed these speeds the brake horsepower gets less and less as olutions increase. The immediate cause of this is, of course, to found in the growing rate of diminution of I.M.P. and B.M.P. h increase of revolutions. The *ultimate* causes are therefore se which have operated to determine I.M.P. and B.M.P. them- ·es, and which have been referred to in sections (2) and (3).

(5) *Relation between Economy and Revolutions.*—On Diagrams and IV., Plates XXXI.-XXXIII., the curve of steam con- ıption per horsepower is given for both indicated and brake ›epower. It will be noticed that in terms of indicated power minimum consumpt for both quadruples and triples occurs ›r near 172 revolutions per minute, but in terms of brake ·er the minimum for quadruples is at or near 147, and for ıles at or near 158 revolutions per minute.

These curves are obtained by dividing the total water used hour by the horsepower, viz., $\frac{W}{H.P.}$.

Reducing this to its lowest terms we have at given R;—

$$\frac{W}{I.H.P.} = \frac{60R\omega \times 26{\cdot}7}{I.M.P. \times R} = \frac{1602\omega}{I.M.P.} \quad . \quad . \quad . \quad . \quad . \quad . \qquad (8)$$

$$\text{and } \frac{W}{B.H.P.} = \frac{60R\omega \times 26{\cdot}7}{B.M.P. \times R} = \frac{1602\omega}{I.M.P. \times M.E.} \quad . \quad . \quad . \quad . \qquad (9)$$

The ultimate and true economical performance of an engine varies inversely as the value of $\frac{W}{B.H.P.}$ and therefore from equation (9) it varies inversely as $\frac{\omega}{I.M.P. \times M.E.}$ We have just seen from the curves how the value of this expression varies as revolutions vary, and we have also seen the particular speeds of revolution at which it is a minimum in the particular conditions special to these trials. Let us enquire as to the probable effect on the value of this quantity, and on the position of its minimum value on the revolution scale, of alteration in the condition which specially concerns us at present, viz., sizes of ports, port openings and passages, for steam and exhaust throughout the engines. Let us assume the ports, etc., to increase in sectional area *pari passu* with the revolutions. This will mean that the speeds of steam and exhaust are constant at all piston speeds. The value of ω would in this case be constant also, were it not that the increasing piston speed affords less and less time for condensation of steam entering during the high pressure cylinder admission period, and hence on this account ω would still fall somewhat as piston speed increased, but how much would be indeterminate except by direct experiment in the new conditions. The value of I.M.P. would in its turn be practically constant at all speeds in the assumed conditions were it not for its dependance on ω, and seeing that ω falls, I.M.P. would also fall, but precisely how much is again indeterminate except by actual trial in the new conditions. As regards the value of mechanical efficiency, this would of course diminish because of the increasing frictional resistances due to the increasing size of the valves as speeds of revolution increased. But how much M.E. would fall from this cause is again uncertain in the absence of direct experiment in the new conditions. It would therefore appear that both the numerator and denominator of equation (9) would decrease with increasing speeds of revolution in the hypothetical conditions assumed above; but whether its value as a whole would decrease or increase, or at what speed of revolution it vould reach its minimum value are equally indeterminate with-)ut the aid of experiment in the new conditions. These new onditions were increase of ports with increase of revolutions, so s to preserve steam and exhaust speeds constant. On the face of t, therefore, it is not by any means obvious that an increase in team and exhaust port sections above the proportions of the ngines experimented with, would have yielded either greater conomy in the results, or have raised the most economical peed of revolution higher on the scale of revolutions.

If, however, one could tell the exact share which piston speed –as contrasted with steam speed—has in determining the value f ω, it would be possible to make a fairly accurate estimate of ie variation in the value of $\frac{\omega}{\text{I.M.P.} \times \text{M.E.}}$ with variation in iston speed. And, therefore, it would be possible to prescribe aximum-economy speeds of steam and exhaust for each piston peed, which would apply generally. Without the aid of further xperiment, however, the writer does not see his way to gener- lise on the subject. And the object of further experiment ould seem to lie in the direction of dissociating the direct effects 1 ω of piston speeds from those of steam speeds. Such experi- ents will be very difficult to make as they would seem to require linders with elastic ports and valves, the capacity of which tter could be altered at will without the necessity of changing ıything else.

One thing is so far certain and that is, that for the engines perimented upon—and which are engines of not at all unusual oportions or design, and of dimensions which place them ite out of the category of toys—there is a definite limit to the ston speed at which they can be run without sacrifice of onomy. And further, the writer believes that this limit is here own to be very much lower than has generally been supposed.

From equation (9) it is obvious that any increase in echanical efficiency will, other things equal, not only raise the onomy in an absolute sense, but will also raise the limit of ston speed at which economy is at a maximum. From this it is rther seen how important is the question of the friction of the echanism, and how great an influence it may have upon the rformance of engines, especially upon those which are intended run at abnormally high piston speeds.

The speeds of steam and exhaust throughout the engines are given in Diagram V., Plate XXXIV., in terms of revolutions per minute. These speeds are in feet per second and have been calculated as follows:—

$$\text{Speed of steam} = \frac{\text{cylinder area in sq. inches}}{\text{maximum port opening in sq. inches}} \times \text{piston speed in feet per second.}$$

$$\text{Speed of exhaust} = \frac{\text{cylinder area in sq. inches}}{\text{port area in sq. inches}} \times \text{piston speed in feet per second.}$$

Conclusions.

The outstanding results of the trials here recorded may be summarised as follows:—

1. For every reciprocating steam engine, when change in power is brought about by change in piston speed, there is a certain limit of piston speed at which maximum-power is attained, and beyond which the power will fall as the speed is increased.

2. For every reciprocating engine, when change in power is brought about by change in piston speed, there is a certain limit of piston speed with which is associated maximum-economy of steam used per horsepower developed.

3. For the engines and conditions of the trials, maximum-economy in steam used per brake horsepower, occurred for quadruples at a piston speed of 441 feet per minute, and for triples at a piston speed of 474 feet per minute, the corresponding mechanical efficiencies being for quadruples ·856, and for triples ·87.

4. The maximum-economy piston speed depends on several factors, the exact influence of each of which remains to be ascertained, but to a very large extent it is determined by the mechanical efficiency of the engines. An increase in the value of mechanical efficiency will, other things being unaltered, not only raise the economy absolutely, but will advance the maximum-economy point on the scale of piston speed.

5. Both maximum-power and maximum-economy piston speeds are for the brake power considerably lower than for the indicated power, and therefore if the indicated horsepower were alone considered, the piston speed of maximum-economy would appear to be considerably higher than it is in reality.

DISCUSSION.

Professor A. L. MELLANBY, D.Sc., said—This is the first time since 1897 that it has been possible for me to be in Newcastle at a meeting, and I am pleased to have the opportunity of speaking upon this paper given by my former teacher, Professor Weighton. Any results obtained from the experimental engines at the Armstrong College are of special interest to me, having been a student at the College when they were first erected and had the honour to obtain the Gold Medal of the Institution for a paper containing some experimental results from the same engines.

The rules usually followed by engine designers for piston and steam speeds were so empirical, that experimental results showing how a variation of these factors influenced the economy of the engine were most welcome. The author has, in his introduction, suggested that the paper, as presented, was somewhat incomplete, but all would agree that a vast amount of time and thought must have been given to it.

I am especially pleased to find that Professor Weighton has not given simply the changes in the steam used per hour per horsepower, due to speed variation. So many experimenters are in the habit of giving nothing but these final deductions that it is often impossible to see any reason why certain changes in the conditions should give certain results. The author has recognised that the economy depends upon two factors, steam per hour and horsepower, and by showing how each of these depends upon the revolutions he has helped them to see why, for this engine, there is one best speed. It is particularly fortunate that it has been possible to run the engine to such a speed that the most efficient number of revolutions in terms of the indicated, as well as the brake, economy has been obtained.

On looking at the diagrams, I am surprised to find that the steam per hour curve is a straight line. Although I have not had an opportunity lately of making tests upon an engine similar to the one under consideration, I have made various series of speed trials upon smaller engines, and have always found the water per hour line to be a flat curve. To illustrate this point I have prepared a diagram (Plate XXXV.) showing the variations in steam per hour with speed obtained from a small engine in the Glasgow Technical College. This engine had a cylinder $6\frac{1}{4}$ inches diameter and 12 inches stroke, and, for the trials illustrated, the admission pressure was 60 pounds per square inch and cut-off was at 0·55 of the stroke.

From Diagrams I. and III. (Plates XXX. and XXXII.), it will be noticed that the steam per revolution diminishes with increased speed. If the reason for this diminution could be found, several of the mysteries connected with steam engine theories would be solved. It is obvious that part of the diminution can be accounted for by the fact that, as the speed increases, the pressure at cut-off is reduced by wire-drawing. The weight of steam shown by the indicator to be present in the cylinder at cut-off would therefore diminish with higher revolutions. It is well known that more steam passes through an engine than is shown by the indicator card, and the important fact to determine is, does the difference between the indicated weight and the weight of steam actually used diminish with increase of speed? This can only be determined by measuring the indicator cards, and I think it will add to the value of the paper if Professor Weighton will either let us have the indicated weights at different speeds, or will publish some of the indicator cards, so that members might calculate these weights for themselves. For the small engine to which I have referred, the indicated weights, and the difference between the indicated and actual weights—so-called the "missing quantity"—will be seen in Plate XXXV.

Professor Weighton mentioned that part of the reduction in the steam used per revolution was due to lessened initial condensation, but I am inclined to think that changes in the initial condensation of the steam will probably be of only secondary importance. It can be shown that if the inside skin of the clearance surfaces went through a temperature range of T degrees, the amount of condensation per revolution will be proportional to $\frac{T}{\sqrt{N}}$ where N is the revolutions per minute. The amount of condensation, therefore, for any given revolutions, depends altogether upon the temperature range. If the range were equal for all speeds, then the higher the speed the less the condensation. It is generally supposed that as the speed increases the temperature range of the metal decreases and this again will reduce the condensation. I am very doubtful whether ıis diminution of temperature range does take place for all ıanges of speed. I have found from actual measurement that ıe average temperature of the metal in the ports diminishes ith the increase of speed, even although the back pressure of ıe exhaust steam increases. It seems evident that this lowerıg of the temperature is due to the fact that the metal parted ith more heat to the exhaust steam on account of the higher ›eeds at which it was rushing over it. It is quite feasible, ıerefore, to imagine that the incoming steam will give up more ɜat to this colder metal, and the probable result will be that the ·mperature range will be increased. As a matter of fact, the ›w experiments made to determine the temperature range of the ıetal in a cylinder, showed that this range was so small that ıitial condensation on the metal could not be the great loss ɜnerally imagined.

It is much more reasonable to suppose that the reduction ı steam per stroke is due to the fact that the valve leakage as practically independent of the revolutions. This was first ıown by Professors Callendar and Nicolson, and their results ave been in a great measure confirmed by the work of Professor apper. Since the leakage per hour is constant, then it follows ıat the higher the revolutions the less will be the leakage per ›volution. The steam per revolution will therefore diminish ith increased speed: firstly, because the pressure in the cylinɜr at cut-off is less; and secondly, because the leakage per ›volution diminishes. In a badly-designed engine with large mounts of exposed surface, it is probable that for some limited ınge of speeds the reduced leakage may be more than counterılanced by the increased condensation. This appears to be the ıse for the engine which gave the data for Plate XXXV., and will be most interesting to see whether the missing quantity lways diminishes with speed for an economical engine like ıat at Armstrong College.

Turning to the effect of speed upon power, Plates XXX. and :XXII. show that the mean effective pressure in the cylinder iminishes with increased speed. This might have been expected ·om our knowledge that wire-drawing losses increase with speed. ·ut the effect upon the brake mean-pressure is not quite so bvious, and it is interesting to find that there is such a marked ıcrease in the friction mean-pressure with speed. This could ot have been determined except by experiment, and Professor

Weighton is to be congratulated for having so much insisted upon measuring the brake horsepower. Forced lubrication would probably prevent this increase being so great. It may be interesting to the members to see how the power is reduced in another type of engine by increase of speed, and for this reason a diagram (Plate XXXVI.) has been prepared from the locomotive trials of Professor Goss. The diminution of mean pressure with speed is here well marked, and for the sake of comparison the mean pressures given in the paper for the triple expansion engine are shown on the same diagram. The locomotive from which these particulars were obtained had cylinders diameter 17 inches by 24 inches stroke, and for this particular series of trials the boiler pressure was 130 pounds per square inch, and cut-off took place at 35 per cent. of stroke.

In conclusion, I cannot help remarking that Newcastle district is to be congratulated on the possession of such an experimental engine as that of the Armstrong College. You are also particularly fortunate in that Professor Weighton uses these engines to carry out researches of commercial importance, in addition to teaching students the ordinary methods of engine testing. Already you have had papers upon best mean pressures, best receiver drops, and the paper now before you is in importance a fitting continuation to those just mentioned. Each of these papers gives some definite information to designers, and, if properly studied, will be of the utmost value in the production of economical engines.

Mr. W. G. Spence said—Personally, I find it difficult to dissociate the usual conditions obtaining in marine practice from those stated in this paper. The conditions in the paper are that the pressure and cut-off are kept constant and the brake load only is varied, namely, a condition practically unknown to marine engineers; it must, however, often be possible in winding engines, or a locomotive going up and down a slope. There are one or two points in the diagrams I cannot quite understand, although they are probably capable of simple explanation. As some other members may be in the same condition of mind, I think it may be well just to ask about them. The first thing I find a difficulty in is to understand the difference between the mean pressure in the quadruples and triples. The steam pressure in both is the same; the vacuum is the same, and the expansion are nearly the same. There are roughly, about 15½ expansions in the quadruples, and 14½ in the triples, yet the mean pressures vary considerably. At 100 revolutions the pressure in the triple is about 23 pounds and in the quadruple 18·6 pounds, and at 220 revolutions in the triple you have a pressure of 18 pounds and in the quadruple about 15 pounds. It may be owing to the difference in the quantity of steam due to the larger amount of clearance in the triple cylinder; but there is something not clear to me, and I should like that explained. With regard to the question of the speed of steam, which is one of the objects of the paper; in comparing the figures given with actual practice, the comparison is, I think, a very interesting one, and it results in this—that one feels, on examining this diagram, encouraged to go to higher speeds than one has been in the practice of doing. Take the triple engine. The point of least $\frac{\text{W.}}{\text{B.H.P.}}$ is at 158 revolutions, and the speeds of steam given there are about 180 for the high pressure, 195 for the intermediate and about 262 for the low pressure. These all appear high, and further, if you follow along the curve to the point where it really begins to rise, instead of taking it at its most efficient point you get a considerably higher velocity, and these velocities are a good deal higher than usually obtain in practice. May we infer that the velocities in practice are on the safe side? I notice in describing the diagram on the wall Professor Weighton referred to the low pressure steam velocity as if it was higher in comparison than the other two. As a matter of fact, I think, in comparison with practice, the low pressure seems to me—I am speaking of ordinary marine practice—the more nearly normal of the three. The high pressure, I think, is a much higher velocity in relation to ordinary practice than is the low pressure. There is one very important point in the paper, in that it seems to show that in the engine experimented on with fairly high steam velocities you can get, what is on the diagram, apparently the most efficient condition. In conclusion, I would wish to thank Professor Weighton for placing his very interesting experiments before us.

The discussion was adjourned.

The meeting then dissolved.

EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWENTY-FOURTH SESSION, 1907-1908.

INSTITUTION DINNER.

nnual Institution Dinner was held in the Great Hall. g College, Newcastle-upon-Tyne, on Friday evening, 7th, 1908. The President, W. H. Dugdale, Esq., E., occupied the chair, and was supported by the fol- ests and officers of the Institution:—The Right Hon. ey, Chairman of the Newcastle and Gateshead Chamber erce; John Ward, Esq., President of the Institution eers and Shipbuilders in Scotland; J. H. Merivale, q., President of the North of England Institute of nd Mechanical Engineers; J. D. Twinborrow, C.E., sident of the Newcastle Students Association of Civil ; Captain Sir R. K. Arbuthnot, Bart., M.V.O., R.N.; iral T. MacGill, C.B., R.N.; the Sheriff of New- alter Lee, Esq.; John Gravell, Esq., Bureau Veritas of Shipping; J. Foster King, Esq., British Corpora- ster of Shipping; Herbert Shaw, Esq., Secretary of astle Chamber of Commerce; E. H. Parker, Esq., of the Institution of Engineers and Shipbuilders in F. H. Pruen, Esq., Secretary of Armstrong College; Esq., President of the Newcastle Association of Fore- neers; H. Campbell, Esq., Chairman of the Graduate the North-East Coast Institution of Engineers and Ship- N. Testrup, Esq.; Sir W. T. Doxford and H. Withy, t-Presidents of the Institution; D. Andrew, Esq., Hunter, Esq., M. C. James, Esq., James Marr, Esq., vell, Esq., W. G. Spence, Esq., and Professor R. L. , Vice-Presidents of the Institution; G. E. Macarthy, Esq., Hon. Treasurer; G. J. Carter, Esq., E. C. Champness, Esq., Alfred Harrison, Esq., R. Hinchliffe, Esq., D. R. Macdonald, Esq., G. Moffitt, Esq., D. Myles, Esq., J. L. Twaddell, Esq., and H. Walker, Esq., Members of Council; Lieutenant-Colonel J. D. Christie; Professor J. J. Welch; John Duckitt, Esq., Secretary.

The following gentlemen expressed regret at not being able to attend:—His Grace the Duke of Northumberland; Sir Andrew Noble, Bart., K.C.B.; Admiralty: Sir Philip Watts, K.C.B., Engineer Vice-Admiral Oram, C.B., R.N., and Engineer-Commander J. D. Thomsett, R.N.; Lloyd's Register of Shipping: H. P. Cornish, Esq., and J. T. Milton, Esq; President and Secretary of The Institution of Civil Engineers; President and Secretary of The Institution of Mechanical Engineers; President and Secretary of The Institution of Naval Architects; Sir Isambard Owen, D.C.L., M.D., Principal of Armstrong College; James Robinson, Esq., Secretary of the Employers' Associations; W. Boyd, Esq., Past-President of the Institution; E. H. Craggs, Esq., Vice-President; Colonel R. Saxton White and G. D. Weir, Esq., Members of Council.

About 160 gentlemen sat down to dinner.

At the conclusion of the dinner, the President, without comment, submitted the toasts of "The King" and "The Queen, the Prince and Princess of Wales, and the Rest of the Royal Family," which were loyally drunk with musical honours.

Sir W. Theodore Doxford proposed "The Imperial Forces of His Majesty the King." He said—I have the important toast to propose of "The Imperial Forces of His Majesty the King." I think we here have special reasons for taking special interest in the Navy of this country. A large proportion of the most important vessels have been built on the banks of the Tyne, and many members of this Institution have been connected with, and responsible for, the building of other vessels belonging to the Royal Navy in other parts of the country, even in those built in the Government dockyards. Personally, I do not think we need fear that this country will ever take a second or back seat in connection with the vessels of our Royal Navy either in number or efficiency. For this reason: that if any government in this country were to attempt to allow the fleet to get below the two-power standard, that government would not remain in office very long. But though we may have no fear as to the number and power of our fleet, I rather fear that we may not be quite so strong in the future as regards the men. But that is a point that is very difficult for outsiders to judge. What I fear is that men may not be trained in sufficient numbers for the work they will have to do in case of need. Our fleet is increasing in numbers; we require more and more men. Whether those men are being trained we do not know. Perhaps Admiral MacGill will be able to inform us, and many of us would feel more at ease if we were assured we were going to have sufficient efficient men to man our fleet. We may take this warning to ourselves, that we should not have six months' notice, probably not six days' notice, when a war is going to begin. The other part of the toast, "the Army and Reserve Forces," is perhaps more difficult to deal with. We seem to be in a transition state, and the minds, even of experts, seem to differ very much upon what the army or the reserve forces should be. I am a member of the Territorial Forces Association for the county of Durham, but I must admit that I have not yet been able to arrive at the exact meaning of Mr. Haldane's scheme, or how far it is going to extend, or what the result is likely to be: but of this I feel sure, that unless Mr. Haldane or the Government of the country is prepared to spend more money on the reserve forces than they appear to be prepared to do at the present moment, there is little chance of the new scheme being the success it ought to be. I do not think that Mr. Haldane or the Government are attempting what they should. I think it is only about 150,000 men that they are proposing to have. There is no difficulty in this country in getting ten times that number if they go about it in the right way and are prepared to spend the money. In offering this toast, I do so feeling every assurance that when the time comes both officers and men in our Navy, the Army, and the Reserve Forces, will rise to the occasion. They will be able to do what they have done in the past if the Admiralty, and especially the War Office, will only give them a fair chance.

The toast was patriotically received.

Rear-Admiral T. MacGill, C.B., responding, said—I have to thank you on behalf of my section of the forces. I was hesitating for a moment as to what the Imperial Forces consisted of, but I leave Colonel Christie to answer that. I know of what they ought to consist. They ought to consist of the manhood of the country, and there would be no necessity for talking of this force or that force. The Imperial Forces should be pointed to as the manhood of the country, and if they could only do that, I am sure we would be better all round. At any rate, it would not hurt anybody to be trained from 18 to 25 years of age. I was present at a banquet some years ago given to about 300 naval officers by the Lord Mayor of London, and Lord Goschen, on rising to speak, said it was not much good talking about the Navy to that assembly. They knew too much about it. I think I may say the same here, so I do not propose to say much about the Navy. The other day I saw Lord Inverclyde in the House of Lords, and he considered the private yards should do all the Government shipbuilding and the Government yards should do all the repairing. Well, that sounds very feasible. But is it so feasible? What do we see now here on the Tyne? Three first-class ships and ten small ships laid up. These were worth about six millions of money, the Admiralty have great difficulty in getting the money, and when they give their orders they cannot get them carried out. I believe of these ten small ships one of them is not here. She likes the air of Sheerness better. I do not know what it is about that place—whether it is the view from Sheerness, or the charms of Southend Pier—but there is something takes these small ships down that way, and she has not come back yet. However, when she does come I hope she will get her 34 knots. It is a serious thing, joking apart, for the nation that they cannot get their orders completed. I have no mandate from the Admiralty, but from a common-sense point of view when the next orders are given out, to where will they go? Well, they will not come to the Tyne, because they cannot get them carried out. They will probably try to do them in their own yards, and that is why they keep their yards ready for work, and why I do not concur with Lord Inverclyde in saying that the private yards should do all the building and the navy yards all the repairing. I see his point, but just consider the present state of affairs. Whatever the distress is in Newcastle now, I fear it will be much worse next year, because I feel sure the orders will not come this way. All I can say is—You give us the ships; I think the Navy will understand how to handle them.

Lieut.-Colonel J. D. Christie, V.D., also responding, said—This toast of His Majesty's Imperial Forces always has a prominent position on such occasions as this, and it is no wonder that it is so. Nowadays, in peaceful pursuits, we occupy the leading position amongst the nations of the earth, and that it has become possible for us to do so is because of the greatness won for us by our army and navy in years gone by. And I think we have good reason to believe that in our army and navy to-day we have got as good material as we ever have had. But the machinery has become rusty and antiquated, and that is the reason for the new army scheme to which Mr. Haldane and his advisers have given so much attention in the past few years. By this scheme we are to have—as indeed we have now—an army—a small army, it is true; but an army well equipped and well trained; able to go anywhere and to do anything; and we are also to have for home defence a territorial army, which will not possibly be able to have the training that it ought to have. Nevertheless, it is a scheme that deserves well, for it appeals to the patriotism of all; and while every Briton has good right to be proud of his country and his ancestors, he also has a duty, and that duty is to take care that his country is kept up in the high position that it has won for itself. And, in spite of the Peace Conference, we have still to maintain our position by our strength. While, therefore, we have all got a duty, I would just like to mention two ways in particular in which I think all employers of labour can and ought to help. They ought to give all the facilities they can for practising rifle shooting. For example, by having miniature rifle ranges in or near their works; and they also ought to do what they can to give the men of the new territorial army as much time as possible to go into training when the annual camp period comes round.

With these remarks I have the honour to respond on behalf of this toast.

Mr. Herbert B. Rowell rose to propose the toast of "The Trade and Commerce of the Tyne." He said—I have been having a rather warm time of it in my corner, as my friends have seen on a piece of paper in my possession the date 1400, and they fear I shall be like the Scotsman one of them once heard who, in his speech, began at the year 1066 and went on year by year until he was shouted down. I am not going to go on year by year, but it is difficult to deal with this toast of the trade and commerce of the North-East Coast without going back to about the period that we see illustrated on the wall here (referring to a large mural picture of the Tyne and Old Newcastle). Newcastle, however, did first attain celebrity as a port in 1400, though, as a matter of fact, if my friends had looked a little further they would have seen another date—that of the earliest known shipments of coal, of which the records begin in 1300. About 300 years after, that is, in 1603, those who controlled the trade had so far advanced in their ideas—they were so much more in harmony with some modern ideas—that we find them actually going into the matter to see how best to restrict the output to keep it below what was then considered the enormous total of 150,000 tons per annum to which it had risen. The other principal exports in early times were salt and wool, wool being described by an old writer of the fourteenth century as "the jewel of the realm." Wool was at that time all shipped to Calais, and Newcastle was, I believe, the only port in the four northern counties from which it was allowed to be shipped. The business was so profitable that those who managed the trade in Newcastle used to bring the wool surreptitiously from further south and ship it as if it had been grown in one of the northern counties. About 1650 the coal trade really began to attract attention, and a number of men from the south came here and put money into the collieries with the idea of making their fortunes. To one of these, who was called Beaumont, an old writer makes interesting reference, describing him as a man of "great ingenuity and exceptional parts" who came here with £30,000 and some "rare engines" by which he proposed to bore for coal with iron rods. He also proposed to haul it by small ponies instead of by hand sledges, and even to go so far as to attempt to remove water from the pits. He remained here two or three years and then went home "on light horse" having lost all his money, though he certainly deserved a better fate. The output of coal has gone on developing until it has risen to 17½ million tons, which was the amount shipped last year. Up to the beginning of this century the river in several places below Newcastle was only five feet deep at low tide, at the bar it was only seven feet, and the river froze so much then and at earlier dates that at one time the people who lived at Shields, near the mouth of the river, were often in danger of starvation because the Corporation of Newcastle would not allow them to have a market, and they had to come to Newcastle to do their marketing. Indeed, the hardship became so great that they petitioned the Government, pointing out that they were thus in danger of their lives from flood and from ice. The deepest place on the river seems to have been off Bill Point where there was thirty feet at low tide, so that it seems to have been predestined as a place for battleships to lie. I do not know whether there is anyone here who can remember it themselves, but I can remember hearing my parents say that when they were young it was customary to picnic on Bill Point to gather wild strawberries, and for the lads to go rabbitting on the Rabbit Banks where the new Edward VII. Bridge abuts on the south side. The great improvement in the river began, of course, about 1850. The River Tyne Commission was established sooner than that, but it was then that dredging was taken seriously in hand, and rapid progress was made. The estimated total cost to improve the river so as to enable ships of the size of the "Great Eastern" to be built in it was something under a million. The cost of the piers was to be £660,000. Perhaps someone here can tell us what the cost has been, but I am under the impression that if any of us who are responsible for estimates in our own works were as far out as that, our works would not go on very long. The amount of dredging that has been done is, however, a very impressive thing. It represents about 120 million tons, and what that really means is that it is equal to six times the weight of the water that enters and leaves the Tyne at every tide. That is to say, if you reckon a fifteen feet tide from the piers up to somewhere short of Blaydon, that volume of water is only a sixth of the weight of material which the Commissioners have removed from the bed of the river. They have also established wet docks of about 120 acres, and the staithes are being much improved, two of seventy feet having been built and one of eighty feet being in hand. It is only a few years since large ships built on the river had to go into the docks to get a certain amount of coal shipped because there were no staithes in the river which they could go under, they had then to come out of dock to take the rest of their bunkers in the river as the dock sills were too shallow to allow them to complete in dock. The staithes, as I have said, are being put right, and I hope we may look forward to improvements in the dock sills as well. I do not want to weary you with figures, but in 1863 there were 18,000 ships coming into the Tyne of an average size of 170 tons, while last year there were 13,000 ships entering the river of an average size of 700 tons, representing 9,000,000 tons as against 3,000,000 in 1863. At the end of last year and the year before, in spite of the bad shipping trade, there were only four and ten ships respectively laid up. Without going into the development of other trades in the district, I think I ought to refer to shipbuilding. In 1862, when the British Association met here, the amount of shipbuilding in hand on the North-East Coast was 57,000 tons, representing only 38,000 tons of steel, and employing 8,000 men. That has increased now to about one million tons, which is half the output of the rest of Britain, and is a very satisfactory and substantial increase. After all, however, perhaps the best gauge one can have of the progress of an industrial district such as this is the increase of the population. At the beginning of last century there were 60,000 people in Newcastle, Gateshead, and both sides of the river down to the sea, including North and South Shields, that is to say, fewer than there are now in Byker. That number has increased until now it is three-quarters of a million taking in Blaydon and Newburn, and I think we may take it that the trade of the district has increased in proportion. When the late Lord Armstrong made his opening speech on the occasion to which I have referred, he pointed out that the British Association had not been here for a generation and described the remarkable strides made in that period. Now, at this later date, we see still more remarkable progress; and when we recollect that among us we have men in the prime of life who bid fair to leave as celebrated names as those of Lord Armstrong and George Stephenson, we may look forward to the future with as much confidence as we look back to the past with satisfaction. In that hope, Mr. President and gentlemen, I ask you to drink to the "Trade and Commerce of the Tyne and of the North-East Coast," coupling with the toast the name of Lord Joicey.

The toast was cordially honoured.

Lord Joicey replied. He said—I confess it is with some nervousness that I get up to reply to this toast before the very distinguished company which I see, for, as was so admirably brought to our notice by the gallant Admiral, if Lord Goschen, a most distinguished Chancellor of the Exchequer, hesitated to deal with questions regarding the Navy before experts, I feel sure that I, as an ordinary commercial gentleman, have some hesitation in dealing with such a toast as this before all the experts of commerce that I see around me. I presume I am asked to reply to this toast because I happen to be in the honourable position of President of the Chamber of Commerce of Newcastle and Gateshead. Well, from my earliest youth I have been very closely associated with the commerce of this district, and while I do not pretend to be able to speak with regard to it as well as many that I can see before me probably could, yet I will yield to none, I think, in the interest and in the energy that I have given to assist the commerce of this district during my lifetime. The city of Newcastle contains one of the most successful commercial ventures perhaps which exist in this country. I allude to the great works of Sir W. G. Armstrong, Whitworth and Company, and we who have watched the growth of that great concern from day to day recognise that the ability, the energy and the success which have attended the efforts only show to us what can be done by north-countrymen when they put their backs into it. We had Lord Armstrong, who with his partners, established these works, and have given them a position second to none in the world. We have now Sir Andrew Noble, than whom there is no better example of a capable and successful shipbuilder in any part of the world, and I am sure that we all recognise the great prosperity which has always attended that concern—a prosperity which all we gentlemen who are in fluctuating trades envy very much. If we could only carry on business with the same certainty of success and financial results as Sir Andrew Noble does his, I think we should all be much happier to-night; but unfortunately we are in speculative business, with fluctuations, because we have the ebb and flow tide. We cannot always see when the flow is beginning, but when we get to high tide unfortunately we see the ebb take place, and the ebb is often as great as the flow. I think that during the last two or three years all of us have had reason to be satisfied with this toast, because nearly all our industries have been prosperous. We have, of course, the two chief trades, the iron and coal trades, and we have the shipbuilding trade. Then we have the chemical industries, cement works, and various other concerns, all of which I think have met with a very fair measure of prosperity during the last two or three years; and the best test of that, which I always think is a good barometer, is what we see in the traffics of our great north-eastern railway system. Depend upon it, when you see the traffics going up by leaps and bounds, one week beating another, and going on for two or three years, you may rest assured that the general prosperity of the district is good, and when you find these beginning to go back you find that prosperity is beginning to wane. Last year—and I speak as a North-Eastern director—showed every week, almost without exception, a great increase. I am sorry to say since the new year turned we began to get into some decreases, and it looks very much as if these decreases are going to continue; which shows clearly that we have been at high tide in our prosperity in the district, and we may look forward to some sort of ebb. Well, that is a very unpleasant view, but I feel sure that we north-countrymen who have been accustomed to see these great changes in our commercial remembrance, will realise that after all we must take the ebb with the flow, and as certain as an ebb takes place, so certain will the tide turn, and we will have the corresponding flow which brings prosperity to the district. I am not going to prophesy how long it will be before that flow takes place. I only hope the ebb may be a short one, and that in a short time we may see a great revival of prosperity such as we have had during the last two years. Well, I am speaking now chiefly to shipbuilders, and engineers connected with that industry. I can imagine each one of you in your minds saying, "Well, that [redacted] a good time owing to the cost of our production, and things are looking anything but promising for the future." I am not only interested in the coal trade, but largely interested in the shipping trade, and I regret to say that during the last one or two years things have been in a very unsatisfactory position. Freights have been extremely low. With regard to shipping, costs have been high, and at the end of a voyage I find there is very little left indeed to pay interest on capital invested in my ships; and what has been my experience I think will have been the experience of most shipowners of this district. Can you be surprised under such circumstances that you have a want of orders in connection with your shipbuilding? Shipbuilding and shipowning depend upon each other; and depend upon it if shipowning is prosperous, if freights are good and profits large, you will find shipbuilding soon follows in its wake, and they are so closely allied that if shipowning is unprosperous you soon begin to find yourselves in want of orders for your shipbuilding. I was much interested to-day in looking over some back numbers in regard to freights, and I will just give you two illustrations to show how things have changed in the last thirty years. In 1873, freights to Genoa were 17s 9d. To-day, they are 6s. 3d.; that is, the outward freight, and I am sorry to say the homeward freight is practically just the same. So you will see, notwithstanding the larger vessels and the more economical working of our ships, freights are so low that really at present there is no inducement whatever for anyone to go on building ships. Then take the case of the freight to Hamburg. In the year mentioned it was 6s. 3d. It is now 3s. 3d. When you consider that 3s. 3d. has to bear all the cost that was borne by the 6s. 3d., you will agree with me that there is not much inducement at the present time to build ships for these various trades. I am extremely sorry to find that there is some difficulty in the industry of shipbuilding. You have got a strike on. Well, I have had some experience of strikes. I hate strikes. I hate wars of all kinds, whether industrial or otherwise; but I am one of those people that sometimes realise that, bad as strikes are, bad as wars are for the community, it is sometimes necessary to go in for them, and if a strike takes place, I think it is the duty of everybody, not only the capitalist or the employer, but the workmen, to consider whether it is in the interest of the community at large that that strike should go on. You cannot expect an employer or capitalist to carry on a business if he feels sure that by carrying it on he will continually lose. All interests are combined in connection with an industry; and if that industry is to be carried on at a time of depression everybody associated with it must bear their fair share of the burden. However, I hope that good advice, and that any conferences that may take place hereafter, will result in a satisfactory arrangement of this unfortunate industrial dispute. I wish I could say that if it were settled there would be work for all, and that things will go on prosperously in the particular industries of shipbuilding; but I am afraid, and you will gather from what I have said that so far as I see, it looks as if we were in for a period of depression, and depend upon it it will be with us as it is with every other producing country in times like these—it will be the person or the firm or the country which can produce the cheapest and best which will stand the depression best. I cannot help thinking all you experienced gentlemen realise that as much as I do, because I know cheap production is more likely to bring prosperity back from a time of depression than anything else. I remember one gentleman talking to me about the coal tax, and I said, "Let me be the cheapest producer of coal in the world and I will fight the world." If you can be the cheapest and best producer of ships, you need fear no competition from any part. I was told I must not speak long, but I have been very much interested indeed with what the gallant Admiral (Admiral MacGill) has said. I do not quite agree with him with regard to the orders given by the Government. I think we have spent a great many millions in connection with the Tyne. We have some of the best shipbuilding yards on the Tyne, qualified to turn out the very best ships of war that the nation, or any nation, can require, and I think that the Government ought to give us a good and a large share of their shipbuilding work. I remember some years ago going down to look through one of the dockyards, and in looking round I saw they were building a ship in that dock. I said, "How does it happen you are building a ship in that dock?" "Oh," they said, "we had not room." I said, "What will happen if you had to repair vessels? Supposing we get to war, how will you put your ships into dock if it is occupied?" I think it is a great mistake to so cram the dockyards as to put them into a position that in a time of emergency they could not use them. Why should they not give such orders to the Tyne, or the Clyde, or Barrow? I see no reason. I think the dockyards in this country should be chiefly repairing dockyards and not building dockyards. Both the late Government and the present Government are going to establish a large dockyard at Rosyth. No doubt they say it is necessary because we have not a dockyard on the East coast. Well, it may be necessary, but I am not in favour of establishing a dockyard the same as at Portsmouth. Here are these places established simply on one industry. Any shortage, and they have to discharge men. There is no occupation for them. They have to leave their own localities. Look at the position of the Tyne. We have always available large numbers of the most skilled and expert workmen who, if they are discharged from a dockyard, can find employment elsewhere, and I think it would have been of great advantage to have had a dockyard established in this district. When you consider the amount of taxes paid on Tyneside we have a claim on the Government to give us the work. I have tried again and again to get the costs of this dockyard building. They have given me the gross, but I could never get the price. I should like to get the establishment charges, and I am sure the cost of building these vessels in our dockyards will not compare with the price paid here. I do think that the Government, and particularly in these days, when there are such claims put forward in all localities to have some portion of the Government work, I certainly think that such a district as Tyneside, where we pay an enormous sum in taxes, has a much greater claim than such places as Chatham, Sheerness, and Portsmouth, which simply are Government dockyards. I do hope that at the next meeting of this kind you will look forward to the future with a much brighter expectation than I do to the next twelve months. Things do not look well. It is no use disguising the fact. I feel sure that so far as holding our position on Tyneside is concerned, we have got excellent workmen in this district, we have got enterprising capitalists, we have got the most skilled men of every description, and I am certain with fairplay Tyneside can hold its own against any district in the country.

Professor R. L. Weighton gave the toast of "Kindred Institutions." He said—The Institutions referred to in the toast comprise the Institution of Civil Engineers, the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, the North of England Institute of Mining and Mechanical Engineers, and, I would venture to add, the Institution of Marine Engineers. These Institutions are represented here to-night, and we look upon them all as having aims identical with our own, and as carrying out those aims by similar means, namely, by meetings, and for the reading and discussion of papers by members. The utility, and, indeed, necessity, for such institutions will be obvious after a little consideration of the nature of engineering as a pursuit. I use the word engineering in the widest possible sense, as including not only engineering proper, but naval architecture and every branch of applied science based on the laws of natural philosophy. There is a definition of engineering which was given many long years ago, and I, for one, have never seen a better or a more general. It was said to be the art of directing the great sources of power in nature for the use and convenience of man. You could not have a better definition than that, and that is the sense in which I use the word; but since this definition was given I think it will be generally conceded that engineering is no longer a mere art. It is essentially a science, and one of the principal characteristics of true science is progressiveness. The extent to which engineering can be applied, therefore, is only limited by the progress of science itself. Now, one of the essentials of all true progress in this world is that we should have intercourse between mind and mind. Hence we see the reason why such institutions as those referred to serve a very useful, indeed, a necessary purpose. It so happens that on this North-Eastern coast of England we were rather late in thus taking advantage of the benefits to be derived from meeting together and discussing different points of a technical character. Indeed, of all the institutions I have mentioned I think I am right in saying we are the youngest but one, and this fact enhances the pleasure and satisfaction we feel in welcoming the representatives of older institutions—institutions that have been in existence longer than we have. We look upon them one and all as our allies, having the same interests and the same aims; engaged as we are in the never-ceasing and the ever-successful and ever-widening endeavour to wrest from Nature her secrets and apply them in the world's work for the betterment of the lot of mankind. We have with us to-night a representative of one of the oldest of these institutions—the Institution of Engineers and Shipbuilders in Scotland, with whose name I am to couple this toast. It seems a very fitting matter that Mr. John Ward should preside over the Institution of Engineers and Shipbuilders in Scotland, representing, as he does, that old and renowned shipyard, Denny's, of Dumbarton. I shall ask you to raise your glasses to the success of "Kindred Institutions," and to the welfare of Mr. Ward.

The toast was drunk with enthusiasm.

Mr. John Ward, in reply, said—Your President, when in Glasgow as our guest at our annual dinner two months ago, paid us the compliment of replying to this toast. You in turn have paid me the compliment of coupling my name with it to-night. For your sakes, I wish it were in abler hands than mine, to do it the justice it merits. It is a subject well worthy of the great cordiality with which you have received it, as in the efficiency of the life's work of the members of this and kindred institutions largely depends our continued prosperity and supremacy as a nation. Our Institution of Engineers and Shipbuilders in Scotland celebrated its jubilee last year, and the story of these years, representing the second half of the century of marine engineering and steam navigation, is both interesting and instructive. It is one of hard work and hard thinking, carrying with it the assurance, which your own kindred institutions have also made clear and manifest—that we are never halting, but going on to greater efforts and results than have yet been attained. We may, I think, fairly claim that Watt's improvements on the steam engine, unceasingly perfected from then till now by many workers, are the foundation of all the changes that have taken place in the naval architecture of this and other countries, and in the accomplishment of which the Clyde and the North-East Coast, as shipbuilding and engineering centres, hold a high and honoured place. At a meeting in Glasgow a fortnight ago, in replying to a somewhat similar toast to this, I gave some figures, which I may be pardoned for now repeating, as bearing on the subject. Within thirty years from the starting of the little steamer "Comet," in 1812, when steam shipbuilding in this country began, radical changes in shipbuilding and in the modes of propulsion took place. In 1837 the first iron vessel made its appearance in Lloyd's Register, and in 1840 the screw propeller made its first experimental trial in the "Archimedes" round the coast of Britain. By 1838, river, coast and channel steam trades were fairly established. In that year there were only 230 merchant vessels over 500 tons belonging to Great Britain, and only one iron vessel over 50 tons register. That one iron vessel was the beginning of the evolution in naval architecture which leaves us to-day with "Dreadnoughts," "Mauretanias" and "Lusitanias." These figures will give the best idea of the growth of our merchant service since the introduction of steam power. These are taken from Lloyd's latest volume, and do not take any account of craft under 600 tons. I find that at the middle of 1907 the British tonnage registered was as follows:—

708	vessels	between	600	and	1,000	tons
1,258	,,	,,	1,000	,,	2,000	,,
1,058	,,	,,	2,000	,,	3,000	,,
1,267	,,	,,	3,000	,,	4,000	,,
637	,,	,,	4,000	,,	5,000	,,
352	,,	,,	5,000	,,	7,000	,,
150	,,	,,	7,000	,,	10,000	,,
57	,,	over			10,000	,,

This last figure does not include the "Mauretania" and "Lusitania," and of the fifty-seven, many, of course, are a good way over the 10,000 tons, several indeed more than double that figure. Our Glasgow Institution has professional records of the work of our own members for the past fifty years, and your own for about half that period; but the story of the development of steam navigation and marine engineering during the whole century is a most fascinating one. It was in 1807 that the "Clermont" commenced running in America, and the "Comet" made its appearance on the Clyde in 1812. The first steps were feeble and imperfect, but, thanks to the worthy successors of Watt and Fulton, they gradually grew in strength and firmness facing and overcoming successfully the inevitable infantile troubles of which the gauntlet had to be run, then reaching in time the fuller strength of vigorous youth, and passing on unhaltingly to years of maturity, until at the end of a century we see the great advancement in dimensions, speed, luxury and turbine propulsion in these floating palaces, the "Mauretania" and "Lusitania." As to whether these great Cunarders mark finality in dimensions—this is a problem more for the shipowners than for us. We as builders and engineers can see no finality. The question resolves itself into one of whether owners can secure such a return from the use of these large high-speed vessels as will make them pay their way, and whether port authorities in the different parts of the world are prepared to provide accommodation of water, etc., as will "house" such cumbrous visitors. Our production on the Clyde shows a steady increase, taken over a series of cycles of years, as the following figures will show:—

1861-1870	1,367,286	tons.
1871-1880	2,116,507	,,
1881-1890	2,965,962	,,
1891-1900	3,849,207	,,
1901-1907 (7 years only)... ...	3,652,316	,,

I regret I have not similar figures for the output of the North-East Coast, but certain I am that, if not equal in quantity, it will compare favourably both in quality and variety. At the present moment, both on the Clyde and in this industrial centre, a great dullness and depression in trade has taken place, and there is little or no appearance of a silver lining to dispel the dark cloud at present hanging over us. In this district the gloom has been accentuated by labour troubles, all the more regrettable because the depression, so real and apparent, can be seen by any one caring to use his eyes. There may be businesses in which orders can be concealed or kept back for a length of time, but in shipbuilding, with delivery dates asked by owners and promised by builders, to which heavy penalties for delay are often attached, this is not possible. The laying of keel blocks and getting structural material into the yard are matters which can be neither hidden nor delayed. That the present depression in our trade is both real and great is patent to everyone, and that those engaged in some of the branches should have refused to accept the facts, and what they involve while it lasts, is a matter for sadness and regret. I hope the mutual spirit which masters and men have been trying to cultivate in recent years, through meetings in conference, will, despite rebuffs, be again soon in evidence, and speedily dispel the present strife. It is impossible for me to mention the names of those men of kindred institutions, who have by their genius and practical skill made so much that seemed unattainable possible, and whose labours in branches outweigh our own—in railway and bridge work, in hydraulics, electricity, mining, mechanical, civil and sanitary engineering—made nearly all parts of the world accessible to man for residence. Their names are many, and, while not written on the "scroll of fame," they have, both at home and abroad, nobly done their part in works and deeds that have helped to make our Empire. Of our own great genius, James Watt, we are naturally proud. His birthplace has made our river Clyde famous, and we who work on its banks have a personal pride in it. With the remembrance of what your own great geniuses—George Stephenson for railways, and the Hon. C. A. Parsons for marine propulsion by his turbine invention—have accomplished, you on the Tyne have also a right to cherish their names with honour and affection as benefactors of mankind. Indeed, like that of Watt, their names in all the coming years need no monument of perishable material to perpetuate them, as through their brilliant inventions they will be as lasting as that element which in different ways they have subdued to the use of man. In this and other countries great progress has been made in, and encouragement given to, research work, the results of which are recorded in the *Transactions* of this and other kindred societies, and I am certain that through the growing interest and incentive given to work of this nature greater results will be achieved in the future. Regions of growth lie before us yet untravelled; what discoveries are in front of us who can foresee? As far as the younger men are concerned, there never was a time when inducements to unselfish living and high endeavour were more numerous than now. The work of this and kindred institutions must soon be left to them, as we, the seniors, fast wearing to the westward, must lay down the industrial banner which we have tried to plant high on the ramparts of progress. Only this week you have had sudden and startling proof of this in the unexpected and unlooked-for death of a notable standard-bearer, your esteemed ex-President, Colonel H. F. Swan, whose remains are to be taken to their last resting place to-morrow. It was my privilege to have known him for over forty years, and few men during all that time have done more for the prosperity of your river, or for the advancement and progress of shipbuilding and engineering on its banks, than he accomplished. His loss will be keenly felt and deeply deplored, and nothing save kindly memories will be cherished by colleagues and friends long and closely linked up with him in professional work, and in the life and ambitions of the famous firms with which he till the end was so honourably associated. In lifting these banners, therefore, and carrying them forward, let our successors not forget that one of the things they cannot buy on credit is experience; but associated together, not in a narrow or selfish spirit, but in broadmindedness of service in the performance of duty, learn by our failures what to avoid, and, with high aims and ideals animating them, ever living and working so as to gain fresh renown for our profession and our country. Our hope and belief is that in their work, and through the efforts of this and kindred institutions, they will prove a greater and larger power for good in science, industry, and the general comfort of mankind than we, their seniors and predecessors, have been. About twenty-five years ago, when on a visit to the North-East Coast with my partner, the late William Denny, after coming from Saltburn to Jarrow, we wanted to get to Newcastle. Not knowing the way to the station, I asked a workman standing close by in which direction it lay. He was evidently having a holiday, as he said in reply: "Aw've gotten a sup o' drink in, an' aw canna speak plain, but aw'll gan wi' thee an' show thee." Well, gentlemen, by and through this Institution and your Armstrong College and higher technical schools and classes you have been nourishing the rising generation with abundance of scientific and technical meat and drink; and in the great work of this famous river, culminating in the "Mauretania," you have gone with us, and shown us what high aims, steadfast purpose and resolute will, together with scientific skill and knowledge, can accomplish.

Mr. J. H. MERIVALE, President of the North of England Institute of Mining and Mechanical Engineers, proposed the toast of "The North-East Coast Institution of Engineers and Shipbuilders." He said—I feel myself in an exceedingly awkward position after the remarks that have been made by Lord Joicey upon the necessity of reducing the cost of production, and it seems to me absolutely bare-faced for any gentleman connected with the Institute of Mining and Mechanical Engineers, so intimately associated with the coal trades of Northumberland and Durham, to have the impertinence to propose your good health when we are about to re-organise our pits upon an eight hours' day, bringing, I believe, one of the greatest blows to the industries you represent that they have ever received. I would not have ventured to appear before you as the proposer of this toast were I not in a position to assure you that there are no persons who have more strenuously opposed the carrying out of this proposal than the coal trades of Durham and Northumberland. I believe if you, the consumers, had wakened up a little bit earlier to the injury that the Eight Hours Bill would do you, and had backed up the coal trades in their opposition to it, we should not have seen this proposal so far advanced in the House of Commons as it is at present. I must not, of course, make any remarks upon the political side of this question, but as it is one in which your health is interested I may say a word or two on its commercial side. I should like the more to do so as the consumer, it appears to me, does not yet realise what this proposal means. The consumers are now tending deputations to ministers and letters to the papers, and almost without exception they go upon these lines—they say the cost of production will be put up by so much per ton; our industry consumes so many million tons; they then multiply one by the other and say, "that is the injury that this Bill is going to do to us." It is most important to discriminate between an Act of Parliament which is merely going to put up cost of production and one which is going to decrease the supply of a prime necessity like coal. It is not so much the increased cost as the fall in production that is going to hit you. The demand for coal increases year by year and this district has barely managed to meet that increased demand, as the present high price of coal bears witness. The sudden and heavy fall in supply which must necessarily follow the coming into force of an eight hours' day, will create a famine and put up prices quite out of proportion to the increased cost of production. You may naturally say, if the increasd price will be so much more than the increased cost of production, why is the coalowner so vigorously opposing this Bill? The reason is plain. The coalowner is long-sighted, and he knows a reaction will follow, and that this reaction will cost him far more than he has put into his pocket during the two or three years after the Act comes into force. It is impossible to say what the ultimate result of this legislation will be, but I believe it will result in the importation of coal from foreign countries. I have committed myself before the Miners' Eight Hours Day Committee to say that it will come from China. Why not? Labour is cheap there, coal is plentiful, and you gentlemen, spurred on by dear coal, will devise improvements reducing freights. I believe we shall see the proverbially impossible, the carrying of coals to Newcastle, come to pass. What is the remedy for this? I think it is tersely put in the motto of this College, *Mens agitat molem*; and it gives me great pleasure to know that you have recently established a Chair of Naval Architecture here. I can wish nothing better for this chair than to hope it may be as successful as the Chair of Engineering, so ably filled by my old friend and colleague, Professor Weighton. There is another point upon which I should like to congratulate you, and that is upon the fact that you are about to return to the old nest. I am sure nobody will deny that the Literary and Philosophical Society is the parent of every philosophical and scientific society in the North of England, and it is with pleasure I see these buildings being erected which are soon to be occupied by you, and which will house under the same roof these three important Institutions, the Literary and Philosophical Society, the North-East Coast Institution of Engineers and Shipbuilders and the Institute of Mining and Mechanical Engineers, to the great advantage, I believe, of all of them. Gentlemen, it gives me great pleasure to propose the health of this Institution, coupled with the name of your President, Mr. Dugdale.

The toast was heartily honoured.

The President (W. H. Dugdale, Esq.), in reply, said—I have to thank you very sincerely for the very kind and cordial manner in which you have received this toast, and as time is running on so quickly and one of our friends has to catch a train, I must alter the toast list somewhat, and therefore will not detain you more than two or three minutes. I would like again not only to thank you, but also, as this is the last time I shall have the honour of being in this chair, take the opportunity of thanking the Council and members of the Institution for the sympathetic support which they have accorded to me during my term of office. There is one matter which has already been referred to by my friend Mr. Ward, but which I must again mention, namely, that during this session we have, unfortunately, lost two of our past-Presidents. First, we lost Mr. Robert Thompson, who was one of the founders and original members of this Institution, and who was for two years the fifth President; and only two or three days ago we lost Colonel H. F. Swan. I am sure we all deplore their loss, and can only hope that the work which they instituted will act as an incentive to us to follow in their footsteps. Our session has been a very successful one, and we have increased our membership by 67, so that our total number is 1,112. We have also been well supplied with papers, and some of them have been not only interesting but likewise very instructive, because we have had the opportunity of obtaining papers upon subjects which are of importance to us, and which have not yet arrived at the text-book stage. For instance, we have had a paper upon "Torsion-meters"; also one from Professor Weighton on "Piston Speeds and Steam Engine Economy," which is an analysis of some experiments that have been conducted on the experimental engine in Armstrong College, and we are just about to have another one on a new system of ship framing, which is being carried out at Middlesbrough. These subjects are useful and instructive, and show that our institutions are not merely debating societies, but media for the diffusion of scientific knowledge, and therefore of great assistance to our younger members. And that is why our Council has this year decided to offer a scholarship to the apprentices who are connected with our engine works and shipyards, in order to encourage them to acquire a better knowledge of engineering, and also to become members of this I[illegible]

I sometimes think that we do not quite sufficiently realise the importance of our scientific institutions, although Professor Weighton and Mr. Ward have just referred to it. There was very little industrial progress until the inception of scientific institutions. And the progress of engineering in this country only dates from about the time of the incorporation of the Royal Society; since then it has gone on more or less by leaps and bounds; and it is to the scientific institutions of this country that we must look henceforth for the maintenance of our industrial supremacy. As scientific institutions we have no politics, and therefore we are able to take up from time to time subjects which are of national and even of international importance. For instance, among other subjects which this Institution is considering at the moment in conjunction with other engineering institutions is the training of engineers for the mercantile marine. We, as engine builders, feel that we ought to have a voice as to the proper training of engineers who have charge of machinery which we construct and place on board steamers, and therefore that question has been taken up with the object of approaching the Board of Trade upon the subject. I might go on and point out several other matters which we at present have under consideration, but, as I have just mentioned, time forbids it, and I must therefore alter our toast list and ask Mr. Harrison to propose "Our Guests," and again thank you for the cordial way in which you have proposed this toast.

Mr. Alfred Harrison, in submitting the toast of "Our Guests," said—The toast I have the honour to propose is one that I am sure every member of our Institution present here to-night will be glad to join in most heartily—it is the toast of "Our Guests." It has been a great pleasure to have had them with us; we have thoroughly enjoyed their company, and we hope they have spent a pleasant evening. We thank them for honouring us with their presence to-night. We thank Lord Joicey, Mr. Ward, and the other speakers for their excellent speeches, and especially for the kind wishes they have expressed on behalf of our Institution. To all our guests we wish good health and prosperity, and I therefore give you with great confidence the toast of "Our Guests."

The toast was received and drunk with enthusiasm.

Mr. J. D. TWINBERROW, President of the Newcastle Students' Association of the Institution of Civil Engineers, replied. He said—The duty of responding for the guests is robbed of one half of its terrors by the genial brevity with which the proposer of the toast has dealt with the matter. The character of your entertainment has also ensured a feeling of thankfulness, so that the only difficulty remaining is to find fitting phrases to give voice to the sentiments with which you have inspired your guests. Speaking for myself, I may say that I feel a considerable diminution in the fineness of my lines since I came into the hall this evening. If it is not quite apparent that my block co-efficient of fineness is approaching the value of unity, still I think it goes without saying my displacement would ensure the immersion of the Plimsoll mark at least to the summer weather load-line. Be that as it may, I hope I may manage to get to port this evening without needing the application of Schlick's gyroscope or the fitting of bilge keels, in order to reduce the angle of roll. It is particularly gratifying to the civil engineer in the pursuit of a branch of his profession on *terra firma*, to associate with naval architects, particularly when they are members of the North-East Coast Institution, who, by their energy, perseverance and ability have been the moving spirits in those large enterprises which have carried the fame of the Tyne, Wear and Tees to the ends of all the earth, and made the names of our northern rivers "familiar in our mouths as household words" to all who "go down to the sea in ships, and do their business in the great waters." The hour precludes the expression of all the feelings engendered by the pleasant and instructive evening spent in your company, but, as a lay observer, I would like to say how deep is my admiration for the works of the naval architects on the North-East Coast. Their chief aim appears to be the solution of the problem of passing a quart measure into a pint pot. I cannot solve the mysteries of their craft in manipulating the relationship between net register tonnage and actual carrying capacity. I have no doubt that during the present time of depression where the actual productive industry is somewhat slackened, the naval architects will be utilising their enforced leisure in striving for still further achievements in that direction, and we shall shortly find that shipowners are being given vessels by which they will be entitled not only to escape the payment of all tonnage dues, but to receive a considerable bonus from the controllers of those ports, rivers and harbours which they patronise. I thank you sincerely on behalf of myself and other guests for the entertainment you have provided, and for the pleasant evening you have given to us.

Mr. SUMMERS HUNTER submitted the toast of "Armstrong College," and in doing so said—The toast I have the honour of giving you, although the last on the list, is, I feel sure, not the least important. The time compels me to cut my remarks short. The toast is that of "Armstrong College." By the courtesy of the Principal and the governing body of the College we are here to-night, and you will agree with me it is very fitting that such a gathering should be held in this hall. I hope it is the first of many. In giving you this toast, one's mind goes back to the early institution, which was founded, I believe, in 1871. At that time it was looked upon, and really was, an off-shoot of the Durham University. The off-shoot has grown into these magnificent proportions—not the proportions of buildings alone, but of great utility, and proportions that have great influence upon the trade and commerce of the district, and particularly upon those industries with which we are so closely identified. The work of Armstrong College is divided chiefly into science and art—hence its close connection with naval architecture and engineering, which may be said to be the staple industries of the district and those mostly connected with this North-East Coast Institution. In referring to this influence of Armstrong College, I mean that it has contributed to by its work the economical carrying of goods and commodities across the seas. I refer chiefly to the work that has been done in the experimental laboratory, known as the "Stephenson laboratory," and the two names combined give a prestige to the College—the names being those of Armstrong and Stephenson, and there is something in this prestige. To the work of this College may be largely attributed the economies that have resulted in modern marine propulsion. In one item alone, the College has done excellent work, and that is in the proportions of engines to the size of the ships. This can be directly traced to the work of the experimental engines, and these results are given to us with the most exact details. Papers have come to us from the College largely through our friend, Professor Weighton, which gives us facts upon which we can base our future work. Just now there are experiments being conducted on the College engines which will have a still greater effect upon marine propulsion, and I have no doubt that in due course the results of these experiments will be put before all who may be interested in marine engineering. Referring to the value of the training here, it is greatly enhanced by the scholarships, but these scholarships perhaps are not all that they might be. Lloyd's give three scholarships; these are for naval architecture only. There is not an engineering scholarship at all in the College. Through the untiring efforts of the President of the Institution (Mr. Dugdale), there is now a North-East Coast Scholarship, and it is entirely due to Mr. Dugdale's initiative that the fund was raised, but the scholarship alternates between naval architecture and engineering. It would be a great boon to the College if there were a scholarship or prize to offer for engineering alone, but the one I have referred to, namely, the North-East Coast Institution Scholarship, does offer the means of the highest education to apprentices who could not possibly get it in any other way, and I hope it will be productive of great good amongst the Graduates of the Institution. There are other scholarships in connection with the science side of the College, which undoubtedly have a bearing on engineering, but they are not so closely identified with our industries. The work of the College, as I have pointed out, has been of undoubted value to commerce, but particularly to shipowners, and there is ample opportunity for shipowners in some way to identify themselves with the College as a small recognition of the great economies they have received from it. From an employer's point of view, it gives me great pleasure to testify to the benefits that we receive from the work of this College, and whilst various firms—shipbuilders and engineers—may have rules and regulations as to the conditions under which their apprentices may attend the College lectures, as a result of my experience, I find that it is a good thing, and undoubtedly it will pay, to take a generous view of the whole position by encouraging the apprentices or students who are the most deserving. Referring to the Chair of Naval Architecture, presided over by Professor Welch, that, when it becomes more firmly established, will undoubtedly further contribute to the advancement of shipbuilding and engineering in this district, although I do not say for a moment that we are not in the front rank already. A great deal of this advance, as I have said, can be traced to the work of this Armstrong College. I regret that Sir Isambard Owen is not present, and I have great pleasure in coupling with the toast the name of Professor Welch.

The toast was heartily honoured.

Professor J. J. Welch, of the Chair of Naval Architecture in Armstrong College, in responding, said—I am very sorry indeed for your sakes that the Principal of the College is not here to respond to this toast as had been intended, because he has at command much more felicitous language than I can attain to. At the same time, I am happy to have the privilege of responding, and to assure you that when the application came before the College authorities for the use of this hall for the purpose of the dinner, it was given a most sympathetic hearing, because they realised that the members of the North-East Coast Institution had been very helpful indeed in matters pertaining to the College. I need, of course, only refer to the Engineering Department and the Department of Naval Architecture, and they were pleased to have the opportunity of showing their appreciation of what had been done. I must thank Mr. Merivale very much for the kind wish he expressed with regard to the new Chair of Naval Architecture. He hoped it would be as successful as the Department of Engineering had become. Knowing, as I do, the great successes of that Department under the able leadership of Professor Weighton, I can imagine no better wish than that we should be equally successful. I was rather pleased that Mr. Summers Hunter did not complain of our having three scholarships. I think they are most valuable adjuncts to the Naval Architecture Department, and we must work to get, at any rate, three scholarships more for the Engineering Department as well. As to Armstrong College itself, I have now had something like twelve months' experience of it, and the high opinion I had when I came has certainly been enhanced by the extended experience that I have had of its work. It is doing a splendid educational work, and I may mention we are not only attracting students from all parts of England, but are getting scholars from the Continent and from the Far East, showing, at any rate, that the courses here are appreciated. I can only, in conclusion, thank you very much for the cordial way in which you have received the toast.

The proceedings then terminated.

DINNER COMMITTEE.

W. H. Dugdale, Esq., *President.*

G. J. Carter, Esq.
J. R. Fothergill, Esq.
Summers Hunter, Esq.
James Marr, Esq.
R. Home Muir, Esq.
Col. R. Saxton White.
Prof. R. L. Weighton.
John Duckitt, *Secretary.*

[N]ORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWENTY-FOURTH SESSION, 1907-1908.

PROCEEDINGS.

[T]HE SEVENTH GENERAL MEETING OF THE SESSION WAS HELD IN THE LECTURE THEATRE OF THE LITERARY AND PHILOSOPHICAL SOCIETY, WESTGATE ROAD, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, APRIL 3RD, 1908.

W. H. DUGDALE, ESQ., M.INST.C.E., PRESIDENT, IN THE CHAIR.

The PRESIDENT said—Before commencing the business of this [e]vening I would like to refer to the loss which the Institution has [r]ecently sustained by the death of one of our Past Presidents—[C]olonel Henry F. Swan. He was one of the original members of [t]his Institution and also the seventh President. I am sure we all [v]ery deeply deplore his loss, and I have asked the Secretary to [w]rite a letter of condolence to his relatives. If you will confirm [t]hat, I hope you will show it in the ordinary manner.

All present rose to their feet in silence.

The SECRETARY read the minutes of the previous meeting, [h]eld in Newcastle-upon-Tyne on Friday evening, March 20th, [w]hich were confirmed by the members present and signed by the [P]resident.

The PRESIDENT appointed Mr. Summers Hunter and Professor [R]. L. Weighton to examine the ballot papers for new members, [a]nd the following gentlemen were declared elected:—

MEMBERS.

Eden, Edgar Mark, Engineer, 25, Coquet Terrace, Heaton, Newcastle-upon-Tyne.
Melvin, Robert, Engineer, 11, Roker Baths Road, Sunderland.
Morrow, John, Engineer, Armstrong College, Newcastle-upon-Tyne.

RETIRING MEMBERS OF COUNCIL.

The PRESIDENT said—In accordance with Article X. of the Constitution, the following gentlemen will retire from the Council:—

President—Mr. W. H. Dugdale (not eligible for re-election).

Vice-Presidents—Messrs. W. C. Borrowman (resigned), G. H. Baines, and E. H. Craggs (eligible for re-election).

Hon. Treasurer—Mr. G. E. Macarthy (eligible for re-election).

Members of Council—Messrs. G. J. Carter, Alfred Harrison, N. E. Robson, R. Wallis, G. D. Weir (not eligible for re-election as Members of Council).

NOMINATION OF NEW OFFICERS.

The PRESIDENT said—In accordance with bye-law 11, I, on behalf of the Council, nominate the following gentlemen to be balloted for to fill the vacancies:—

President—Mr. Summers Hunter.

Vice-Presidents—Messrs. G. H. Baines, G. J. Carter, E. H. Craggs, Alfred Harrison, and R. Home Muir (three to be elected).

Hon. Treasurer—Mr. G. E. Macarthy.

Ordinary Members of Council—Messrs. C. T. Adams, J. T. Batey, A. E. Doxford, M. S. Gibb, Andrew Laing, Hugo MacColl, and Harold Thomson (five to be elected).

I would like to know if you wish any other names to be added to those which have been submitted by the Council.

There was no response from the meeting.

The PRESIDENT—I take it, then, that you agree to the nominations submitted.

NOTICE OF ALTERATION TO BYE-LAW 35.

The PRESIDENT said—On behalf of the Council, I give notice that, at the Closing Business Meeting of the Session, to be held in Newcastle-upon-Tyne, on Friday, May 15th, 1908, I will move that the following addition be made to Bye-law 35:—

(*The addition is printed in italics.*)

35.—Copies of papers to be read during any Session will be sent seven days before the date of reading to members who shall have applied to the Secretary for them, in writing, at the commencement of the Session. The discussion on a paper shall not be considered closed on the evening on which it is read, but shall be open for renewal at a subsequent meeting, prior to *or after* the reading of the paper set down for that date.

It has been found necessary to make this alteration because sometimes we have received a paper from a gentleman living at some distance, and if we have left the paper to the very last on the agenda it has been impossible for him to catch a train, and occasionally also gentlemen have attended from a distance to take part in the discussion, with the same result. Therefore, it has been thought desirable to leave it to the option of whoever happens to occupy the chair at the particular meeting to use his discretion in altering the arrangement.

The discussion on Mr. J. Hamilton Gibson's paper on "Torsion-Meters" was resumed and concluded.

The discussion on Mr. A. E. Long's paper on "Notes on the Form of High Speed Ships" was resumed and closed.

The discussion on Professor R. L. Weighton's paper was resumed.

Mr. E. Hall Craggs submitted a paper on "The Framing of Vessels."

ESUMED DISCUSSION ON MR. J. HAMILTON GIBSON'S PAPER ON "TORSION-METERS, AS APPLIED TO THE MEASUREMENT OF THE HORSEPOWER OF MARINE STEAM TURBINES."

Mr. R. J. WALKER said—I regret I was unable to be present the evening on which Mr. Gibson read his paper, and the bsequent meetings at which the discussion took place. I have, wever, read the paper with great interest, and should like to y a tribute to Mr. Gibson for his valuable contribution to the *ransactions* of this Institution. The subject of torsion-meters s attracted some little attention in the turbine world of late, d Mr. Gibson has undoubtedly given a very comprehensive cord of the various types now in use. In the few remarks I ve to offer I do not propose to enter into any controversy arding the relative merits or demerits of the various torsion-ers now on the market. Although the "Turbinia," the first el to be fitted with turbine engines, and the two subsequent royers were built on the Tyne, Messrs. Denny were the first ers to be associated with the construction of turbine vessels ommercial purposes, and to the best of my knowledge were rst in this country to introduce an apparatus for measuring ower transmitted by turbine engines. Mr. Gibson has told other types of torsion-meters that have been introduced . The reliability or trustworthiness of torsion-meter records ften been questioned. Of course, in all instruments such as n-meters one has to be perfectly satisfied that the design is ct, that the apparatus is in good order, and that care is sed in taking the records. It has been my privilege to have associated with a number of turbine vessels where torsion-rs have been fitted, perhaps more especially with the "Denny-son" and the "flashlight" types, and from an analysis of results of the records taken by these meters, and comparing with the theoretical estimate of the power transmitted by turbine, we have every reason to believe that the results so ined are fairly accurate. In fact, it would appear that quite eliable a result of shaft horsepower could be obtained as the icated horsepower derived from the indicator diagram of a reciprocating engine. Trials have recently been carried out on a large turbine steamer on the Clyde, where "Denny-Johnson" and "flashlight" torsion-meters were fitted on the same shafts, and, if Mr. Gibson is in the position to give an indication of the comparative results that were obtained in this vessel, it would no doubt be of interest to the members of this Institution, and would help to clear any doubt that may exist on this point. I do not propose to take up any further time of this meeting, but I am glad to have had the opportunity of adding these few remarks to the discussion on Mr. Gibson's paper.

MR. GIBSON'S REPLY.

Mr. J. HAMILTON GIBSON said—Before reading my reply which I have taken the precaution to write out, so as to save your time as well as my own, I should like to thank Mr. Walker for his very kind remarks. I am glad he has had the opportunity of coming here this evening, and giving us something like a reliable testimonial as to the accuracy of the torsion-meters with which he is acquainted. He has seen a few of them, and the accuracy of the torsion-meter as compared with the indicator diagram has evidently impressed itself upon his mind. With regard to his query as to an actual comparison between two types of torsion-meter, namely, the "Denny-Johnson" torsion-meter and the "flashlight" torsion-meter, one of the previous speakers raised the same point, and I have dealt with it in my written reply.

In replying to the discussion, I trust I may be excused if I do not traverse *seriatim* the points mentioned in each individual contribution. I will, however, endeavour to deal with every question that has been raised, and make my reply as concise and comprehensive as possible. The paper has evoked wider interest than I had anticipated, which is in itself most gratifying, and I thank heartily all those gentlemen who have so generously assisted in thus enhancing the value of the paper as a contribution to our *Transactions*. The extreme courtesy I have experienced at the hands of those whom I may term my competitors in the domain of torsion-meter invention, is also, I think, a marked feature of the discussion, and is, I can assure them, highly appreciated.

More than one of my critics have pointed out a lack of clearness in some of the paragraphs, and as one who usually attaches importance to such matters, I must plead guilty. In preparing a technical paper to be read before men acquainted with technical terms one is apt to take it for granted that his audience will not only follow him, but will actually be ahead of him; consequently, there is a tendency to "short-circuit" instead of expanding the sentences in correct literary style. This, gentlemen, though not an adequate excuse, is at any rate a reason why I did not make it quite clear that when I referred to a turbine as standing still I meant that the shaft was locked and prevented from turning, and that under such conditions the amount of steam that would pass through the turbine would be very nearly the same as if the turbine were working at full speed and exerting full power. The range of pressures along the turbines would also, I take it, be approximately the same in both cases. The point I wish to emphasize is this: that a record of the steam pressures is an insufficient guide to the power of a turbine. Unless a turbine is driving its full number of revolutions against the resistance of the propeller it is not exerting its full power, and the only way to get at the actual effective power is to combine the revolutions with the actual work done on the shaft as registered by a torsion-meter or a brake.

Mr. Harold Thomson asked the very pertinent question as to whether a torsion-meter and brake had ever been tried on the same shaft simultaneously, and I am now able to answer that this is one of the things that they do "better in Germany." At the turbine works of the Allgemeine Elektricitäts Gesellschaft in Berlin, I saw recently a turbine-testing plant which comprised a huge hydraulic brake to which was permanently attached a calibrated length of shaft and a Föttinger meter. I understand that the 3,000 horsepower Curtis turbine units of the "Kaiser Wilhelm der Grosse" were actually tested in the shop to full power with this apparatus, and that the shaft horsepower agreed with the brake horsepower within 2 per cent. Whether a more delicate torsion-meter would give a closer approximation to the brake horsepower I am not prepared to say; but, personally, I should like to see a flashlight torsion-meter tried under similar conditions. A 2 per cent. error, however, is very small compared with the variations met with in connection with "indicated" horsepowers, and shows that we are getting pretty well down to bed-rock figures in the measurement of effective powers.

But engineers will not rest satisfied until they are able to record the "thrust" powers, thus eliminating propeller inefficiency, and showing the actual "push" exerted by the propeller on the thrust-block. I hear rumours, and I hope they are true, that experiments in this direction are being made in this district with a view to arriving at the actual thrust exerted by turbine propellers. The axial clearance of the turbine dummy rings is so small that I have not, so far, ventured to experiment in this direction; but I have obtained some series of thrust diagrams from reciprocating engines, illustrated on Plate XXXVII., and which are, at least, suggestive. Just think how important such data would be! Knowing the shaft horsepower, and the actual thrust exerted, we can at once deduce the propeller efficiency. Tow-rope resistance takes no account of the disturbance of the wake caused by the action of the propellers, but here we have the real thing and can proceed on ascertained facts.

Mr. Thomson enquired whether for the same power an alteration of torque is observed as the revolutions vary? We had a striking illustration of this very point during the full power trials of a 33-knot destroyer on the Clyde. An observer came up on deck from the gland space where the torque-finders were placed, and reported that although the starboard and port torque readings had been constant for the last hour something had now apparently gone wrong, and there was a marked difference between the wing shafts. The difference only amounted to ·03 of a degree; but it was definite and had been checked by the other observer. The explanation was quite simple. We were then rounding Ailsa Craig in a wide sweep about 10 miles radius, and the port shaft being on the inside of the curve, was going some four revolutions slower than the normal, and showing $\frac{3}{100}$ of a degree more torque.

In reply to the question as to whether two different makes of torsion-meters have been tried on the same shaft, I may say that, by the courtesy of the Fairfield Company, we were allowed to fit a set of torsion-meters of the flashlight type on the shafts of the turbine steamer "Cairo," where a set of Denny-Johnson meters were already installed. Simultaneous readings were taken during the whole series of trials, including the progressive trial, and whilst the individual readings varied slightly the average totals came out within 0·6 per cent. of each other. On setting out the two sets of readings on curves with revolutions and speed bases, it is only fair to say that the flashlight readings were more consistent throughout, and this was most marked on the low-speed runs, where there is an acknowledged difficulty in getting reliable Denny-Johnson readings, due to the faintness of the sound in the telephone receiver.

This naturally raises the point (which was touched upon last year at the spring meeting of the Institution of Naval Architects, when Mr. Denny and I read papers on our respective torsion-meters) as to the relative delicacy, or sensibility, of the ear and the eye in perceiving sound *versus* light. I am naturally inclined to think that the eye has the advantage, and that the ear is more easily deceived. Our experience on the "Cairo" at any rate proved that the apprentices lent us for relief purposes in taking flashlight readings, and who were quite new to the job, became expert observers in a very few minutes, and could take readings and spot the horsepowers on the diagrams quite as well as our experienced observer. As Mr. Grant says in his letter, "the actual point of eclipse of the flash is apparently very definite, and one is distinctly conscious of the faintest flickering glimmer of light when the finder is moved a minute distance."

The torque-finder is the very kernel of the invention, and inasmuch as no other torsion-meter is fitted with a like device, I claim superiority of accuracy for the flashlight torsion-meter, notwithstanding Mr. Charles Johnson's sly dig at me as being too sanguine.

The imperative necessity of obtaining extremely delicate measurements with torsion-meters has been fully demonstrated during the discussion, and Messrs. Hopkinson and Thring are to be congratulated on the results they have obtained with such short lengths of shafting. There is no virtue, however, in using a short length of shafting if it is possible to take a longer length. As Mr. Collie pointed out, there is always the possibility that the torsional stiffness of a shaft may alter along its length, and we know that tensile and elongation test pieces taken from opposite ends of the same shaft frequently give different results. Then again, with a short length of shaft the base is so short that it is a difficult matter to determine with certainty the exact length that is being utilised for torsion measurement. An error of $\frac{1}{16}$

inch is pretty considerable in a length of 12 inches, whilst the same error spread over a length of 50 or 60 feet is almost negligible.

For these reasons it is desirable to take as long a length as possible, whenever possible, and this we always aim at in arranging the axial type of flashlight torsion-meter.

As to the re-calibration of shafts after a period of service, I do not know that this has yet been done in any instance; but torsion-meters have been in general use so short a time that the opportunity and occasion have probably not yet occurred.

It would be a very interesting investigation, and one worth bearing in mind. I should think, however, that the line shafting of a turbine-propelled vessel, with its uniform turning moment and comparative freedom from the shocks experienced by tail shafts, would not be liable to appreciable deterioration in this respect. It is very seldom that the line shafting of even reciprocating engines requires renewal. Certainly I have not yet come across an instance except once, and in that case the flaw proved to be an original defect.

Reference has been made by several speakers to torsional oscillations, and Mr. Collie thinks that when such variations in the torque are encountered the torque-finder of the flashlight torsion-meter will record only the peaks of such oscillations and show too much horsepower. The same fear possessed me when we first tried the flashlight apparatus, and we therefore always took maxima and minima readings, that is, the torque-finder was moved to cut off right and left, and both readings taken to get a mean. After a few trials the differences were found to be practically non-existent. Over a long series of readings, most of which were absolutely identical, the maximum difference was only ·025 degree, and as this was just as likely to be an error in observation as anything else, we abandoned the practice as taking up too much valuable time, and now we only take such readings occasionally for verification. There is another reason, however, for taking right and left readings with the flashlight torsion-meter, and that is the difference in keenness of vision of two or more observers. An observer with abnormally good eyesight can see a fainter flicker than another not so blest, and will work the torque-finder over a shade beyond his co-observer. If, however, right and left readings are taken the mean is the same in all cases, and the personal element is eliminated.

Mr. Johnson is of opinion that differences of temperature along a tunnel, tending to bend the light ray by refraction, might vitiate the accuracy of flashlight meter readings. In thinking the matter over, I have come to the conclusion that even supposing the light ray is bent out of its course it makes no difference to the result. The apparatus depends for its accuracy on *time effect*, not on the optical straightness of the ray of light. The eyepiece of the torque-finder covers a fairly wide field, and what we actually do when we work the torque-finder over is to cut off the light at the finder disc *at the same instant of time* as it is cut off at the lamp disc. In other words, we so arrange matters that the instantaneous shutters at both ends of the shaft open and close simultaneously. I therefore think we can afford to neglect this consideration.

My estimate of 20 per cent. as the figure representing the proportion of thrust stress to torsional stress was taken as a maximum for the shaft calibration experiments, and is no doubt excessive for normal working conditions. It is greatest, of course, in hollow shafts with relatively large holes. I have worked out some actual results since Mr. Speakman called attention to the point, and my maximum is 17·4 per cent. If the same vessel were towing, however, which she might at any time be called upon to do on actual service, the percentage of thrust might easily exceed 20 per cent. The approximate percentage of compression is applied during the operation of calibration and modifies the modulus of rigidity which is taken in calculating the torsional stiffness of the shaft. It therefore appears as a constant *pro rata* influence in all power results.

I cannot say that I have ever come across a case where the shaft horsepower came out in excess of the indicated horsepower. There are variations certainly, but these may be put down to the usual variations met with in indicator diagrams. It is usual to take two or three indicator diagrams from each cylinder on each run, and to pick out the best-looking set of cards irrespective of the exact time. This practice probably accounts for some of the variations noticed.

As to changes of torque during one revolution of a turbine shaft, Mr. Thring told us that he had observed a variation of about 3 per cent., and this might be taken as the reply to Mr. Neill's query pending further experiments. I am fitting a reciprocating engine torsion-meter with twelve slots to a turbine shaft in a vessel shortly to be tried, and will be happy to communicate the results in due course as a further appendix to this paper.

With reference to Professor Welch's esteemed communication, I notice that he, with others, has been analysing some of the results recorded as to the relation between indicated and shaft horsepowers. I am not prepared to enter into the question of engine efficiency at any length at this stage. It is perhaps beyond the scope of this paper to do so, and may well form the subject of another paper when further data has accumulated in the natural course of events.

It only remains for me now to thank you for listening so patiently to this somewhat lengthy reply, and to express the hope that the many valuable suggestions that have appeared in the course of the discussion will bear fruit in a further elucidation of the problems involved, problems which are of equal importance to the marine engineer and the naval architect.

The PRESIDENT said—I am sure you will all agree with me that we should give a hearty vote of thanks to Mr. Gibson for his interesting and instructive paper.

The proposition was carried by acclamation.

RESUMED DISCUSSION ON MR. A. E. LONG'S PAPER ON "NOTES ON THE FORM OF HIGH-SPEED SHIPS."

Professor J. J. WELCH said—I understand that some gentlemen have expressed disappointment—bearing in mind the title of the paper—that Mr. Long has not brought forward a form of vessel which he could recommend to us, from his experience and knowledge, as superior to all others. For my part, I did not indulge this hope, as in the first place I reflected that to treat the subject with rigorous scientific accuracy it would be necessary to have access to experimental tank records; and in the second place, I imagined that if Mr. Long had hit upon an extremely good form, there would be no special temptation to give exact particulars. It seemed inevitable therefore that the subject should be discussed on general lines, and the author is to be congratulated on having given us such an interesting paper.

I will confine my remarks to one or two points, rather in amplification than in criticism. Mr. Long states that with a given area of rectangle (A say) the wetted perimeter (P) varies with alteration of ratio of beam to draft, and it is easy to calculate when this perimeter is a minimum. For if a represent draft and b breadth, we have $a \times b = A$ and $P = 2a + b = 2a + \frac{A}{a}$. And this is a minimum when $2 - \frac{A}{a^2} = o$ or $a^2 = \frac{A}{2}$. From the figures given in the paper $A = 6$, and then $a = \sqrt{3}$: $b = 2\sqrt{3}$, and the perimeter is then $= 6{\cdot}928$ feet at the minimum point shown in Fig. 6 (Plate XXVIII.) This method can be extended to ships. Mumford's approximate formula for wetted surface is $S = 1{\cdot}7L \times D + {\cdot}35\frac{W}{D}$; that is for a given displacement W tons, and given length L, the wetted surface is a function of the draft D, and that surface is a minimum when $1{\cdot}7L - \frac{{\cdot}35W}{D^2} = o$ or draft $= \sqrt{\frac{{\cdot}35W}{1{\cdot}7L}}$. This gives approximately the draft for minimum wetted surface, and although for the reasons given by Mr. Long, the total resistance is not likely to be absolutely a minimum at the draft corresponding to minimum wetted surface, yet Rota's experiments indicated that in this region fairly large variations in the ratio of beam to draft are possible without very appreciable departure from minimum resistance. With reference to Mr. Long's remark that "there will possibly come a speed where the shallow section will, owing to its skimming action, give a less resistance than the deep," there will, I believe, be published very shortly experimental results justifying this prediction; or, rather, results tending to show that even at relatively moderate speeds, a very shallow ship, suitably formed, will give smaller resistance than one of normal shape.

As I remarked at the outset, for the full discussion of the problem, tank data are necessary, and an extract from a recent report of the Chief Constructor of the U.S. Navy is of interest in this connection. He says: "From careful and systematic experiments made during the year, the Bureau will be able to adopt for the new destroyers a type of after-body which will practically permit the speed of the flat-stern type to be maintained, but will result in distinctly superior seagoing qualities, the flat-stern type not being well adapted to rough water. Hitherto, the flat stern has been regarded as essential to high speed, and was therefore adopted for vessels of the destroyer type. Three vessels of the destroyer type were authorised. . . . On the conservative assumption that with their improved seagoing capabilities they will be only one per cent. more valuable than similar vessels previously designed, the department will gain in these three vessels an increase in efficiency equivalent to the total sum expended during the year for the entire work of the experimental model basin."

MR. A. E. LONG'S REPLY.

Mr. Long said—In replying to the discussion, I will take the speakers in their order. Mr. Hogg began by stating that he had no practical knowledge of this branch of naval architecture—very few people have--and there is internal evidence in his speech that he has paid little or no attention to it even from the theoretical side. When he does this he will, I think, find that a great many of his ideas want revision; I will therefore merely here draw his attention to a few points, leaving the others for his own reconsideration.

The straight lines in Fig. 1 (Plate XXVII.) do not cause any difficulty regarding fins or squat boards, as there is really no connection between them; squat boards are applied to vessels of ordinary forms of water-line, not necessarily straight, and so could fins be. The shifting about of the centre of buoyancy in a longitudinal direction has nothing whatever to do with the difference in form shown in these figures. The most elementary inspection would have shown Mr. Hogg that the difference between the afterbodies of, say, A and B (Plate XXVII.) is one of shape, not area—the centre of gravity of immersed volume is in the same position in each case. Surely the classification of A, B, D (Plate XXVII.) and ordinary steamers in the same type is a very advanced "terminological inexactitude." To judge of the enormous latitude which Mr. Hogg gives himself, compare the D type body plan in Fig. 9 (Plate XXIX.) with that of an ordinary steamer. Two cases of careless quotation occur towards the close of the speech. I did not say that B and D are the ships of the future; what I did say was that they were possibly models for the ships of the future, a very different thing. Mr. Hogg credits me with the statement that the present type of big ship must be altered; he should have included my qualifying words, "unless the dimensions of ships can keep pace with the increased demand for speed."

It would be a very regrettable thing if Mr. Hogg should try to cross the Atlantic in a "small freak" at "40 to 50 knots," or, indeed, at any other speed, as we would thereby almost certainly lose for ever his interesting contributions to our discussions.

Mr. Alexander is not quite correct in attributing the first use of straight-line figures to the late Dr. Kirk; as mentioned in the paper, Chapman, in 1775, used two such figures, and some writers half a century before did the same. Beaufoy's experimental models were also similar figures. The question as to how the angle of entrance and run should be measured is a disputable one. Mr. Alexander's method makes those of A and C (Plate XXVII.) the same, as the area of the midship section is the same; whereas my figures alter considerably. Now we know as a fact that these forms give very different results, and I would like to put it to Mr. Alexander that a method of measuring the angles which also gives a difference is more likely to be correct than one which does not. Another way of looking at the question is, suppose that we take C and make the breadth very great and the depth correspondingly small, while keeping the same area, does the true angle remain the same as Mr. Alexander's method makes it?

Mr. Alexander's remarks on the hydroplane question are a very interesting addition to the paper. The subject is a very tempting one, and I may state that originally that part of the paper was much longer than it is now. I hope that Mr. Alexander's remarks as to windage foreshadow a paper from him on the subject, as it is yearly becoming more and more important with the great increase of deck erections. I have done some little work in that direction, but cannot go into the matter here, except to suggest that the wind resistance of models and small vessels close down to the water level may be very different from what it is high up as on large vessels.

Mr. Hinchliffe in his speech goes rather upon the lines that this is too much a paper for the future at the expense of present-day practice, and he considers that we are not likely to have any practical use for these uncommon forms. With that view I do not concur, and I suggest that history is rather against Mr. Hinchliffe's way of thinking. When I began to study this particular subject in the old "Lightning" days, the chances of there ever being a 36-knot vessel, of a displacement approaching 2,000 tons, seemed to be quite as visionary as a 40-knots or upwards Atlantic liner seems to-day. But we have now the 36-knot vessel, and it appears to me that further advances will be more, rather than less, rapid, looking to the quantity of data which is now available.

With a view to the possibility—even if it seems remote—of extremely high speed in large vessels being required in the future, I do not think that it is advisable to adopt any ostrich-like policy with regard to small freaks, such as motor-boats, etc., no matter how fantastic they may appear to be. All of their features may not be of use for larger craft, and others may have to be considerably modified, as they are to-day in destroyers. We should not forget that the destroyer of the present is the lineal descendant of the small launches away back in the seventies of the last century.

Although Mr. Hinchliffe has rather misconstrued my reference to the faint-heartedness of some designers, he has brought out a point with which I am very cordially in sympathy with him, the baleful influence which engineers have upon the pure course of naval architecture. He instances the forward boiler as an objectionable nuisance. He might have gone further, and said that the modern water-tube boiler is a peculiarly fiendish instrument of obstruction. The designers of these things do not seem to have paid any attention to the use to which they are to be put, namely, to go into a ship. They have, therefore, with a lamentable unanimity adopted a cross section which is approximately a triangle with the point upwards, whereas the section of the ship into which it has to go is the exact reverse. If our engineering friends could design something in the way of a boiler which did not turn out its toes in the regrettable way the present ones do, they would earn our undying gratitude.

Mr. Hinchliffe regrets the fixing of the speed at $2\sqrt{L}$ and upwards, and that I have not given information regarding actual vessels of A type. The opportunities for comparing A with, say, B, at speeds approaching $2\sqrt{L}$ are very rare, and for the other types practically *nil*, but the superiority of B over A comes in at a very much lower speed, and I have had some very useful experience on that point, although I did not design the A type vessels. The ships were of fair size, being all over 200 feet, and sufficiently close to each other in other respects to allow of the necessary corrections being made without risk of appreciable error. The A's were poor performers at speeds a little under $1{\cdot}5\sqrt{L}$, although designed by experienced men, and in two instances attempts to get higher speeds by increasing the power were very unsatisfactory, except as object lessons. In the case of the corresponding B vessels the speed was easily attained, and the same vessels also gave very good results at $2\sqrt{L}$. The difference between the wave making at corresponding speeds was very striking. The B's, of course, suffered somewhat owing to their engines not being at full power at the speeds compared, so that the comparison was, if anything, unfair to them.

The few words which I wrote upon the subject of the big ship of the future has brought out some interesting figures from Mr. Hinchliffe, showing the stagnation in speed in relation to length. He might have added that there is a similar deadlock in the construction. I have no doubt Mr. Hinchliffe has a reason in his own mind why that is so, and why when we want, say, a knot more on the Atlantic, we simply enlarge the last design to the corresponding length, etc. As, however, he has not favoured us with that reason, I will suggest one which may, or may not, be the same. We enlarge the ship because the type used—a very pronounced A—is not suitable for any higher relative speed, and the attempt to drive her faster, even if we had the power, would be extravagant. If we want to keep to the present length and economically use the advances in engineering which may become available for getting higher speeds, it seems probable that we will have to depart very considerably from our present form of hull. The foregoing is, of course, apart from the question whether it is desirable to enlarge the ship for other purposes.

I have to thank Mr. Alexander and Mr. Hinchliffe for their kind references to my work, practical and literary. The latter reminds me that I am the only member of the Institution now contributing papers who wrote one for the first session in 1885.

Professor Welch opened his speech with such an apt explanation of the reasons for the form this paper has taken that I will ask the other speakers to accept it in reply to them. I am glad that Professor Welch has dealt with Fig. 6 (Plate XXVIII.), as it is one which I have found useful for selecting ratios of draught to beam; his addition is also an interesting completion of the subject. It is satisfactory to find that my prediction based upon inferences as regards the effect of shallow draught at high speed has been borne out by experimental facts. As a general rule, I do not care to pose as a prophet, but in this case I thought I was on fairly good ground. As regards the flat form of stern, there is still a great deal to be done before that part of high-speed vessels is quite satisfactory, at least to people who do not build ships merely to run trial trips. If the Americans can produce a stern which does all that they claim for it, they will have done all designers a great service. I might, perhaps, suggest that they are not the only people who are working at this problem.

A hearty vote of thanks was accorded to Mr. Long for his paper.

RESUMED DISCUSSION ON PROF. R. L. WEIGHTON'S PAPER ON "PISTON SPEED AND STEAM ENGINE ECONOMY."

The SECRETARY read the following communication:—

22, OTTERBURN AVENUE, GOSFORTH,
NEWCASTLE-UPON-TYNE,
April 2nd, 1908.

DEAR MR. DUCKITT,

As it is doubtful whether I shall be able to be present at the discussion on Professor Weighton's paper to-morrow night, I am sending the following remarks, which, if considered apposite, might be added to the discussion:—

The wonderful thing about Professor Weighton is that, unlike the bad workman, he never complains to us about his tools, but makes the most of his opportunities. It is absolutely plain that his efforts are hampered most seriously by lack of boiler power. It will be noted that he has to run his engine under somewhat abnormal conditions on this account.

Then again, I suggest that it would be very useful if he could be given an opportunity of carrying out somewhat similar experiments with piston valves in, say, the first two cylinders, especially in view of Professor Mellanby's remarks regarding the importance of valve leaks, and perhaps one might also suggest experiments with a slide valve of longer travel and with ports of less perimeter and greater height.

My personal feeling is that it is one of the world's wonders that the slide valve has not been improved out of existence. The objects that one sees removed from valve chests after a few months' work on marine engines, with valve travels reduced by linking-up—as rendered necessary by the engines being of unnecessarily large dimensions and ratios—make one long for a good reliable test of some alternative, either in the form of piston valves or lifting valves.

Work such as Professor Weighton can do is really of national importance, and, if it cannot get official national support, deserves all the local help it can obtain. Perhaps contributions for such purposes look too much like philanthropy to be popular. Shipowners or enginebuilders may think the accumulation of knowledge on the points which Professor Weighton sets himself to clear up is as likely to benefit their competitors as themselves, but, in this, they may comfort themselves by the reflection that nine out of ten of their friends will be too conservative to make any application of the new information until the contributors with faith and enterprise have had a good long start. In any case, any increase in the local reputation for good economical engines would be a valuable advertisement to every firm in the district.

In steam engineering we have got far past the point where anyone can perform a parallel to the feat of making two blades of grass grow where one grew before, and it is only by careful investigations such as Professor Weighton's that we can hope to equal the performance of making each blade a little longer.

Yours faithfully,

C. Waldie Cairns.

The discussion was adjourned.

FRAMING OF VESSELS.

By E. HALL CRAGGS, B.A., Vice-President.

[Read in Newcastle-upon-Tyne on April 3rd, 1908.]

Since first I put together a few notes for this paper, I have been constrained by some of my friends who have taken a very kindly interest in its preparation, and also by the force of circumstances, to alter my plans to some extent.

I had intended to say more about the various systems of framing that have been practised from time to time both in wood and iron ships, and in that way to trace out the history of my subject in detail. After spending considerable thought on the matter, I came to the conclusion that it would serve the objects of our Institution best if I confined myself to such structures and systems as I have been intimately connected with in the drawing office and the shipyard.

When I first began to make a practical study of ships' framing, the transverse system was taken almost as a matter of course by all naval architects and shipbuilders. In the drawing office we were then familiar with the open floor system, varied where water ballast was required in the double bottom, by the McIntyre system; and in warships the bracket system was the most familiar one to me, though found undesirable for big cargo carriers. If we are to believe writers of shipbuilding text books, among others, Mr. Thearle, now one of the well-known surveyors at Lloyd's head office, the idea of transverse framing came lirectly from the practice of wooden shipbuilding, and here my ıbject compels me to touch on the history of shipbuilding to ne extent. Important writers on the subject of shipbuilding e entered their protests against blindly following a method, ch, although found admirably adapted for the construction ooden ships, of such dimensions as were generally adopted vessels of that material, is not what one would logically expect in dealing with material of comparatively great tenacity and offering the utmost facility for joining either in the direction of its length or its breadth, such as iron and steel.

In the practice of building wooden ships, the transverse framing was obviously necessary. Generally, no attempt was made to join the breadths of planking together along the edges. On the contrary, in the operation of making the planking water-tight by wedging oakum into the seams, forces were brought to bear upon the planking tending actually to open them out. As a rule, the transverse framing of wooden ships was very firmly and massively constructed and bound together by strong iron knees, the frame timbers being usually disposed room and space. It is worthy of remark that it was a common practice to allow the frames towards the extremities of the vessels to be spaced wider apart than amidships. The tendency to-day in steel ships is to space the frames nearer together, especially at the bow. It was thought necessary in the large wooden ships that decks should not be spaced more than about 8 feet apart, and the influence of the practice in wooden decks is still felt at the present time; for instance, where vessels are built to Lloyd's class. When I first commenced business, it was still quite a matter of serious consideration to leave the tier of beams out of a vessel 24 feet in depth, and it is only really in recent years that the proper nature of compensation for leaving out another tier of beams in such a ship, thereby producing a single decker, has been thoroughly appreciated and understood. Before passing to the consideration of iron and steel vessels, it is as well to bear in mind that the thickness of planking of decks bears a very substantial ratio to the interval between the transverse supports. The builder had, therefore, no need to consider the local buckling of the planking or deck owing to longitudinal strains. In other words, the wooden vessel was relatively an incompressible structure as compared with a metal one.

We come now to the consideration of iron and steel vessels. The strakes of plating take the place of planks, with this great difference; the nature of material allows us to firmly attach the breadths of plating by lapping them and through riveting them at their adjacent edges. With a suitable arrangement, therefore, the skin of the ship can be at once brought into the transverse strength, and, in fact, can be made a very important member of the transverse girder. For the remainder of the transverse stiffening shipbuilders have found it convenient to follow the practice in wooden shipbuilding as closely as possible.

Coming now to the question of longitudinal strength, the analogy is not so perfect. The breadth of the metal frame sections supporting the skin is necessarily greatly reduced, and the unsupported length between the frames is greatly increased. The thickness of iron plates, as compared with the distance between the points of support, bears a far less ratio than the thickness of the planking in the wooden vessel between their points of support, and herein I have tried to express as simply as possible the weak point of the ordinary transverse system of framing. So long as the length of vessels was kept within a moderate compass there was little trouble, but as dimensions increased, especially length, shipbuilders found the want of better support against longitudinal stresses. Scott Russell felt so keenly on this point that he took pains to carefully enunciate his views. In his great work on naval architecture he favoured the principle of longitudinal framing. In the construction of that marvellous steamer the "Great Eastern," he employed a modified system of longitudinal framing which was known as the box unit system, and depended for the continuity of its transverse strength upon a complete inner skin, which inner skin was continued underneath the principal deck so as to form a double deck. There appears to be really little doubt that Scott Russell was greatly influenced in all the details of construction of the "Great Eastern" by the famous civil engineer, Brunel, who was in the main responsible for the creation of that leviathan of the deep. In practice, Scott Russell almost invariably employed the ordinary transverse system, which there is no doubt he greatly improved by his powerful advocacy of the use of iron for decks. He appears to have thought, with other designers of his day, that the great stumbling block to the adoption of longitudinal framing was a certain lack of skill in the personnel of the shipbuilding yards. This, however, I suggest was not the real cause of his failure to introduce longitudinal framing generally. The underlying error of his attempt was surely contained in his method of endeavouring to secure his transverse strength. He actually goes out of his way to make it perfectly clear that the shell plating must not be connected with the transverse strength. He announced that the transverse strength was to be secured by means of bulkheads placed at intervals rather less than the length of beam of any ship, but he describes in detail how these bulkheads must not be carried out to the shell and riveted thereto, as the connections of the bulkhead directly to the shell might be expected to cause trouble. From bulkhead to bulkhead, bridging over a distance of about 36 feet in a vessel of, say, 40 feet beam (which would only be a very moderate sized vessel indeed), he proposed to stretch his longitudinals. These were to be bound together by a series of iron hoops, fitted in short lengths between the longitudinals. It is obvious that a vessel built on this system would be of prodigious weight. With very fine model, heavy engines and boilers, and the enormous quantities of bunkers required in the time of Scott Russell, it would be a very poor cargo boat indeed. Moreover, Scott Russell's idea of making the intervals between the bulkheads corresponding to about the width of the ship, would rather appear to have been prompted by an instinct for symmetry and not deduced from exact mathematical investigation. One experiment only, I think, was made upon this system, and then it was abandoned, at which one need not be surprised.

Notwithstanding the fact that, generally speaking, longitudinal framing disappeared from practice for many years, I am sure that every student of naval architecture will freely admit with me that these two great men—Scott Russell and Brunel—were a long way in advance of their times in their opinions as to the distribution of materials in iron vessels, and that shipbuilding science, as a whole, owes them a deep debt of gratitude.

I need not take up your time in reciting how the first generally accepted method of compensating for the lowest deck in vessels of 24 feet depth was by hold beams and a marginal stringer, which then gave way to web frames connected to strong beams at the next deck above, while to support the intermediate frames, intercostal stringers efficiently attached to the web frames were introduced (see Plate XXXVIII.). The intermediate frames remained of the same strength as formerly required if deck and stringer were fitted, and obviously on the removal of this support be-frames. I have often wondered in the drawing office why the scantlings of these frames were governed by a number obtained by the summation of the measures of the half breadth, half girth, and depth, and had so little relation to the distance between the intercostal stringers which defined the points of support of these frames. Web framed ships in their day, however, did good service, and very little fault could be found with them, if we except the fact that not sufficient importance was attached to the riveting of the webs to the shell, and, where double bottoms were fitted, the connection at the margin plate left much to be desired. On the whole we must admit that it was not sufficiently well understood that the webs, acting in conjunction with the side stringers, had to be strong enough to support all the intermediate frames. The expensive form of the riveted attachments necessary for web framing encouraged the development of the deep frame system, obviously a more scientific arrangement of material than that adopted in web framed vessels, inasmuch as a proper depth of frame girder is secured, and each frame in this system is able to take care of its own portion of transverse strength without borrowed support, with the exception of that obtained from the shell plating as previously explained. The increased demand for single deckers of larger size quickly brought up the question of compensating for the omission of all decks, except the upper deck, and a succession of rather extraordinary types of framing was the result, the most curious being a mixture of the web frame system and the deep frame system, with a tier of beams at the height of the lower deck (see Plate XXXVIII.). It is obvious, in this system, that if the web frames were of any use at all in supporting the intermediate frames, there was no reason whatever for fitting these frames according to the deep frame rule. Further, if the web frames were not strong enough to support the intermediate frames, there was no object whatever gained in fitting them, as deep frames of the same size as the other deep frames would have been efficient.

Turning back to the deep frame system without web frames, I need not remind my hearers that a strong attempt was made by fitting H or double bulb angle stringers, with an intercostal plate riveted to the shell, to support the deep frames at intervals between the deck and the floor (see Plate XXXIX.). It eventually became obvious that this was a great waste of material, as the distance between the bulkheads was usually so great that these stringers were ineffectual as girders with such a great length, and mostly being situated near the neutral axis, were unimportant as regards longitudinal strength. Shipowners naturally objected to these serious objections in the holds, and eventually the Classification Societies, recognising that these side stringers did not materially support the framing, reduced the dimensions of these stringers, at the same time somewhat increasing the depth of the frame girder (see Plate XL.). The attention of naval architects in single deck ships, and vessels with deep lower holds, was then forcibly directed to the connections at the margin plate and at the beam knee, which were considerably improved.

Quickly following these developments came the demand for single deck ships without shelf stringers or hold beams of any kind. While my firm was constructing one of these ships, materially over 24 feet in depth, per Lloyd's rules, I became greatly impressed with what appeared to me a great waste of material in the frame girder, which, in the vessel to which I refer, was 12½ inches deep by $\frac{10}{20}$ to $\frac{9}{20}$ inch in thickness by 3½ inches flanges and 3½ inches overlap. It appeared to me that a considerable reduction could be made in the effectual length of the frame girder, and consequently in the scantlings, and at the same time the danger existing in single deck steamers of the margin plate cracking would be guarded against by working from the tank top as a foundation, and in curving the reverse frame gradually to a point at a comparatively great distance above the tank top. This suggestion met with such strong approval from the Classification Societies that it led to the development of what is known as the "C" system of framing, on which system my own firm has built six steamers. The frame was reduced to 12 inches by $\frac{9}{20}$, with single attachment angles and no increase in way of long hatches. Owing to the reverse frame being secured so far in-board, there is less liability to trip and there is full justification for the omission of some of the stringers (see Plate XLI.). The form of frame naturally suggested making a similar curved connection at the upper end of the frame girder (see Plate XLII.), but I have never gone to the extent of curving the reverse frame into the beam knee, as sufficient recognition of such an improvement to justify the expense has not been given.

In the vessel shown in the diagram (Plate XLI.), however, there is a very substantial saving of material, leading on the whole to a gratifying economy in construction, and increased deadweight with reduced tonnage. This system of framing has been well received by owners and their superintendents.

The transverse system that I have referred to has given at the very best what is relatively a compressible structure lengthways. Those who have experience in ships' repairs, especially consulting engineers and superintendents, are well aware of the compressibility of the upper structures of vessels by the panting that is evident of the plating between the points of transverse support. Since the Classification Societies introduced the system of wide spaced pillaring in connection with the girders riveted to the decks, a good deal has been done by builders adopting this system towards overcoming the compressibility of the upper structure. These intercostal girders, however, are a serious addition to the number of parts in the structure and contain a large amount of costly riveting, and, while carrying us in the right direction as regards strength, take us further from simplicity.

From the very shape of the close spaced transverse frame, which, commencing in an ordinary cargo vessel with a riveted attachment on the keelson, advances to the bilge with several vertical riveted attachments carrying the intercostal girders; then at the bilge with an expensive watertight attachment at the margin takes a sharp curve and extends up the side of the vessel, affording riveting attachment to the side stringers; reaches the first beam knee and sends out a branch at right angles necessitating a very heavy and expensive riveted attachment, and of which the rivets can only be fitted in after special fairing and drilling. At every deck in the ship this branching process must be repeated until it arrives at the upper deck, when the frame, with another similar riveted attachment, turns at right angles across the deck. Exactly the same number of turns, branches and riveted attachments are repeated on the opposite side of the vessel. This circuitous transverse frame must be pillared either by one, two, or three rows of pillars, and we must either put a pillar on every beam or collect the beams in groups by means of strong riveted girders, in order to open out the pillaring. It is difficult to conceive, without the minutest study in detail, what a mass of useless weight is worked up in these transverse members, for a large part in riveted attachments, which are a source of weakness rather than strength, and not a pound of which can be called upon to do service in the direction in which the most serious strains affecting a ship must be met.

I wish now to say one word more in regard to the value of longitudinal material in transverse framed vessels. I understand that Classification Societies and naval architects generally, in calculating the longitudinal strength of vessels, assume that when the upper works are under compression, and a vessel undergoing sagging stresses (I am paying particular attention to the upper works, as herein most failures have been experienced), the value of the plating between the beams is reckoned as able to withstand a somewhat higher stress than experience teaches the material is able to stand in order to provide a factor of safety of about 3 to 1 with a dead load. From recent causes of collapse of decks, it has been admitted that the plating between the beams has buckled under stresses of probably 12 to 14 tons, according to thickness. This assumed factor of safety, I fear, therefore, in transverse framed vessels, is in ordinary cases non-existent, besides which it is a question whether it is safe to assume such strains as dead loads. For a number of years my firm has been in the habit of fitting some longitudinal framing underneath the midship portion of the uppermost deck in all vessels, and, in every vessel of extreme proportions, has adopted the longitudinal girders on all decks to ensure increased longitudinal strength.

I think I need say no more to convince my hearers what my attitude has been for some years towards the ordinary transverse system of framing, and I would add that since the first day upon which I found myself in close sympathy with Mr. Isherwood on this subject, I have not had one single moment of misgiving. I would venture to say, also, that the true guide to simplicity in a ship's structure is to take the skin framing through from stem to stern, instead of following the other tortuous route at close spaced intervals throughout the vessel's length, leaving blanks between.

Without further remark, I will refer you to Plate XLIII., illustrating the section of an oil steamer, 355 feet in length, now [redacted] with which Mr. Isherwood's name is associated. In this system the floors, frames, and beams are fitted longitudinally, being for the most part in long straight lengths. I would suggest that the chief merit of the system is the way in which the transverse strength has been dealt with, and I would add that this has received the first consideration. Longitudinal stiffening is for the most part woven through the transverse member in the neighbourhood of its neutral axis. The transverse girders are directly attached to the shell, securing the greatest possible value from the shell plating transversely. It will be seen at a glance that this reinforcement of transverse strength is obtained from the shell at the expense of very slight stress, owing to the proximity of the neutral axis of the transverse girder to the skin plating. In this oil steamer advantage has been taken of the circumstance that broken stowage is not a serious detriment with a liquid cargo, and full play has been given to the transverses as regards depth, and deep bracketing at the upper and lower parts, to reduce the effective length of girder. The longitudinal strength of frames, floors and beams is maintained while passing each oiltight bulkhead by bringing up the riveted attachments to the strength of the member attached. This arrangement lends itself to greatly improved distribution of strains round the margin of the bulkhead, and the rivets passing through the bulkhead attachments are found to be subject to a much less severe stress than has been the case in transverse framed vessels.

The next plate (Plate XLIV.) is the elevation of the same steamer, clearly showing the distribution of the transverse structures, and which explains itself.

In designing the scantlings, an effort has been made to keep the stress at the bridge stringer equal to that at the stringer in way of the oil tanks. This desirable state of affairs is comparatively easily obtained by the aid of the new system.

I will next throw upon the screen a series of photographs taken of this steamer during erection. The vessel has been brought into fair shape by templating the longitudinals and the brackets attaching them to the bulkheads. The bulkheads have been erected and riveted as the erection of the vessel progressed from aft to forward. The stiffeners and the angles connecting all attachments on the bulkheads and webs were all riveted by hydraulic machine before the plates were lifted.

It has been thought by some that serious difficulty would be found in erecting a vessel on this system, and I think the best answer to that must be that the greater part of this structure has been erected and faired by the boys, in the absence of the carpenters, who are unfortunately on strike. It has been proved by experience that the system gives unusual facility for completing all internal work as the erection advances, and this circumstance alone is having a marked influence in the direction of economy. The number of lugs and knees saved in the oil ship is very great indeed. Moreover, there is no necessity for fitting stringers, and the keelsons, with their enormous connecting knees at bulkheads, are dispensed with, their functions being more efficiently taken up by the longitudinal floors and deep transverses, resulting in economy in material amounting to about 275 tons, and at the same time reduced stress on plating and riveting throughout, and consequently much less liability to leakage, and easier maintenance. The massive appearance of the structure has been the first impression of almost every practical man who has inspected.

I now refer you to the framing plan (Plate XLV.), which shows at a glance how the spacing of the longitudinals is preserved, and how the endings are arranged, and also the provision against panting. One remarkable feature of this plan is the great facility afforded at the ends of the vessel by using a little transverse framing. Two great authors on shipbuilding matters have stated the opinion that a longitudinal system of framing would be found especially useful at the extreme ends of the vessels. In actual practice, however, it has worked out quite otherwise up to the present time.

Next, I draw your attention to Plate XLVI., the plating plan of the same ship, showing how, in the system of framing we are now considering, by a very simple arrangement of plating, crossing and landings may be avoided almost entirely.

I come now to Plate XLVII., which gives an elevation of a shelter deck steamer, 360 feet long; this will be the first cargo steamer constructed under the new system of framing. The drawing shows very clearly how the intervals between the transverses may be easily adapted to the deck and hold arrangements of such a steamer. In the present case an uniform interval of 12 feet has been selected.

The last illustration (Plate XLVIII.) shows the full midship section of this steamer. I feel sure that the simplicity of structure will appeal to all practical men who are present to-night. The question of erection, however, will be foremost in their minds, and I have therefore explained that to facilitate this important part of the building of the ship, and to quickly secure the fair shape of the vessel, the transverses are erected as complete as possible. The two side girders in the double bottom and the tank side are fitted intercostally, so that the correct distance between transverses is quickly adjusted. It will be noticed that the longitudinal frames are graduated in size according to the water pressure they are required to withstand. The facilities afforded by the system to produce a design of double bottom of very great strength and durability of the internal parts is probably the most striking feature of the plan now before you.

DISCUSSION.

The PRESIDENT said—I am sure we are very much indebted to Mr. Craggs for having come here to-night, and I shall be very glad to hear any remarks on his paper.

Colonel R. SAXTON WHITE said—I am sure that you will agree that the Institution is indebted to Mr. Craggs for the paper he has given to us on a most interesting subject. I regret that Mr. Craggs has not given us more information. So far as I personally am concerned, he gave me the opportunity of visiting his yard to see this vessel in construction, and I extremely regret that circumstances arose which put it entirely out of my power to do so. I learn from the paper that not only has Mr. Craggs satisfied himself, but he has also satisfied the authorities of Lloyd's, Bureau Veritas, and the British Corporation; and, therefore, I hesitate, after only having had an opportunity of listening to Mr. Craggs and his description by the aid of the screen, to offer any opinion on this question in the way of criticism. I consider, however, from the information before me, that we are still a long way from a complete longitudinally framed ship. Of course, one's idea might be entirely different after inspecting the ship, but, looking at the views of the vessel thrown on the screen, that is my opinion. In regard to the saving in weight, Mr. Craggs claims 275 tons on a ship about 350 feet long, but, again, judging from the screen, I do not quite see where it comes in; and I think the Institution might appreciate the value of this paper more if Mr. Craggs, without giving away the whole show—which I have no doubt he has not the slightest intention of doing—would give us some information and figures by which this very great saving of weight, whilst retaining the strength of the present construction, can be obtained. I do not desire to throw any doubt whatever upon the figures which Mr. Craggs has put before us, because I am certain he would not put such a figure in front of this Institution unless founded on a well-calculated basis. Mr. Craggs rather looks down upon the old style of framing, and I hope I may still be able to appreciate that there can be designed an equally good system of construction; but he refers, I think it was more particularly in connection with the web frame construction, to all the other frames as "weaklings"; and therefore, presumably, not equal to do the work they are called upon to do unless they were supported by the web frame. That is true; but I think the old-fashioned vertical framing is worthy of a more respectful greeting than to call them "weaklings," because there are far too many ships crossing the ocean at present absolutely depending on these "weaklings" for the good work they are doing. The longitudinals which are put in place of the vertical frame, supported as it is by what Mr. Craggs calls his Transverses, which may be a new name, but is very like an old friend, namely, the web frame. The mere transposition of these frames from the perpendicular position to the horizontal does not, in my opinion, change its character, as the new frame is equally a "weakling" with the vertical, depending as it does upon the support of the Transverses. Whether it will do its work as satisfactorily in the future as the old vertical frame has done in the past, of course time alone can tell, but, again, speaking from the slides thrown on the screen, where is the great advantage in the new system in regard to cargo capacity and clear holds? because, after all, shipowners have a great desire to do away with all internal obstructions, and obtain the clearest hold that it is possible to get. The deep frame which Mr. Craggs shows in the C section, I mean the double angle iron frame without the web frame, I think presents a much clearer hold than in the new construction as represented on these slides, because it seems to me that these Transverses will interfere most seriously with the stowage of cargo. It may, of course, be that in the ship they might not be so prominent, but seeing, as I understand, in an ordinary cargo steamer that these Transverses are placed every 12 feet apart, again I rather seem to think that there is a very strong family likeness to our old friend the web frame. I quite appreciate the advantages that Mr. Craggs seeks to claim in regard to the omission of large brackets in the construction of oil steamers if he can properly dispense with them in actual practice. Of course, you can do many things in a drawing office, but, after all, there is such an old-fashioned thing as experience. I recollect the first tank steamers that we built, and we had in those early days little or no experience to guide us as to the part played by bracket plates at the bulkheads in oil-carrying vessels. These, by the experience of years, were gradually strengthened, made larger, and, of course, naturally, more costly and more weighty. Whether Mr. Craggs's experience in the future may run on lines of our experience in the past, time alone can tell. The present structure of a tank steamer has been built up largely as the result of experience, based originally, possibly, on inadequate knowledge. But I am certain Mr. Craggs will in like manner bring to bear, in the event of his system requiring further consideration in the form of extra strengthening, the same clever adaptation of material to get over it, as is shown in his present departure. Frankly, I admit, Mr. Craggs's system looks more favourable from the tank steamer point of view than for the ordinary cargo vessel, because there necessarily we have, as he has shown you on the screen, a large number of bulkheads. You have in an ordinary tank steamer a matter of fifteen or sixteen bulkheads. Of course, that gives you a tremendous transverse strengthening to start from, and therefore the so-called longitudinal system advocated by Mr. Craggs appears to me—I speak without really having studied the question in detail—possibly better adapted for a tank steamer than an ordinary steamer, because I cannot get away from the idea that this large number of Transverses must inevitably be an objection in an ordinary cargo vessel; but when Mr. Craggs says in reference to tank steamers that he has taken full advantage of his Transverses, and this certainly is the case, as they appear to me to rather take the form of partial bulkheads, I again refer to the slides thrown on the screen, they may not be so large as they appear, but they look pretty substantial—I do not know what they are——

Mr. CRAGGS—Thirty-three to thirty-six inches.

Col. SAXTON WHITE—Well, that is about double the ordinary web frame width, and in a 30 feet tank brings them 10 feet apart, with, it seems to me, considerable interference with stowage: but, as Mr. Craggs points out, in a plain oil steamer, not intended for the carriage of general cargo, such a question as interference with stowage is absolutely immaterial. So long as a steamer is carrying petroleum, of course, the fluid will go round any corner, but the experience of many of us with tank steamers is that they have not only to carry petroleum or liquid cargo, but large numbers of them also have to carry on the return journey general cargoes, where the question of interference with stowage, of course, must arise. I do not make the claim that the present system of framing, in tank steamers, does not present considerable interference with stowage of general cargo. Whether Mr. Craggs's system would make any improvement is, I venture to think, doubtful. I apologise both to Mr. Craggs and the meeting for not being able to speak on this question with a greater degree of preparation, because I should have liked very much to have accepted the invitation which Mr. Craggs kindly gave me to see the tank steamer now building, because without that you may get a very fleeting idea from the slides shown on the screen. They are not always self-explanatory, and some of the objections to the system might disappear; but I am sure that the members of this Institution, especially those who are present and who have seen the very interesting slides thrown on the screen which Mr. Craggs has presented to us, will feel that the Institution is under a debt of gratitude to him for his great trouble in preparing this paper, because I know it must have been done under stress of other engagements. I am sure the Institution appreciates very highly this paper, which should bring out a most interesting discussion.

The discussion was adjourned.

The meeting then dissolved.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

TWENTY-FOURTH SESSION, 1907-1908.

PROCEEDINGS.

THE CLOSING MEETING OF THE SESSION WAS HELD IN THE LECTURE THEATRE OF THE LITERARY AND PHILOSOPHICAL SOCIETY, WESTGATE ROAD, NEWCASTLE-UPON-TYNE, ON FRIDAY EVENING, MAY 15TH, 1908.

W. H. DUGDALE, ESQ., M.INST.C.E., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the previous meeting, held on Friday, April 3rd, 1908, which were confirmed by the members present and signed by the President.

The PRESIDENT appointed Mr. Summers Hunter and Mr. J. L. Twaddell to examine the voting papers for new members, and the following gentlemen were declared elected :—

MEMBERS.

Aitkenhead, Thomas Elliott, R.N., Engineer Lieutenant, H.M.S. "Grafton," Portsmouth.

Arnesen, Olaf, Principal Surveyor for Det Norske Veritas, York Chambers, Sunderland.

Cormack, Charles, Sup. Engineer, 7, John's Place, Leith, N.B.

Craggs, Robert Henry, Shipbuilder, Teesside Dockyard, Middlesbrough.

Doxford, William, M.Sc., Shipbuilder, c/o Messrs. W. Doxford & Sons, Pallion Shipyard, Sunderland.

Isherwood, Joseph William, Shipbuilder, Roman Road, Linthorpe, Middlesbrough.

Morvig, Georg B., Surveyor, 34, Azalea Terrace South, Sunderland.

Robson, John Potts, Marine Engineer, 58, Forster Street, Roker, Sunderland.
Ross, Archibald C., Marine Engineer, 4, Collingwood Terrace, Newcastle-upon-Tyne.
Thomas, Thomas Roberts, Eng. Surveyor, 261, Chester Road, Sunderland.

ASSOCIATE.

Murray, David, Accountant, 13, Argyle Square, Sunderland.

GRADUATES.

Deas, Charles Douglas, E. Draughtsman, 30, Harrogate Street, Sunderland.
Haddock, Gilbert Forster, E. Apprentice, 16, Azalea Terrace South, Sunderland.
Hill, Anderson C., E. Draughtsman, 4, Park Place West, Sunderland.

THE LATE MR. WIGHAM RICHARDSON.

The President said—Before we resume the ordinary business I would like to refer to the death of Mr. Wigham Richardson, who was one of our Past-Presidents, and one of the very early members and founders of this Institution. I am sure we very much deplore his loss, and the Council at its meeting asked the Secretary to write to his family and record our regret at their bereavement.

The discussion on Prof. R. L. Weighton's paper on "Piston Speeds and Steam Engine Economy" was resumed and closed.

The discussion on Mr. E. Hall Craggs's paper on "The Framing of Vessels" was resumed and closed.

RESUMED DISCUSSION ON PROF. R. L. WEIGHTON'S PAPER ON "PISTON SPEEDS AND STEAM ENGINE ECONOMY."

The two following communications were put before the meeting:—

NEWCASTLE-UPON-TYNE,
May 12*th*, 1908.

DEAR MR. DUCKITT,

As I am unable to be present at the meeting for the resumed discussion on Professor Weighton's paper, I send you the following communication:—

At the outset I may remark that without further experiments carried out under conditions extremely difficult to obtain, it does not seem possible to draw any safe deductions regarding the effect which piston speed in itself may have on steam engine economy. The author has clearly pointed out that if it is desired to find the effect of altering one condition, that condition only must be varied during the trial. In these trials this essential has not been complied with owing to the impossibility of increasing the piston speed without at the same time correspondingly increasing the steam speed through the ports. The author, of course, is fully alive to this fact, and has called attention to it in his paper, but I gather from the title of his paper and from his remarks when reading it that he is inclined to consider *piston speed* rather than *steam speed* the dominant factor in producing the results shown by his curves. My own feeling is that probably the steam speed through the ports has had more to do with the effects noted than the piston speed, at any rate in the trials at the higher piston speeds. If we examine the curves we find that the piston speed is comparatively moderate and well within the limits of ordinary practice, even at the maximum revolutions, while the steam speeds become abnormal compaıed with ordinary practice at quite an early stage. To illustrate this point I enclose a diagram (Plate XLIX.) in which the vertical height represents steam speed in feet per second, while the base line represents piston speed in feet per minute. The spots give the steam speeds through H.P.

ports in a number of engines by various builders and in various vessels ranging from tramps to warships. The horizontal line, AA, gives approximately the mean steam speed for H.P. ports of these vessels, while the line, BB, shows the H.P. steam speeds (for the triples) during the author's experiments at corresponding piston speeds. It will be seen that BB crosses AA at about 315 feet piston speed, in other words, that after this speed (*i.e.*, 105 revolutions) the steam speed rapidly becomes excessive when compared with ordinary practice. Had I taken the L.P. steam speed, I think this would have been even more clearly shown. Remembering then that all conditions are quite normal except the steam speeds, I am forced to the conclusion that the fall in economy at the higher speeds is due principally to steam speed, especially when we know what excellent results are obtained by engines running at high piston speeds. If we examine Diagram 2 (Plate XXXI.) we find that the point of maximum efficiency or least value of the expression $\frac{W}{B.H.P.}$ occurs at about 441 feet piston speed. It seems to me reasonable to suppose that up to this point the curve of $\frac{W}{B.H.P.}$ falls owing to the gain obtained by increasing piston speed and decreasing condensation in the cylinders, but that after that point the effect of abnormal steam speeds more than counterbalances this gain and the curve rises very rapidly. It would be interesting to know whether the indicator diagrams show signs of much wire-drawing during admission of steam. Professor Weighton points out that the conditions under which these trials were carried out are not those usual on board a ship, where alteration in revolutions is carried out by means of alteration to steam pressure or cut off. I ventured to remark, however, during the reading of the paper, that the conditions were similar to those when two different propellers were tried on one ship. For this case it will be readily appreciated that these curves have a very strong bearing on practical design. Take, for example, the curve of B.H.P. in diagram 2 and imagine that we have two equally efficient propellers, each taking about 94 B.H.P., one designed to run at 190 revolutions, and the other at about 235 revolutions. The power required by each propeller would be the same but the water consumption in the latter case would be anything from 15 per cent. to 20 per cent. more, or in other words the weight of the boilers would be increased from 15 per cent. to 20 per cent. for the same speed of the ship. Can a condition such as this be the explanation of some of the results that have been obtained by changing propellers? As regards the mechanical efficiency of these engines, I would be glad if the author in his reply would explain more fully why it is so low. Of course I am aware that the conditions are not strictly comparable, but we have now a number of determinations published of the ratio between B.H.P. and I.H.P. as found by the torsion-meter. Mr. Gibson gave some in his recent paper, Mr. Denny has published others, and the investigations of Dr. Fottinger in Germany are well known. In all these cases the efficiency curve rises as the power increases and at its maximum value generally reaches about 94 per cent. In Dr. Fottinger's experiments I understand that the torsion-meter was checked by a brake and found to give accurate readings. In his article upon "Engine Vibration" in *Engineering* a few years ago, Rear-Admiral Melville of the U.S. Navy gave an account of two torpedo boats where it was proved that excessive vibration had the effect of a brake upon the engine, so that the desired revolutions could not be obtained until the engine was properly balanced, after which the revolutions were obtained with ease and reduced steam pressure. Prof. Weighton mentioned that his engines were unbalanced and he did not on that account care to run them any faster. I should like to ask him whether excessive vibration may have had something to do with the results obtained at the higher speeds and also whether the inertia of reciprocating parts at high speeds has any effect on the results as compared with those obtained at low speeds. In conclusion, we must be careful to remember the author's warning that these results only apply to one particular set of engines and in the present state of our knowledge of this subject it would be most unwise to argue from the particular to the general. Similar trials on other engines would probably give totally different results, and in view of the importance of the subject, I hope that such trials will be carried out at some other university or college that has the necessary facilities.

Yours faithfully,

HAROLD THOMSON.

GLASGOW,
May 14th, 1908.

DEAR MR. DUCKITT,

Anything I have to say regarding Professor Weighton's admirable paper is more in the direction of expressing my admiration of the excellent work done by the engineering staff at Armstrong College, and my thanks to Professor Weighton for the clear and lucid manner in which the results of the experiments conducted there have been put before the members of our Institution, and the results placed at their service. The paper, as a chronicle of results, stands upon its merits, and the uniformity shown in Diagram 1 is proof, if proof were needed, of the care and accuracy with which the experiments have been conducted.

Experiments in the direction of showing the effect upon indicated and brake horsepower, as well as upon steam consumpt, due to speed of revolution, or, as the paper names it, piston speed, have been conducted by other experimenters, but never, so far as my knowledge goes, upon an engine which is of the modern marine type and of normal proportions. These experiments are therefore of exceeding value, and call for careful study from everyone concerned in marine engine economy. The rapid attainment of a speed beyond which no further increase of brake horsepower is possible with the valve settings experimented upon, must be of the nature of a revelation to most marine engineers, but the point which has attracted my attention most is the rapid increase in the work absorbed by friction in the case of the quadruple engine. The pressure (P_f) upon the area of the L.P. piston necessary to overcome the engine friction is for the quadruple,

P_f = 2·22 at 100 revolutions
2·65 at 160 „
3·27 at 220 „

while for the triple it is,

2·62 at 100 revolutions
2·62 at 160 „
3·12 at 200 „

From the records of some experiments contained in Professor Mellanby's paper upon the "Relative Efficiencies of Multiple-Expansion Engines" (*Trans. Royal Society of Canada*, 1896-1897), I deduce the following figures:—

Compound engine $\frac{9-18}{15}$ 12·3 expansions.

P_f = 6·35 at 91·78 revolutions
7·11 at 147·12 „

Triple expansion engines $\frac{9-13-18}{15}$ 12·3 expansions.

P_f = 7·3 at 89·82 revolutions
7·2 at 148·84 „

Triple $\frac{6\frac{1}{2}-9-18}{15}$ 12·3 expansions.

P_f = 4·97 at 90·23 revolutions
5·68 at 149·38 „

Also, same engine, 22 expansions.

P_f = 5·52 at 91·45 revolutions
6·40 at 149 „

Quadruple expansion engine $\frac{6\frac{1}{2}-9-13-18}{15}$ 22 expansions.

P_f = 6·4 at 91·00 revolutions
7·41 at 148·9 „

In *Locomotive Performance*, by Professor Goss of Purdu University, there are many interesting experiments upon the locomotives Schenectady No. 1 and No. 2, at various speeds from 78 to 300 revolutions. The results are distinctly interesting and are of the same nature as those shown by the experimental engine at Newcastle, upon all points except that of engine friction, which, while varying on different tests, is practically constant at all speeds from 78 to 300 revolutions.

The difference shown above in Professor Weighton's tests of triple and quadruple, Professor Mellanby's tests of compound, triple and quadruple, and Professor Goss's locomotive tests, are sufficiently startling to raise the question in one's mind as to whether the increase in friction observed in the marine type of engine are inherent in the design of the engine or in the system of lubrication, and although the influence of increased friction is more apparent at the low mean pressure at which it was necessary to run the Newcastle tests than it would be at higher mean pressures, the question is nevertheless one of considerable importance.

The full value of these experiments will only be seen as the results obtained become fixed in our minds, and it seems to me that Professor Weighton has laid the whole profession under a very great debt by showing the enormous influence speed has upon the efficiency of the ordinary type of marine engine. It is too early yet to see what this line of investigation may lead to, and I for one will await with the greatest interest further developments along this line of research.

Yours faithfully,

E. HALL-BROWN.

PROFESSOR WEIGHTON'S REPLY.

Prof. R. L. WEIGHTON, replying to the discussion, said—The first speaker on the paper I had the honour of laying before you some weeks ago was Professor Mellanby, of Glasgow. The information which Professor Mellanby contributed was most interesting and helpful, and I wish to thank him for it. He has since supplemented what he said by sending a diagram giving results of a somewhat similar character from a very small engine in his laboratory at Glasgow. He asked if I might add to the paper a curve or a table showing the consumption of steam as given from the high pressure indicator diagrams. I have done so. (See Plate L.) I had it prepared before, but I did not think it added very much to the practical character of the paper. It bears out what Professor Mellanby anticipated, that the amount of missing quantity gradually diminishes as the revolutions rise, that being the characteristic of an economical engine such as that at Armstrong College. I also thank him for the suggestion that valve leakage is probably a factor in determining the effect shown in the paper. I must confess that it had not occurred to me. It is certainly a factor, though I do not think an important one. There would also, of course, be piston leakage, as well as valve leakage. Mr. Spence next spoke, and he asked a question—a question the answer to which he said quite rightly might afford information to others than himself, namely, why there should be such a difference—and it is considerable—between the mean pressures of the quadruple and triple expansion engines working under apparently the same conditions? A little investigation shows two things. First, that the nominal total number of expansions in these two engines is not quite identical, being 15·9 in the quadruple and 14½ in the triple. This would make some difference in favour of the triple having a higher mean pressure. But another feature which Mr. Spence rather surmised might explain the difference is that the triple, having the bigger high pressure cylinder, had a much greater volume of clearance. As a matter of fact, that greater volume of clearance is also larger than it would otherwise have been because the cylinder was designed to take a liner 12 inches in diameter instead of 10½ inches. That has the effect of diminishing the actual expansions and raising the mean pressure to what it actually is. Mr. Spence also made a remark with regard to what I said with respect to speeds of steam and exhaust, which was a misunderstanding of what I said. I said the speeds of steam and exhaust in the low pressure were disproportionately great as compared with those in the others. That is absolutely so. There is a greater difference between the low pressure and its predecessor than there is between any one of the others and its predecessor. Mr. Spence evidently thought I meant as regards other engines the low pressure had the greatest speeds. That is not so.

Mr. Cairns sent a communication which I think was taken as read. It is well worth reading. Mr. Cairns writes in a style which is racy, and gives matter which is instructive. He suggests many experiments, amongst others those with piston valves. These experiments would doubtless all be very instructive if carried out. He also makes a remark, which I endorse, that the amount of improvement which in these days can be made upon good samples of modern steam engines is small, and it is hopeless to look for it in the course of ordinary commercial or industrial practice. You cannot discern it as a rule, and to look for it in any effectual way under such conditions would entail prohibitive expense, and probably in most cases it could not be done at all. Therefore it is only by experimenting in special conditions where all the factors are under control and can be varied at will, that you can hope to find out effects with the causes of them. Anyone who has attempted to experiment will, I feel sure bear that out.

There is also a communication from Mr. Harold Thomson, which has been taken as read. I am sorry Mr. Thomson is not here to-night. I do not understand the precise meaning of some of his remarks at all. I do not think he means what his words lead one to infer, but I suppose I must interpret them literally. Mr. Thomson begins, and I am obliged to him for it, by emphasizing the fact—which the paper had already emphasized twice over—that the number of conclusions you can legimately draw from such a paper are very limited, and particularly warning readers from drawing general conclusions from particular instances. I have read a few papers in my time, and I have been accused of drawing conclusions which were not warranted by the premises, but I do not think I have ever been accused of drawing conclusions which I have not drawn at all, as Mr. Thomson's language might be interpreted to infer. In the very beginning of the paper I not only said the subject was not completely and fully investigated owing to circumstances beyond my control, but I went further, and said I wished the paper to be looked upon as of a preliminary or introductory character, and not at all as a complete solution of the principal question. Yet, according to the literal text of Mr. Thomson's communication, I rather gather that he has the impression that I have drawn conclusions which are not warranted. All I can say to that is the paper has been before the members, and nobody—not even Mr. Thomson in express language—has found any fault with the conclusions I *did* draw, and which are given at the end of the paper and numbered 1, 2, 3, 4, and 5. I said we could not draw certain conclusions because the subject required further elucidation. I cannot change these engines into other engines. I cannot make experiments which the engines will not permit me to make. I made all I could in the meantime, and I thought I might comply with the request of our President for a paper by presenting these results—incomplete as they were—now. Premising that, I proceed to take up one or two points which I am compelled to dwell upon, because they bring home to my mind how much I may have been misunderstood. The subject is very involved indeed, and one is apt to be misunderstood. Mr. Thomson says, "From the title of the paper, 'Piston Speed and Steam Engine Economy,' the author is inclined to consider the dominant factor to be *piston speed*." Well, so it is—in a sense—in the circumstances, because it is the piston speed alone which determines everything else. Only by altering piston speed could we vary steam speed and exhaust speed; but the author does not by any means consider it as the dominant factor in determining all the results. There is not only piston speed, but steam and exhaust speeds, and they each have their share in determining the results; but in searching for a title which would be descriptive without being too long I thought the phrase "piston speed" was the best I could adopt, because it was the determining factor in the circumstances. Next, Mr. Thomson comes to a certain conclusion in these words:—"Remembering all the conditions are normal except steam speeds, I am forced to the conclusion that the fall in economy at the higher speeds is due principally to steam speed, especially when we know what excellent results are obtained by engines running at high piston speeds," and he submits a diagram which is here. (See Plate XLIX.) I have put it on the board with the two curves in red which Mr. Thomson did not put on. The co-ordinates are piston speeds and steam speeds, and a lot of spots are given of the relation between piston and high pressure steam speeds of several vessels, embracing war vessels and tramps. Then a line is drawn through the average of the spots which Mr. Thomson calls ordinary practice, giving a mean value of steam speeds at about 117 feet per second. Then he says, "it is obvious that the experimental engine came within ordinary practice as regards piston speed," meaning it does not go away far beyond the end of line AA one way or the other. First of all, that is scarcely correct, because piston speed has no significance technically, unless you take account of length of stroke, and piston speeds which might be high for a short stroke engine may be very moderate indeed for a long stroke engine. The experimental engine has only 18 inches stroke. I presume Mr. Thomson's engines have strokes very much longer than this. So that the matter of piston speed is not a fair basis of comparison in these circumstances. However, assuming that it is a fair comparison, he says the only abnormal thing about these engines is that they have abnormal steam speeds, and therefore the falling off in efficiency at high piston speeds must be due to abnormal steam speeds, because it does not accord with the steam speeds of what he calls practice. You see the fallacy of that. It is tacitly assumed that the steam speeds of what is called "practice" are best. That is not in accordance with scientific method. We must bring practice to the test of experiment; and in the background of Mr. Thomson's mind there lurks—although I presume he would not confess to the soft impeachment—an idea that practice has already determined the best. In refutation of this, to show that it is not an argument which is germane to the point, I have ventured to put the two red curves on to Mr. Thomson's diagram. These curves give the pounds of water per horsepower for the experimental engines. The minimum value of $\frac{W}{B.H.P.}$ indicates the particular piston speed at which maximum economy occurred, and the particular steam speed. Maximum economy occurred at a steam speed of 180 feet per second. Mr. Thomson says, "117 is the value for ordinary practice." How does he know that economy would not be increased by bringing it up to 180 in ordinary practice? If this were a valid comparison, which, however, I do not think it is, the legitimate conclusion that can be drawn violates Mr. Thomson's own contention, which is that owing to the fact that steam speeds go up much higher in the experiments than those usual in practice, the want of economy at those high steam speeds is due to them and not to piston speeds. My contention is there is no want of economy at the high steam speeds as is shown by Mr. Thomson's own diagram. Whether you take the case of brake horsepower or indicated horsepower, in either case you get steam speeds far and away above those of admitted ordinary practice, and only at these abnormally high steam speeds were the engines working most economically. Mr. Thomson asks if the indicator diagrams showed much wire drawing. Of course they did at the higher steam speeds. Then there is a question Mr. Thomson asks which shows that we marine engineers, in my opinion, have not studied engine economy so closely as land engineers have done. It is this. "Why," he asks, "is the mechanical efficiency of the engines so low?" He goes on to adduce cases which have been published of engines, including the results given by Mr. Gibson when he read his paper on the torsion-meter, and he says in all these cases the mechanical efficiency of the engines rises as the power rises, and he asks why it is so low in the engines in the paper. Well, it is a first principle in engine working that if an increase of power is due to increase of mean pressure and revolutions—which are the conditions of marine engine working—then the mechanical efficiency rises as the power rises. And it must be so; it cannot be otherwise. But in all these cases the efficiency of the engines rises as the power rises, he says. It so happens that in the case adduced by Mr. Gibson, where he gave indicated horsepower and also shaft horsepower taken with the torsion-meter, there is a very curious anomaly. As the power rises the efficiency falls off. There is certainly something wrong there. It is a point which Professor Welch raised in the discussion on Mr. Gibson's paper, and Mr. Gibson did not answer the question. There is an anomaly there that requires examination. But, first of all, the mechanical efficiency of the engines in the paper before us is not low—it is fairly high. It is not low considering the conditions. First, the engines are very small in dimensions, and the mechanical efficiency is usually higher, other things equal as dimensions are increased; and second, these engines on the trials recorded were not being worked at their maximum power, and when you work an engine at less than its maximum power its efficiency falls. These engines at full power gave an efficiency of about 91 per cent. I scarcely think that any ordinary triple expansion marine engine will give a true mechanical efficiency as high as 94 per cent. Only 6 per cent. for friction of all sorts seems to me exceedingly small for such engines, even under best conditions. Then I spoke about vibration at high speeds. These engines did show slight vibration, and I did not put them to their highest possible speed, as I did not want to risk too much with so many young observers about, and Mr. Thomson asks, "Did vibration not affect the mechanical efficiency?" I do not know; I do not think it could possibly affect it much. No doubt frequency of reciprocation will affect mechanical efficiency to some extent, but that again is a point which would occur in any engine driven at high speeds. Mr. Thomson ends by emphasizing the fact that we cannot draw any lessons from the paper, and again emphasizes what I said twice over in the paper itself that we must not draw general conclusions from particular instances. But when Mr. Thomson goes on to make this remark, namely, that similar trials with other engines would probably give "totally different results," I think he is violating his own very wholesome dictum and is drawing a general conclusion from no evidence at all. There is nothing whatever to warrant one in concluding that exactly similar results would not follow from similar engine trials. If such trials were made with vastly dissimilar engines then you might get different results, but try similar engines and they will give the same general qualitative results—though not necessarily the same quantitative. I feel sure a fuller consideration of the results would convince Mr. Thomson he is entirely wrong on this point. This is a subject which I have been studying for years, and I am only sorry I have not so far been able to draw more definite and general conclusions than I have, but the more one studies it the more one sees the need for further experiments before fuller conclusions can be drawn. One thing is certain, no rough and ready comparison with full-sized large commercial engines can give any information whatever. Reference must be had to the last equation in the paper, namely, equation 9, which relates the economy of the engine to the water used per revolution, to the indicated mean pressure and to the mechanical efficiency, and only by studying the effect of various revolutions on each of these factors can you possibly arrive at any general conclusions.

I have to thank Mr. Hall-Brown for a communication which I have only just had the opportunity of reading. I do not think there is any special point in it which calls for any remark from me. Mr. Hall-Brown's experience has enabled him to seize at once on what is probably one of the most significant features of the results, viz., the increase in friction losses with high speeds of complicated engines such as triples and quadruples.

The President said—I am sure you will agree with me that we ought to accord Professor Weighton a most hearty and cordial vote of thanks for the paper which he has contributed. As he mentioned in his paper, it is an analysis of results which he has obtained from his experimental engines and he is engaged just now with these experiments. They have not yet been completed, and therefore we may hope that in our ensuing session we may have something further from him upon this subject. I hope you will most heartily carry a vote of thanks to him.

The proposition was carried by acclamation.

RESUMED DISCUSSION ON MR. E. HALL CRAGGS'S PAPER ON "THE FRAMING OF VESSELS."

The PRESIDENT said—For obvious reasons I do not wish to take up much of your time, but I would like to point out that Mr. Craggs has not claimed in his paper having originated the idea of longitudinal framing. He admits that Brunel adopted a partial form of longitudinal framing in the "Great Eastern;" that Scott-Russell adopted a similar system in the "Annette," also that it was adopted in some other steamers. I believe Mr. Craggs is also aware that a patent was subsequently taken out by another gentleman. But the system does not seem to have attained very much popularity, and I am sure we are very much indebted to Mr. Craggs for having brought forward the subject to us for discussion. I wish to point out that although we as an Institution do not exploit any particular patent, we are always glad to receive information from any of our members who have conducted research work, and glad to have the results of their investigations. I therefore hope that the discussion to-night will take such a form as to render it a valuable addition to our *Transactions*, and also to the literature of our profession. I would like to ask you to remember that the subject we have now to discuss for the next hour or so is upon the relative advantages or disadvantages of longitudinal *versus* transverse framing, and not the validity of any particular patent. Therefore if those about to take part in the discussion will kindly remember this, and confine themselves to what I think we may reasonably consider to be the main issue of the question, I believe that the paper and the discussion will really be a valuable contribution to our *Transactions*.

Mr. E. W. DE RUSETT said—We are thankful for a practical paper like this, especially as it draws attention to such a departure in ship construction. I am glad the drawings have been added to the paper, otherwise we should have lost the value of the lantern slides which were exhibited when the paper was read.

With regard to design of longitudinal side framing, I remember an arrangement which was brought to my notice some ten or fifteen years ago by a workman living in Tynemouth, and in which the principal object in view was that of facilitating hydraulic rivetting of shell. He proposed web frames at the usual intervals, with longitudinal frames between, placed one on each strake of shell in a similar manner to that illustrated in Plate XLVIII. At that time difficulties presented themselves principally with regard to erection and fairing. These difficulties, by the experience of Messrs. Craggs, appear to have been groundless. The design, however, was not taken up by the Wallsend Shipyard. I have no doubt hydraulic rivetting of shell would be materially simplified by the adoption of longitudinal framing. I thought I might mention this incident as a matter of history.

Longitudinal framing and beaming will be especially valuable where the plating is subjected to severe buckling strains, as in the bottom and upper decks, and practice has been tending this way for some years past, by the introduction of longitudinal girders in conjunction with transverse beams, and more numerous hold stringers, but Mr. Craggs has made a bolder departure with, I think, more decided advantages, especially so with regard to the upper and lower members of the structure. For in the system described in the paper, the longitudinals will enable the shell and decks to endure the tensile and compressive strains which come upon them better than by the present system.

The savings, especially in furnacing, must be considerable. It would be pleasing if Mr. Craggs could favour us with the saving in cost of erection, which he states was all done by apprentice labour.

I think the longitudinal framing specially lends itself to tankers, because in them we do not have to consider broken stowage, but when applied to ordinary cargo vessels, and especially to insulated steamers—the deep transverse webs and deep hatch end beams will break bulk a good deal. Besides, there would be a good deal more difficulty in keeping the holds clean on account of the many ledges formed by the longitudinal frames, upon which coal, grain, sweat and dirt would lodge. Further, as the cargo battens would have to be placed vertically, there would, I think, be extra work in fitting them, especially at the ends of the ship, where they would have to be sprung into place.

In Plate XL. the reverse frames are extended over the tank top. This is a nice detail in construction. It was adopted in the construction of the "Mauretania," where the connection of the frame to the tank top and side proved very efficient.

It seems to me that sufficient provision has not been made for resisting lateral strains in the design before us, for so far as I can see the only provision made, apart from the bulkheads, is by webs spaced 10 or 12 feet apart and they appear to be only attached to the tank side and top by the usual lugs and gusset plate. Whereas in an ordinary web-framed vessel, having the usual number of bulkheads, we have, in addition to webs spaced about 12 feet apart, frames spaced about 2 feet apart, all the feet of which are attached to the tank in a substantial manner. Probably most of us remember trouble experienced before this detail received the attention it now has; therefore I cannot help thinking that some trouble may be experienced in this vessel for want of lateral stiffeners, unless the drawings do not show all the provisions which have been made in this respect.

I like the bottom; it appears to be very accessible, also suitably supported, provided the longitudinals are properly connected to the transverse parts.

I omitted to mention what I think is an important advantage in longitudinal framing, and that is that the scantling of frames can be varied to suit the pressure which comes upon them, say by the varying depth of water, whereas in ordinary framing this is practicable only to a limited extent, hence a considerable saving in material. Besides, as has been pointed out, the system lends itself to dispense with packing and joggling by projecting the frames and beams for outside strakes beyond the moulded line.

On again looking at the diagrams, I do not see whether the longitudinals are thoroughly attached to the transverse webs and floors, etc., or whether they simply rest or bear against the notch which is made for them? If the latter, I fear it will be found that movement will take place in consequence. The diagrams do not show this detail except in the tanker, and in Plate XLVIII., where I notice the alternate fore and aft beams are attached by a lug to the deep beam, the others appear to be simply resting in the notch and against the sharp edge of the punched plate. I fear this will prove to be unsatisfactory, as in practice it is doubtful whether the platers will punch the notches with sufficient accuracy to form a reliable and fair support to this part of the structure.

In my opinion, an arrangement combining the proposed longitudinal framing for bottom and deck, with the ordinary deep side framing, without hold stringers, would be more suitable for tramps than the entire longitudinal system described in the paper. And that longitudinal bottom framing, with the usual transverse beaming and side framing, would make a good combination for passenger steamers.

Personally, I thank Mr. Craggs for having been good enough to read this paper. I hope he will reap all the benefit he should receive by the boldness of his venture, and the way he has overcome difficulties of detail in design and construction, and for the cordial invitation he has given to the members of the Institution to visit his yard and see for themselves.

Professor J. J. Welch said—In the course of the remarks which Mr. de Rusett has just made he said questions of history were of interest, and I wish to confine my remarks almost entirely to one or two historical points associated with the earlier attempts to introduce longitudinally framed vessels, as I think this aspect of the question might with advantage have been dealt with at somewhat greater length by the author of the paper.

I am not sure I understand the author's remarks to the effect that "one experiment only, I think, was made upon this system." If it means that only one "Great Eastern" was built, I agree: but if it is intended to convey the author's impression that only one vessel was constructed on the longitudinal system, it hardly represents the facts, since the "Annette" was also built by Scott-Russell on this system to class at Lloyds, and at least two others were built abroad by Mr. B. Jensen, of Danzig, a gentleman who was at one time an assistant to Mr. Scott-Russell. An account of the "Annette" is given in Scott-Russell's work on *Naval Architecture*: whilst those built abroad are described in an early volume of the *Transactions of the Institution of Naval Architects*. Although differing in details, Somebody has said that he found most of his best ideas stolen by *the ancients*, and it seems to me that Mr. Craggs and Mr. Isherwood have just cause for complaint in the same direction. In these earlier vessels bulkheads were worked about 40 feet apart, whilst longitudinal frames on each strake of plating and also under the deck, were worked between these bulkheads, and were securely attached thereto at their ends. Between these bulkheads transverse partial bulkheads or *broad frames*, as they were called, were worked 10 feet apart, with special plate beams under the deck. These correspond with the *transverses* worked in the later vessels about 12 feet apart, although in the Isherwood system these transverses are *continuous*, whereas in the earlier vessels they were fitted *intercostally* between the longitudinal frames and were connected across those frames by diamond plates. The bulkheads, too, in the earlier vessels were carried out to the shell plating, as in the Isherwood system, so I cannot think the theory advanced by the author for the failure of the earlier system of construction, namely, want of direct connection of bulkheads to shell, can be sustained in face of the facts. It is true that in the "Great Eastern," where a double bottom was fitted, the bulkheads were stopped at the inner skin for easily-understood reasons, but this method of construction was not an integral part of the system and was not adopted in the smaller vessels.

As to the weight involved in the "Great Eastern," the author says, "It is obvious that a vessel built on this system would be of prodigious weight," but Sir William White has put on record ("Presidential Address," Inst. C.E., 1903) the following statement: "I have most thoroughly investigated the question of the weight absorbed in the structure of the 'Great Eastern' and my conclusion is that it is considerably less than that of steel-built ships of approximately the same dimensions and of the most recent construction," and after pointing out differences tending to make modern vessels heavier than the earlier one he adds, "after making full allowance for these differences my conclusion is that the 'Great Eastern' was a relatively lighter structure." Scott-Russell, too, claimed for the "Annette" that, with the same weight, the hull was 25 per cent. stronger than a vessel of the same dimensions of ordinary type, whilst Mr. Jensen asserted that the hull of his vessel, designed with shell plating somewhat thinner than allowed by Lloyds in association with the ordinary type of framing, was 7 per cent. lighter and 10 per cent. stronger than the vessel of ordinary type; or, with bottom plating equal to Lloyds, the hull was 3½ per cent. lighter and 18 per cent. stronger.

It should not be forgotten that although the longitudinal system failed to make headway in the Mercantile Marine it was and is adopted to a large extent in a modified form in battleships, particularly in double bottoms, the main framing in these parts being worked longitudinally throughout, whilst the transverse frames are 4 feet apart.

It will thus be seen that a system of construction very similar in its main features to that detailed in the paper before us and recommended on the grounds of easier construction, and lightness combined with strength, has been already tried, but failed to find acceptance in the Mercantile Marine, principally, I believe, for the reason given by Mr. Scott-Russell, namely, an indisposition to change from a well-known to a comparatively untried system.

The longitudinal system has now been re-introduced by Messrs. Craggs, and their plans, worked out as they have been with great skill by Mr. Isherwood, show some important differences of detail from those of the earlier constructions, whilst their workmen have the additional skill accumulated from 40 years further experience in shipyard methods; it may therefore very well happen that this re-introduction will be attended with the success denied to earlier workers in the same field.

Mr. Rowland Hodge said—The President remarked at the opening of this discussion that we were to overlook the fact that this paper, read by Mr. Craggs, related to any special patent, and to confine the discussion to the methods, or benefits, or otherwise, of the longitudinal system as compared with the transverse system of framing.

The President—What I said was, as an Institution, we did not exploit any particular patent, and as the paper is upon the framing of vessels I thought it well to indicate that.

Mr. Hodge—I was unfortunately unable to be present at the meeting when Mr. Craggs's paper was read, nor was I able to be present at the meeting in London. I regret that, because there is no doubt this system of framing resurrected by Mr. Craggs and Mr. Isherwood is of great interest. After the meetings I was in London, and my old friend Mr. James E. Scott came to see me in connection with this suggested invention of Mr. Craggs, and he brought with him a patent specification taken out by Mr. Scott, which I found was dated 1871, and he brought also a report of the Institution of Naval Architects of a paper read in London by Mr. Scott in 1872, bearing almost identically on the subject. Mr. Scott asked me if he might come down to be present at the discussion of this paper. I put the matter before the President, and he was kind enough to invite Mr. Scott to come down and give his views on the paper. He is here to-night, and therefore I will not detain you by saying anything further.

Mr. R. HINCHLIFFE said—Mr. Craggs, in his able paper, has given us a very interesting description of the latest effort to introduce into the construction of mercantile vessels a longitudinal system of framing, or, to speak perhaps more correctly, a system of framing in which longitudinal frames play a more important part than in the usual present-day practice. This is not by any means the first attempt that has been made to bring about such a change; it remains to be seen whether Messrs. Craggs and Isherwood will be able to accomplish what their predecessors have failed to do. The first feature of this system of framing which will appeal to designers of mercantile vessels is the claim which Mr. Craggs makes, that he has been able to satisfy the requirements of the various classification societies and yet effect a saving of 275 tons of structure as compared with the usual methods of construction. Provided the writer of this paper can effect a proportionate saving in other types of vessels he will have established one very strong claim for the universal introduction of his system of framing. It would be interesting if Mr. Craggs could give us the weight of structure he hopes to save in the construction of the shelter deck cargo vessel mentioned in the latter part of his paper.

The main purpose of the framing of a vessel is to form a framework to which we can attach the watertight skin and which will maintain the form of the vessel. If, whilst attaining these objects, certain portions of the framing material can be utilised to give longitudinal strength, an advantage is gained, especially in vessels of large size. The Isherwood system of framing seems to be especially good in this respect.

Given a certain area of shell to support, the system adopted in all systems of framing consists of dividing the surface into a series of panels. If one system of framing is lighter than another, it logically follows that either the panels have been made larger, or the frame of each panel or certain of the panels, has been made lighter. If I have gathered a correct impression from the diagrams presented by Mr. Craggs, the panels in the system he describes are somewhat larger than those adopted in the ordinary transverse system of framing. By placing the largest dimension of the panel horizontally instead of vertically, however, the material is made equally efficient, and possibly more efficient in the case of vessels which are subject to large bending moments.

Given a certain area to support by means of a framework, two methods are available; we can either adopt strong stiffeners widely spaced or weaker stiffeners can be used and closely spaced. The former arrangement generally gives the greater stiffness for a given weight of structure. Both these methods have been adopted in the transverse system of framing, the strong stiffener in the web frame system, and the weaker stiffeners in the deep frame system. The web frame system, it is generally recognised, gives a stiffer framework for a given weight of structure than the deep frame system. This fact notwithstanding, shipowners have leaned to the deep frame system on account of certain practical advantages which need not be discussed. In the method of framing described by Mr. Craggs, the system of strong stiffeners widely spaced, has been adopted, indeed the system might be fairly correctly described as a glorified web frame system, and hence it carries with it certain of the objections essential to this system. It remains to be seen whether shipowners will overlook these drawbacks in return for the other advantages gained.

With regard to the details of construction it is not possible to criticise them to any great extent from the limited information supplied. Considered purely from a theoretical standpoint, however, it at once strikes an observer that, considering each longitudinal frame with its corresponding piece of shell as a continuous girder, it is weakest at the point at which the greatest bending moment will come, *i.e.*, in way of the transverses; the weakness being caused by rivet holes. Brackets worked at these points would serve to strengthen the girder and might permit of the scantling being somewhat reduced. Their introduction would, however, tend to complicate the structure, and they have probably been omitted for this reason.

In Mr. Isherwood's paper, read at the last meeting of the Institute of Naval Architects, he shows that as far as those stresses, whose amount can be approximated to by calculation, are concerned, the system of framing under discussion gives an equal amount of strength, and in many cases more strength than the usual transverse framing. There are, however, certain ship stresses which do not admit of exact mathematical analysis, such as racking, grounding, and docking stresses. Judging by inspection only, it appears somewhat doubtful if this new system of framing is quite so well adopted to meet those stresses as the old, especially in the case of the shelter deck vessel. It may, however, provide all the strength that is necessary, and in this respect a year or two's sea experience will be more convincing than any amount of theorising. I would conclude by expressing a hope that Mr. Craggs will give us another paper upon this subject when more vessels have been built upon this system and tried in service.

Mr. ARCHIBALD HOGG said—I thank Mr. Craggs for giving us this opportunity of discussing his system of framing. I am certain that shipbuilders are very glad to welcome any system which is at least as good as or better than the old one, and is more economical in weight of steel used, and Mr. Craggs's system will be especially welcomed if his claim in large economy and increased strength can be proved.

I have carefully studied Mr. Craggs's description of his system and I find some points in the construction and in the principle to which I would draw attention. We are discussing the "framing" of steamers, and I would repeat Mr. Craggs, in saying that a main point in the principle of construction in his system is the great inclusion of the "plating" as part of the "framing;" by doing this he effects a considerable part of his saving of weight.

I think the old transverse system is not being quite blindly followed, neither is it maintained simply because it was used in wood shipbuilding. The reason for its use is that it is a convenient and an economical way to use the weight of steel; it is a principle in construction by which, even though there may have been faults in details, the framing by itself and unaided by plating, except where unavoidable, stiffens the bottom and sides and leaves a flat surface for the hold ceiling, sparring or tank tops, without any or the least possible obstruction to the cargo, while Mr. Craggs's system adopts projecting transverses with longitudinals next the shell, deck and double bottom plating, and largely depends on the "plating" for its strength.

The weight of steel framing for either system may be said to be practically the same if they are calculated to do the same work with the same amount of obstruction, without the aid of the plating; but Mr. Craggs's framing on this basis will not be as strong as the old one, nor nearly so. One of Mr. Craggs's claims is that he is building a tanker of 355 feet length, constructed with his system of framing, which framing weighs only about two-thirds of the weight it would have if it (keeping same size of ship) had been built with the old system of framing; it is actually less by about 275 tons net weight or, say, 300 tons gross. The very fact of this great saving is apt to arouse one's suspicions of the strength of the framing and to make one afraid of serious trouble arising the moment the strains are started in a seaway.

Mr. Craggs's system of framing is composed of bulkheads used as transverse stiffeners and large transverses supporting small longitudinals and including assumed services to be rendered by the shell tank top and deck plating. I have no details, so I cannot judge whether the bulkheads are properly constructed, but they may easily act as transverse stiffening. The transverses, however, I consider are not properly constructed, because at least one flange of the girder is entirly cut away at every longitudinal, so that they have, say, only half the strength they might have or are calculated to have; both flanges are actually cut away at certain parts. Of course, Mr. Craggs calculates on the shell or other plating acting as flanges of the girders. I ask him to explain why he can reckon on the plating acting thus for his transverses and for his longitudinals and at the same time reckon on it for the main structural strength, as well as for the resisting of the water pressure between the frames; the stress due to the latter pressure will be 40 to 50 per cent. greater in Mr. Craggs's system than it is in the old. The plating is not nearly strong enough to do all this work safely. It is wrong to reckon on material doing work in two directions at the same time, especially when it is fully worked up in one direction. In ship practice a small fraction may be available, but it is not proper or safe construction to reckon on it. If you take a piece of steel, 1 inch area, and pull 30 tons in one direction it will break, leaving nothing to get a hold of to pull in a right-angled direction. Mr. Craggs reckons on the shell plating as active and entire flanges of his transverses, but to do so he ought to increase the thickness of the plating, and I ask him to say what he has done in this respect. The large weight of steel saved seems quite proof that he has not increased the plating, in fact I understand he rather proposes to reduce it, so that with the plating doing so much work the girders proper ought to be constructed so that they can be relied on to do the whole work, but these being cut at the longitudinals, are much too weak for that purpose. Thus we have here what looks like a serious reduction in the calculated strength of this steamer's framing. To begin with, the framing is about two-thirds of the weight one would expect it to be and the steel framing that is there, with broken flanged transverses, may be put down as being, at the most, say about half as strong as it should be.

I would like Mr. Craggs to tell us what is the stress per square inch, in tons, on the midship bottom plating due to water pressure, assuming that his ship is at rest on a long wave with the crest of wave amidships.

Mr. Craggs maintains the longitudinal strength of his frames, floors and beams, while passing each transverse bulkhead by bringing up the riveted attachment to the strength of the member attached, all longitudinals being cut at the bulkheads (this is something new in "butt" shifting). He claims that this improves the distribution of the strains around the margin of the bulkheads, he claims a saving in lugs and knees, including what he terms the enormous connecting knees of the stringers and keelsons, and on the top of this he claims a reduction in the structural stress form about 10 tons to about 7 tons per square inch. I hold no brief from Lloyds, but I believe it is not their intention that a steamer 355 feet long should have a stress of 10 tons. Mr. Craggs includes his longitudinals in the structural strength, but these have already more than their own work to do, and especially so, if you neglect the plating, and Mr. Craggs says their scantlings are designed to do that only; thus they are not made with the view of doing any more, so that Mr. Craggs has no right to include them in the structural strength, and thus, when you omit them from the structural strength, the stress remains as it was and so he does not reduce the stress. With the view of including the longitudinals in the structural strength he continues their strength at the bulkheads, and note, only their strength and no more; thus he admits having fitted no extra knees to distribute the effect of the bulkhead, so that he cannot claim to save that which he only omits to fit and which he ought to fit because they are necessary.

These tranverses of Mr. Craggs are extra strong rings supporting all the plating, and they create strains around their margins, similar to those at the bulkheads, yet Mr. Craggs fits no brackets to distribute the effects; he does not even attach his longitudinals to the transverse. I would like to know why he omits to fit these attachments. The fact is that his steamer should really have a greater stress than the 10 tons, because the framing is so much weakened by cutting the flanges of the transverses; thus none of these claims seem to hold.

I fail to see any tie pillars in the oil tanks and no preparation for any. I wish Mr. Craggs to explain what he fits as compensation for their admission; his transverses are weak, so of course they cannot act as tie pillars.

The longitudinal frames are graduated in size according to the water pressure they are required to stand. This is a new principle and does not provide extra strength for the larger strains due to the larger size vessels, which must result in weakness.

I think Mr. Craggs's system will give a very weakly stiffened flat of bottom in general cargo steamers with double bottoms. With the old transverse floors every 2 feet apart, each supported on side frames, the strength is not excessive, yet his are about six feet apart or more and they get little or no support from the long longitudinals; these transverses should have heavy top and bottom flanges, but Mr. Craggs's have no flanges at all, and what makes it worse is the fact that the "intermediate" transverses in Mr. Craggs's system have no webs or brackets on the ship's side to take the reaction there, so that these lose most of their strength; they are almost unsupported girders.

I understand Mr. Craggs to say that he continues his transverse plates through the main deck stringer plates and fits no compensation, because he calculates that the ship has ample longitudinal steel; in fact he cuts away about 5 feet of one of the main factors in the longitudinal strength. I think it is quite necessary to fit compensation.

Mr. Craggs points to what he terms the weak point of the old transverse system, but I think he is wrong; it is not the framing that is weak if the plating buckles, it is the plating that requires thickening. The old transverse system may have minor faults, but the minutest study in detail will not find a "great" mass of useless weight worked up, especially in double bottom steamers. The large full formed steamers of to-day require more. I believe even Mr. Craggs will not say they are too strong. If the framing was so bad as to have one-third more weight than is necessary it would be apparent at the first glance and would not require the minutest study in detail to find it, as Mr. Craggs says.

I ask Mr. Craggs, if Lloyds, British Corporation and Veritas have approved of the construction and scantlings as being fitted in his tanker and general cargo steamers which he illustrated. He does not say so in his paper, but if they have approved I think the fact should be recorded in Mr. Craggs's reply.

It would be interesting to know if Mr. Craggs's firm gives the purchasers of these steamers a guarantee of strength. I have no fault to find with the principle of longitudinals and transverses, provided you properly construct them with the necessary amount of material, but having done so I am afraid the old weights will not be very much affected. The transverses would be an obstruction when stowing dry cargoes, more so in an oil tanker, and there need be no such obstruction with the old system.

To sum up my remarks, I consider Mr. Craggs's details of construction are seriously inadequate. I consider his principle of including the plating, without increasing its thickness, as forming nearly half the framing strength, is an entirely erroneous one. I consider that it is wrong to calculate on the plating as part of framing in any way except where it is quite unavoidable. I think it would greatly add to the usefulness of this paper if Mr. Craggs will follow it up with another after these steamers have been thoroughly tried at sea.

Mr. JAMES E. SCOTT, London (by permission of the President), said—I am very much indebted to you indeed for the kind way in which you have received me here, and, as the President said at the beginning of the meeting, we should confine this discussion to the framing of vessels, and not to exploit any one patent over another. To be done with the matter of strong transverses, Scott *versus* Isherwood, I patented this inside transverse tie frame in 1871, and I have nothing more to add to it; that is my last word. As to Mr. Craggs's paper regarding Scott-Russell with his longitudinally built ships, as one gentleman remarked he did not only build the "Great Eastern," but the "Annette," and I added the "King Koffee" and the "Sourabaza" in 1876-1877. So far as getting at the tranverses strength is concerned, I might read you some of the remarks of Mr. Scott-Russell in the discussion on my paper read before the Institution of Naval Architects on March 22nd, 1872. He said:—"His longitudinals are certainly much improved by putting the transverse frames on the inside, because they are all steadied. . . . . . I think with his internal framing, which is an approximation to an inside lining or a second skin, only much cheaper and lighter, I should be disposed to leave out a great deal of the intercostal filling; and my reason is this, I think the skin would do, and be strong enough without the intercostal filling." I left out the intercostals above the bilge, so that this inside transverse tie frame that I was fortunate enough to bring into use, Scott-Russell points out, took the place of his inside lining or second skin. The next point I would call attention to in Mr. Craggs's paper is this. He says the expense of intercostals in an ordinary deep frame ship is enormous. What does he do in these strong transverses that he proposes? He proposes to make every one of these intercostal up to the decks, with no connection whatever to the longitudinal frames, as Mr. De Rusett pointed out, neither in the deck beams, nor in the longitudinal frames in the bottom, nor in the deep floor plates that he has given us nearer the centre line—there is no connection in any shape or form. As Mr. Isherwood, in his paper upon it, said—" the transverses are slotted to receive the longitudinal frames "—a frame 12 inches deep, without any attachment to the inside frame is sure to work; and the first thing he will have to do is to attach these longitudinals to these transverse frames. The next point is broken stowage. What really sounded the death knell to the web frames and those extraordinary fastenings or stiffenings that were introduced into cargo steamers was the broken stowage. Now here Mr. Craggs tells us he is going to put in these strong transverse frames projecting into the hold. There is no owner going to stand that sort of thing. You take away the capacity of your ship at once for any general cargo except grain in bulk. Then as to the shape. Mr. Craggs says: " The vessel has been brought into fair shape by templating the longitudinals and the brackets attaching them to the bulkheads." Will any practical man tell me he will build a ship by setting up the bulkheads and putting the longitudinals between those bulkheads? Sometimes we have them 50 or 60 feet apart. How are we going to keep these longitudinals in place? Simply because they are fastened to the bulkheads? It is nonsense. That was the origin of the tranverse frame that we have to-day, and was handed down to us from our forefathers. That was the object of the transverse frame. It was to give the form to the ship, and that can only be done by setting up the transverses in the very first part of the construction of the vessel. In Plate XLV., as Mr. De Rusett pointed out, there is no connection at all. There is simply a slotting out of the transverse to receive the longitudinal, and thus, as another gentleman pointed out, the connection is left to the covering plate of the outside shell. The outside shell has quite enough to do, and especially at that point where he has riddled it with rivet holes. I wish Mr. Craggs had gone a little further and given us some figures as to the relative strength of longitudinal *versus* transverse. That is what I think we as scientific shipbuilders want to come at. When I had the honour of reading a paper before the Naval Architects in 1872, I took out some figures as to the relative strength of these vessels, and I found that the cross-section of transversely-framed vessels is to longitudinally-framed vessels as 12 to 15, and that the resistance to longitudinal bending is as 9 to 10, and that the resistance to horizontal bending is as 9 to 12. That is, vessels of exactly the same weight, not taking anything off for the extra strength given to the longitudinal ship, but taking the same weight as a whole. That is equal to about 15 per cent. more strength longitudinally in longitudinally-framed ships, which would enable a lot of our ships to do more service. Suppose a vessel to have a certain longitudinal strength, then take the difference between transverse and longitudinally-framed ships; this would make a difference of 11·6 lbs. per foot, which equals 105 tons in a vessel of 900 tons weight—that is, the total weight of material or an exact total saving of 11½ per cent. on the gross weight of the ship. It may be thought that there was too little transverse strength in the cross-sections of the keelsons put transversely, but you will find you have a superabundance of transverse strength by transferring the usual keelsons material to the wide-spaced transverses. The greatest longitudinal thrust was reduced from 4·24 tons on the square inch in the transversely-framed ships to 3·65 tons in the longitudinally-framed ships—nearly a ton on the square inch—that is in vessels of exactly the same gross weight. The greatest bending strain in a transverse ship classed to Lloyd's was 5·52 tons per square inch, while if the framing and flooring material was applied longitudinally the vessel would only have 4·39 tons on the square inch. So you see it is actually more than a ton difference on the square inch. Another point I would bring to your notice. In this small vessel that I took out, well, comparatively small, only 300 feet by 34 feet by 29 feet moulded, the deduction for rivet holes in the transversely-framed ship was 108 inches. The deduction for rivet holes in connecting the longitudinal frames to the skin was only 66 inches, leaving 40 inches to the good in the longitudinally-framed ship; but if Mr. Craggs is going to riddle the ship every 12 feet with a double row of closely spaced rivet holes from keel to upper deck, he is missing all the advantages of the longitudinal system. There is nothing stronger than the weakest part of a chain, therefore there is nothing stronger than the weakest part of his transverse section of skin plating. I am pleased this longitudinal framing is being now pushed, and I hope that we will get lots of shipowners bold enough to come forward, as Messrs. Lennard have, and give orders for longitudinally-built ships, and that will induce other builders to come in and gain the advantage that can be reaped from this longitudinal system.

Mr. JOSEPH W. ISHERWOOD said—I had studied Mr. Craggs's paper with great interest, since it touches on several types of ships, the construction of which I am intimately acquainted with. It is only on reading such a paper as the one under discussion that we realise the enormous strides that have been made in ship construction during the last quarter of a century. North-East Coast ship builders and shipowners are in my opinion to be congratulated on the part they have taken in the various developments in spite of the opposition they have had from time to time to face.

Mr. Craggs remarks that the influence in the practice of wooden ships is still felt at the present time. Fortunately, this influence is gradually disappearing, along with the influence of those who learnt their shipbuilding in the wooden days, and with those who found themselves unable to adapt their methods to the advance of science and knowledge. That this influence is undoubtedly felt yet, however, is shown by section 41, paragraph 13, of Lloyd's rules, which to my mind demand extortionate compensation for the omission of the wood middle deck, although the middle deck beams and stringers are retained, and the omission of the wooden platform does not affect the transverse strength to any greater degree than would the removal of a few bundles of firewood. I would respectfully suggest that our able representatives on Lloyd's Technical Committee should take up this matter and put an end to this particular form of penalty for omitting a platform which an owner may not require, as if he does not require this platform, why should he be robbed of the deadweight saved, which is most valuable since it is obtained without increasing the draft?

As previously mentioned, the North-East Coast has been to the fore in all developments that have taken place in ship construction during the last quarter of a century. As is well known, the North-East Coast was the home of the well decker, a very useful type you are all familiar with. A development from the well decker was the part awning deck steamer, also a North-East Coast production.

These vessels did very good work in their days and were found to be very suitable and economical cargo carriers. The author of the paper remarks that some time ago it was a serious consideration to leave a tier of beams out of a vessel 24 feet in depth. In the year 1895 my old firm, Messrs. Furness, Withy and Co., of Hartlepool, had the courage of their convictions, and put their foot down in a very decided manner, and in face of great opposition, by building a single-deck steamer without hold beams, which was beyond the mystic depth of 24 feet. It is difficult to say how much we are all indebted to the courage and foresight of our respected representative on Lloyd's Technical Committee in taking this most important step, and to the British Corporation Register for their total disregard of antiquated conventionality.

Messrs. Doxford had then also introduced their well known turret ship. We are all aware of the huge success that has attended Messrs. Doxford in their enterprise, again in the face of opposition which events have proved to be unreasonable, and I think we should be proud of the fact that we have such a courageous firm in our midst. Messrs. Dixon have also developed an admirable type of steamer which is worthy of the success that has attended it. If Mr. Craggs had included in his paper the consideration of this latter type of steamer, I am sure that he would at once have agreed that the upper part of the vessel is not a compressible structure lengthways. Messrs. Ropner have also made great strides in the development of their well known trunk steamer, where the deck is well supported to resist longitudinal buckling. We have also McGlashan's well known side tank steamer, a type which admirably combines strength and utility. I am sorry Mr. Craggs has not had time to touch on these types of vessels, since they are all interesting in considering such a paper as the framing of ships.

We also have Messrs. Armstrong, Whitworth & Co., whose staff will design anything from a warship to a ferry steamer or ice-breaker. While in regard to the number of oil steamers built they easily hold the record, we must not forget that the oil steamer is also an East Coast production, built up in face of great opposition. I was sorry to hear Mr. Saxton White, however, state that the present structure of a tank steamer had been designed largely as the result of experience based possibly on inadequate knowledge. Whilst I do not wish to decry experience, I will say this, that in every case of a vessel giving trouble, where mathematical investigation has been subsequently made, it has been proved that failure should have been expected. How much better if the mathematical investigation had been made beforehand and the design modified accordingly. Mr. White also remarks, "Of course you can do many things in the drawing office, but after all there is such a thing as old-fashioned experience." My experience, though it may not be old-fashioned, has shown that the most successful ships are those that have had the most careful investigation in the drawing office, and I would much prefer to pin my faith on investigation—such as that done in bridge building for instance—than trust to old-fashioned experience. It takes old-fashioned experience a long time, probably accompanied by a long series of failures, to develop wrong into right, whilst a close and careful calculation on sound principles can quickly arrive at reasonably accurate conclusions. I cannot for one moment admit that our great North-East Coast reputation has been built up even largely as a result of experience or we could not have made the huge strides we have as pioneers, and credit should be given to the drawing office staff where it is undoubtedly due.

I trust that I am not taking up too much of your time, but this paper covers so much interesting ground that one could almost write another in commenting on it. It appears to me that Mr. White takes a wrong interpretation of the writer's designation of "weakling" for the intermediate transverse frames in web-framed ships. I took it that he (the writer of the paper) wished to lay emphasis on the fact that the intermediate frames are dependent on the support they obtain from the web frames, through the side stringers, and I cannot agree with Mr. White when he states that there are far too many ships crossing the ocean at present absolutely depending upon these weaklings, as such is not the case, the intermediate frames being so small as to be of very little value without the support obtained from the web frames. Mr. White tells us that he has spoken without studying the matter in detail, and on looking into it carefully I think he will agree that the obstruction in an oil-tank steamer built on the new system is not nearly so serious as in a web-framed vessel where there are deep horizontal plate stringers fitted in association with the web frames. Further, the transverses are not about double the ordinary web frame's width, and I do not think Mr. White would be satisfied with a materially less depth of web frame in an oil-tank steamer built on the ordinary system of the same depth as the vessel made reference to in Mr. Craggs's paper. He probably overlooks the fact that this is by far the deepest single-deck oil steamer ever built, and if built on the ordinary system the web frames would probably require to be of the same depth. The depth moulded of this steamer is 28 feet, and no intermediate deck or hold beams are fitted.

I have already mentioned several of our North-East Coast developments, and fully agree with the writer's remarks in his description of the extraordinary types of framing that resulted from the commercial necessity of dispensing with the mystic steel middle deck. I refer particularly to Plate XXXVIII. of the paper which shows a vessel having both deep frames and web frames in addition to a tier of widely-spaced hold beams in association with a broad stringer plate. This type of vessel is almost exclusively a North-East Coast production. Here we have not much to be proud of. There is no doubt about the strength of these vessels, but it is a most regrettable circumstance that they are carrying hundreds of tons of useless weight about the ocean. I challenge anyone to give a valid reason from a strength point of view for the necessity of fitting both deep frames and web frames. North-East Coast builders are not responsible for the design of this steamer. They shrewdly recognised the demand to meet trade requirements, but the method of compensation was determined by the classification society which classed all such vessels. To put back the weight of the middle deck, in any form whatever, appears to have been the only desideratum apart from any question of strength, and the result is a great blot on British naval architecture and a continual drain upon the already overtaxed owner of such shipping property, to say nothing about the unnecessary initial expenditure.

In my opinion the most simple and efficient form of transverse framing so far devised is that shown in Plate XLI. of the paper, another North-East Coast development. Shipowners who have had trouble with margin attachments will at once realise that this method of framing will overcome their difficulties, and it is to be regretted that more consideration has not been given to Mr. Craggs's proposal to provide a similar attachment to the beam, which would obviously be of great advantage in deep single-deck ships.

Our crowning North-East Coast achievement is that marvellous steamer "Mauretania," the fastest and largest steamer in the be proud of their remarkable exposition of not only what can be done in the drawing office by careful investigation, but what can be done by North-East Coast workmen under skilful direction. Enough I think has been said of North-East Coast development, and it is a pity that encouragement has not been given to the advance in naval architecture which it deserves.

About two years ago an alteration was made in the freeboard tables which almost added a year's production of deadweight carrying capacity at one fell swoop, and which may have in a large measure contributed to the present depression in ship-building. This is experience—bitter experience—and the sooner it is old-fashioned the better. Would it not have been better had the freeboard tables been brought up to date, and kept up to date, by careful investigation from time to time, thus making use of the valuable experience gained. For, after all, what is calculation but a scientific application of knowledge gained from experience. From a strength point of view the freeboard tables are based on a set of rules which are now obsolete. These rules make no provision whatever for dispensing with the third or lower tier of beams in a vessel 24 feet deep, and make no provision for web-frame ships or even deep-frame ships. I would give another instance of lack of encouragement. Although we have been building deep single-deck ships without hold beams or broad stringers since 1895, when Furness, Withy & Co. built the first of these vessels, none of the classification societies have yet made rules for this type of vessel.

It was with great interest I listened to Professor Welch's remarks on the various longitudinal systems of ship construction, but I was somewhat disappointed with Professor Welch. I expected more, from that gentleman, in the nature of a technical criticism—one that would have gone into the strength of the structure and dealt with the new system on technical grounds. I gather from Professor Welch that the weight of the "Great Eastern" compared favourably with the weight of a ship built on the ordinary system. But at that time there were no ships of anything like the dimensions of the "Great Eastern." The "Great Eastern" had plating $\frac{3}{4}$ inch thick. It is a matter for consideration whether we should consider plating $\frac{3}{4}$ inch thick sufficient for a vessel of the same dimensions built on the ordinary system.

Professor WELCH: The authority I quoted was making comparison with ships of smaller size, and said the structure compared favourably with ships built at that time, and was a most satisfactory structure from the point of view of strength.

Mr. ISHERWOOD: At that time the only vessels built on a longitudinal system were the "Annette" and one or two small ships, but certainly there was no ship approaching the dimensions of the "Great Eastern" to make comparison with.

Professor WELCH: There were other ships built. The "Annette" and the two other ships were actually built on the longitudinal system, and a direct comparison could be made with the smaller ships at that time and classed at Lloyd's.

Mr. ISHERWOOD: Mr. Hinchliffe makes some interesting remarks, and he touches on the stresses which cannot be calculated. Docking stresses, I think, are stresses that could be very readily calculated. Racking is a doubtful stress to estimate, but grounding stresses we certainly cannot calculate beforehand. Mr. Hogg also makes some remarks with regard to the strength of the framing structure. In a deep framed ship the shell plating forms part of the transverse girder, and that, I think, is one reason why deep-framed ships have been so successful.

Mr. N. H. BURGESS said--I consider Mr. Craggs's paper one of the most interesting that has been before the Institution for some years, but it might have been more so, if the main scantlings had been given for the new system of framing. It might be interesting to several members present to know that after obtaining the scantlings of Mr. Craggs's 355 feet oil steamer from Mr. Isherwood's paper to the Institute of Naval Architects a detailed estimate of the weight of steel in that vessel showed a saving of 275 tons, thus proving to be correct that which seems to be a matter of doubt with several people who have seen the construction of the ship, also others who have a considerable experience with ships' weights. This saving represents roughly about 12 per cent. on a vessel built to + 100 A1 Lloyd's. It is well known that a saving of steel can be effected in transversely framed vessels when built to a certain classification society's requirements, which apparently do their work quite as satisfactorily as those built to more exacting rules, the saving being often as much as 10 per cent., which all goes to prove that with a little scheming and careful arrangement of the several component parts of the structure a considerable saving can be effected. Especially is this the case with Mr. Craggs's reducing of the scantlings to suit the varying water pressures from the keel upwards, his system of construction lending itself very simply for this reduction. There is often a great difficulty in getting a classification society to pass a scheme of scantlings which would produce a saving on the weight of steel material. Experience teaches us that where a classification society has conceded anything, that concession is generally counterbalanced by an increase in the scantlings elsewhere, and I congratulate Mr. Craggs that he has been able to produce such a scheme of scantlings so as to pass the chief classification society's criticism and effect a saving of 12 per cent. That the structural strength is quite sufficient gives a good field for debate amongst the older members of the Institution. In the meantime I pin my faith on the experience and judgment of the several classification societies.

In conclusion, I thank Mr. Craggs for his interesting paper.

The SECRETARY submitted the following communications:—

May 14th, 1908.

DEAR MR. DUCKITT,

I only venture to comply with the President's request for some remarks on Mr. Craggs's paper, because I have myself been very much interested in the question of the most efficient system of framing in ships and have some time ago read a couple of papers dealing with the same subject as the communication under consideration but from a somewhat different point of view.

I am sure the thanks of all interested in shipbuilding are due to Mr. Craggs, in the first instance, as the reader of this paper and in the second instance to him as the builder and to the owners who have had the courage of their convictions and made it possible for such radical changes in the method of construction as they advocate to be put to the test of actual experience, and everyone will wish the builders and owners the success in their venture which they deserve.

I quite agree with Mr. Craggs as to the practice of wood shipbuilding having had too great an influence on iron and steel ship construction, an influence from which we have not yet by any means emancipated ourselves. Such radical structural modifications as practised by Messrs. Craggs will, however, bring us nearer the time when we shall be quite rid of any undesirable influence of wood construction, but I do not go so far as to say we shall then be entirely without transverse frames.

With steel as the material, endless varieties of construction are possible, many of which may be of practically equal structural efficiency although differing widely in character and cost of production, but in practice there has not, so far, been great changes in the general disposition of the material. This latter fact could be interpreted as the best system having already been established, but I agree with the author in believing that the evolution is not quite complete yet or the general type of construction has not become stable in all respects.

An examination of this question must necessarily in a great measure be theoretical. In transferring the experience we have gained by existing structures to new and untried arrangements of material mathematical methods must be employed. Certain points can be examined by the mere span and moment of inertia calculation, but this method fails where there are radical changes in the structural arrangements and must therefore be employed with extreme caution. When there are considerable differences in construction between the structures compared it is necessary to look at the question from a broader point of view and to employ more general methods which we may or may not be able to put into exact complex mathematical formulæ.

The problem of the general efficiency of the various systems of framing is therefore a very difficult question, which cannot be settled categorically. What will be the most efficient construction under certain conditions and for certain sizes and types of vessel will not be so for other sizes, types, or conditions. For a certain depth of webs and a certain depth of deep frames the web system may be the more economical structurally. With deeper and thinner frames the deep-frame arrangement may be more efficient. The result of a comparison depends, therefore, Generally speaking, it may be said that when the designs are reasonably sound for the various systems compared there will not be any great difference in their relative efficiency. A good and strong ship can be constructed either way. It is not necessary to adopt the transverse system of framing for the sake of getting transverse strength, because that can be quite well obtained by the longitudinal system, and on the other hand it is not necessary to adopt the longitudinal system for the sake of obtaining longitudinal strength, because that can also be easily obtained by the transverse system. The question is largely one of depth of girders *versus* hold obstruction. When deep girders can be used economy of material may always be effected in whichever direction the parts are arranged, but when the important point is unobstructed hold space, a uniform depth of girders is essential and that is only obtainable with a transverse arrangement.

With regard to the stringers in vessels with deep frames I always felt very strongly that the huge four angles and plate girders were useless. The gradual reduction to two bulb angles, two angles and a single plain angle have been slow but sure steps in the right direction. The practical reappearance of this longitudinal material in the shape of girders under the deck beams has also been an improvement in the efficiency of the transverse arrangement, but against pure buckling tendencies the close spaced fore and aft disposition of the beams is certainly the more efficient.

Mr. Craggs mentions the question of stress at gunwale and factors of safety. I think it is somewhat misleading to speak of factors of safety in connection with the stresses on ships, because they cannot here have the meaning usually attached to such figures. Their use presupposes the exact estimate of the ordinary stresses, and this is, I fear, impossible when we are dealing with sea-going ships. The calculations are here necessarily based on hypothetical conditions, and if our stress comes out high and the factor of safety consequently small it may only be because our assumptions have been too severe. It is really only possible to use the stress estimates, both longitudinal and transverse ones, as figures of comparison, and even as such they have to be used with considerable discretion where the conditions are not very similar.

It is interesting to look back on the history of longitudinal ship construction, which commenced as far back as 1834. Quite a number of vessels were built on this principle by Scott-Russell, at least four, namely, the "Annette," "Baron Osy," "Der Preusse" and "El Rey Jaymes I." being classed in Lloyd's Register. With regard to their construction, I would like to point out that Scott-Russell did attach the bulkheads to the shell plating, and thus incorporated the latter in the transverse strength. He states in his work on Naval Architecture: "The rigidity produced by the bulkheads must not be imparted to the skin, or it will there be seriously crippled; and yet with all this the bulkhead and the skin must be thoroughly united, incorporated, and made watertight." What he did insist upon was that the longitudinal girders should be continuous, and if they are to be relied upon for their full amount of longitudinal strength, I think he was wise in so doing. The bulkheads in the above mentioned vessels were attached by double angles to a transverse foundation plate on the top of the longitudinals and the intervening spaces below were filled in by intercostal plates attached also by double angles at top and bottom.

The so-called partial bulkheads, being really only intercostal girders between the longitudinals, were also attached to the shell plating in sea-going ships. This attachment is, however, not necessarily required in small vessels, and it was not adopted in a couple of shallow draught vessels built on the longitudinal system by Messrs. Randolph, Elder & Co. In the "Great Eastern" there were also very few transverse intercostal girders, but the two skins, the longitudinal bulkheads and her form rendered them unnecessary in her case, and it is to Brunel's and Scott-Russell's great credit that they realized they could safely be dispensed with.

I would recommend anyone interested in this question of longitudinal construction to read Mr. John's paper on "Cellular Construction," read at the Institution of Naval Architects, 1880. It concluded the previous discussion on the subject which had then been going on since 1860.

It is to be hoped that the present discussion will be as interesting as the previous one, but that it will be of briefer duration owing to the undoubted superiority of the new longitudinal system over its predecessors.

Yours faithfully,

J. BRUHN.

May 18*th*, 1908.

DEAR MR. DUCKITT,

In describing the method of framing re-introduced by Mr. Isherwood, Mr. Craggs gives no figures illustrating the relative value of the system as compared to the ordinary method from the point of view of strength. I may, therefore, be excused for referring to a paper read by Mr. Isherwood at the spring meetings of the Institution of Naval Architects in April, in which a comparison is made between this system and the ordinary system of construction, of the longitudinal stresses obtained by the usual method of calculating these, *i.e*, assuming the loaded vessel on a wave of her own length, showing an advantage of 18½ per cent. in favour of Isherwood's system. So far these figures seem to be correct, but the method of calculating for water pressure does not appear to take any account of local strength. For instance, the Isherwood ship has longitudinals spaced 29 inches apart, and transverses 10 feet apart, giving a rectangle 120 inches by 29 inches, equal to 3,480 square inches, while by Lloyd's rules a vessel of the same size and general arrangement would have longitudinal stringers spaced about 5 feet apart, and transverse frames spaced 25 inches apart, giving a rectangle of 60 inches by 25 inches, equal to 1,500 square inches. Thus it would seem the Isherwood vessel has more than double the unsupported area of shell plating, and so far from having any compensation for this the thickness of shell is $\frac{1}{20}$ of an inch less.

In Lloyd's rules there is a note to Table S. 1, for the spacing of frames, to the effect that "wider spacing than the above may be adopted, provided the framing and plating be increased to the satisfaction of the committee." It is difficult to reconcile this requirement with a reduction in the thickness of shell plating in the Isherwood ship; on the contrary, to be consistent, the rule would involve an increase.

With regard to the oil ship now building, it would be interesting to know how the tonnage compares with an ordinary framed vessel. The depth for tonnage, if taken to the inside of the bottom longitudinal frames, which are only about half the depth of Lloyd's ordinary floors, would mean a very considerable addition to the tonnage under deck, and in a vessel carrying oil in bulk a loss of this kind has no compensation to the owner.

As to the system generally, the weak points appear to be the want of homogeniety in framing material, too large areas of shell plating unsupported, and also, for general cargo vessels, the obstruction in holds and 'tween decks of comparatively close spaced deep webs. While I am greatly in favour of a redistribution of the framing material in ships and would welcome the adoption of any system which would be an improvement on the present one, I can only conclude that if this system in the form in which it is put before us, proves satisfactory, then the weight of the framing material now in general use, as required by the classification societies, is excessive.

Yours faithfully,
J. L. Twaddell.

MR. E. HALL CRAGGS' REPLY.

Mr. E. Hall Craggs, in reply to the discussion, said—I must acknowledge with thanks the contributions that have been made to this discussion, several of which give evidence of very careful thought on the matter of the paper and contain valuable criticism. It will probably be convenient if I reply to the various speakers in the order in which they have joined in the discussion.

On looking over Mr. Saxton White's remarks, I find that Mr. Isherwood has dealt rather fully with some of the points brought forward, so it is unnecessary to go over the ground again. I would specially thank Mr. White for the kindly spirit in which he has given his contribution. He has made a strong point of strengthening in the way of bulkheads in oil vessels, and he has told us how his experience of the ordinary system (which has been considerable and to which we must give weight) has led to the increasing of the knees where stringers are attached to the bulkheads. I feel that Mr. White was justified in dealing with the position which came before him by increasing the knees and other attachments, but I think he could have done better still by going further into the matter, and endeavouring to discover the reason of the weakness that led him to increase the knees. A careful examination of the system of framing of the ordinary transverse oil steamer with the scantlings as usually accepted in the past by the Classification Societies, has brought out the important fact that the web frames are not generally of sufficient depth to do the work required of them, and consequently when severe stresses arise, and especially during testing, these web frames have to fall back upon the stringers for support. These stringers, therefore, must be considered as girders under these conditions between the bulkheads, and a very short calculation will show that the stresses on the riveting through the bulkhead plating attaching the knees of the stringers thereto must have been very serious, and the wonder is that more damage has not occurred. It would appear, therefore, that a better method of improving the attachments at bulkheads would have been to have gone to the root of the matter and substantially increased the webs, and so relieved the riveting at the bulkhead attachments of the excessive strain. I might incidentally remark here that my own firm has by preference adopted this latter course of increasing the webs, and this was the result of investigating the strength on the lines indicated. In regard to the value of investigation in working out the strength of vessels, I feel very strongly that it is impossible to attach too much importance to this. In doing this, however, I do not wish to be misunderstood as to my estimate of the value of experience, as this is equally great. What I would, however, beg our members, and especially the younger members, to bear in mind is that while attaching full weight to experience, the question of calculation must in no way be separated from the guidance of experience. After all, it must be admitted that calculation is but the formula of experience. On closer reference to the text of my paper, Mr. White will find that he has not correctly followed my allusion to the well known web frame system. I have not described the intermediate frames in the complete web frame vessel as "weaklings." I described how the removal of a deck or a tier of beams with wide stringers in a lower hold would hypothetically leave the frames as "weaklings," until, by means of webs and several intercostal stringers depending on the webs, the necessary support was restored. I did this to emphasise the importance of the riveted attachments of these webs to the shell and at the margin plate, and sharing Mr. White's view I said that "web frame ships in their day did good service and very little fault could be found with them, etc." I followed this line of argument out further in order to clear up if possible the anomaly that existed in vessels where the web frame and deep frame principles were combined, and on closer consideration I feel sure that Mr. White's sentiment in favour of the ordinary frame should be more than satisfied when I went on to show my respect for such a useful member of ship construction by offering to accept it even in preference to a deep frame, when proper support by means of webs of necessary strength combined with intercostal stringers was already present, and I am happy to think this opportunity has been given me by Mr. White to shew how closely we are in agreement on this point.

Referring to the new system, Mr. White with other speakers, has called attention to the possible obstruction caused by transverses in the holds. The removal, however, of the tank side knees, which now in large vessels extend a considerable distance above the level of the tank top, and also of one or more tiers of beam knees and of the side stringers more than compensates for this in vessels of the same dimensions. In the case of the tanker possibly carrying ordinary cargo, Mr. Isherwood has pointed out that the vertical obstruction of the webs is really very slight compared with the horizontal obstruction caused by the deep stringers called for in the transverse oil steamer and the several large knees required at each of the four corners of the tanks, besides which the webs should be of practically the size shewn in tanks of equal depth if the same transverse strength is provided for.

In regard to the justification of economy in weight, we now have ample proof of this in the remarkable facility with which the tanks have passed the pressure test notwithstanding the unusual depth of the tanks and the proportionately greater pressure resulting therefrom.

I must next thank the President for his few kind remarks and for his endeavours to keep the discussion on technical lines, and I shall do my best in my reply to adhere to his ruling, and therefore I shall pass over all observations directed to the merits of patents as I do not think they come within the scope of our *Transactions*.

In reply to Mr. De Rusett, I quite agree that in the new system of framing, facilities are offered for hydraulic riveting that have not been realisable before, and I feel that Mr. de Rusett is well able to speak as an authority on this subject. I am glad to have Mr. De Rusett's support in regard to the advantages of the system in resisting severe buckling strains, and I also understand he has examined the strength of the double bottom, and considers that it is satisfactory, provided connections are fitted attaching the longitudinals to the transverses, which is the case. Mr. De Rusett, however, questions the transverse strength at the tank side, assuming in error connection is by the usual lugs and gusset plate. On referring again to my paper, however, it will be found that the transverse member is continuous at this part, and that the tank side is fitted intercostally. I feel sure that Mr. De Rusett will recognise on further investigation the solidity of the structure so obtained. In reply to his query as to the attachment of the longitudinals to the transverses, etc., these have been provided throughout the tanker except in the deck erections, and in the shelter deck steamer they are being fitted throughout, although in the diagram given they are not shewn, as I particularly desired an expression of your opinions on this point.

I cannot quite follow Mr. De Rusett's remarks as to Plate XL., as in the "Mauretania" the reverse frame proper is not divided from the frame, and both run down to the tank side bar, and the gusset angles are carried out from the tank side to scarph upon the channel frame, but all will agree that this gives a most efficient arrangement.

In reply to Professor Welch I explained in the early part of my paper how I had been constrained to curtail my remarks on the historical side of the framing of vessels in favour of the technical side as far as it came within my own experience. One of my reasons for so doing was that I hoped to bring the discussion on to technical grounds, and therein I had the strong support of our President, and I much regret that I have not been able to induce Professor Welch to bring his valuable technical knowledge and experience to bear upon this discussion. He has implied that it is his desire to make good my omission, but with great diffidence I must venture to prove that the history he has supplied to the discussion cannot be taken without question.

In the course of the discussion, Mr. Hinchliffe has emphasised the difference between a longitudinally framed ship and a ship framed on a system in which longitudinals form an important part, and it is most necessary in considering the history of framing of vessels to keep the distinction clearly in view.

I did not refer to the "Great Eastern" as the one experiment made upon the longitudinal system enunciated by Scott Russell in the *Transactions* of the Naval Architects, volume 3, as this enunciation was made some time after the "Great Eastern" was built. The reference was, of course, to the "Annette" and this reference I simply take from Scott Russell himself. It was not my intention in any way to suggest that longitudinals had not been used in several vessels built by Scott Russell, and in alluding to the "Great Eastern" I think the words I used, "modified longitudinal system," are correct, as it must be borne in mind that the decks for the greater part were framed transversely. Professor Welch is not correct when he says that the two vessels built by Mr. Jensen of Dantzic, were similar to the "Annette." These two vessels, while shewing strongly the influence of Scott Russell, mark a very decided retrograde step in the use of longitudinal frames, and it must be noticed that the deck is framed entirely transversely, and that also the whole of the vessel aft of the engine room is on the ordinary transverse system, and that a large part of the bottom of the vessel is framed on what may strictly be termed a modified transverse system.

There is humour in Professor Welch's suggestion that Mr. Isherwood and myself have found most of our best ideas stolen by the ancients, but I would assure him that neither of us have felt the slightest cause for complaint. I took the trouble in my paper to point out how in my opinion the framing of vessels had drifted for many years in the wrong direction, in fact ever since the influence of wooden shipbuilding was predominant at the commencement of iron shipbuilding. The future alone can shew whether our attempt to take shipbuilders, including my friend Professor Welch, back for a fresh start from that point where we parted company with the ancients, and in my humble opinion began to drift in the wrong direction, is to be justified or not.

I pass from Professor Welch's description of the method of framing some of these vessels, as it does not differ in any material respect from my own reference, but would point out that the distance between the bulkheads of about 40 feet was merely incidental and not a fixed distance. Scott Russell, in stating his longitudinal system, says that the number of bulkheads in a ship is to be determined by dividing the length by the beam.

Professor Welch says that I have advanced a theory for the failure to introduce longitudinal framing, viz., want of direct connection at bulkheads to shell. I must ask to be allowed to correct this statement very decisively as I have advanced no such theory. On referring to my paper it will be found I said, as regards Scott Russell, that the underlying error of his attempt was surely contained in his method of endeavouring to secure his transverse strength. I then went on to give one instance which I thought shewed his failure to master the problem of transverse strength. I thought this instance was sufficient, but herein I fear I have assumed familiarity with Scott Russell's works and contributions to the *Transactions* of Technical Societies to be greater than evidently is generally the case. To shew my grounds for believing that Scott Russell's failure to secure the general adoption of his system chiefly lay in his methods of providing transverse strength, I think I cannot do better than refer to his own plans and statements wherein he consistently relies on the bulkheads for the main part of his transverse strength. As regards the attachments, in Scott Russell's works, volume i., page 618, he says—"It is a matter of question whether in all ships it would not be desirable to keep most of the bulkheads from touching the skin of the ship, and in longitudinal ships it is quite practicable and convenient though somewhat costly to do so."

I would next allude to the "Great Eastern" as being the most familiar example of Scott Russell's work. This ship was built *practically without transverse floors*, and generally speaking the structural plans shew that the transverse strength did not receive the consideration now found necessary, so much so that a considerable amount of transverse material had to be added, principally in the 'tween decks, after the ship had been in service some time. In particular it will be specially noticed that in the three 'tween decks above the level of the inner skin, with the exception of the partial bulkheads at considerable intervals, the plating which is ¾ inch in thickness *is devoid of all stiffening, either transverse or longitudinal*. In his comments upon Mr. J. E. Scott's paper in 1872 Scott Russell throws considerable light upon the peculiar views he held in regard to transverse strength.

Next as to the fitting of bulkheads, I find that Professor

Welch differs with me, but I must be excused if I prefer to adhere to Scott Russell's own description of the method in which he says he has carried out his system. In his works, volume i., page 368, he clearly states that leakage in the neighbourhood of bulkheads has been the result of fitting the bulkheads too firmly to the shell, and that he prefers to take the longitudinals as intermediaries by which to connect the bulkheads to the skin, obviously introducing, therefore, in place of the continuous riveted attachment right round the bulkhead margin, an intermittent attachment depending upon the spacing of the longitudinals.

Professor Welch is not quite correct either in regard to the bulkhead attachments in the "Great Eastern." Scott Russell admits that in this case for insurance and water ballast purposes the bulkheads were carried to the outer skin with double angle attachments. He doubtless recognised that he could rely on the double skin as compensation for the weakness he feared.

Dr. Bruhn, in his contribution, also refers to the attachment of the bulkheads, and I think the above extracts from Scott Russell's works are sufficient reply to what he says on this same point. I am quite aware that Scott Russell says a watertight bulkhead must be "thoroughly united, incorporated, and made watertight." What I am trying to bring home to our members is the point that what Scott Russell meant by thoroughly uniting and incorporating was something quite different from the meaning now generally accepted in the light of present day experience and investigation, and in fact that Scott Russell's definition of the relation of the transverse strength in combination with the skin of the ship was of an "Athanasian" character, particularly as regards bulkheads.

In reply to Professor Welch's next criticism, I would point out that my remarks in regard to weight were not made in reference to the "Great Eastern" particularly, but in regard to the system adopted in the "Annette," as it was in connection with the "Annette" that Scott Russell made his enunciation on his system of longitudinal framing. In any case, I would point out that I agree with Mr. Isherwood that consideration as regards the weight of the "Great Eastern" does not serve a useful purpose, as there was obviously no contemporary vessel with which to compare the "Great Eastern." Sir William White's remarks on the subject, although interesting historically, are purely academic, and do not appear to fully take into account many important factors, such as the placing of the sets of machinery abreast in modern ships as compared with the fore and after position of the "Great Eastern"; *also the absence of floors in the bottom, and the absence of skin stiffening in the 'tween decks.* In regard to Scott Russell's and Jensen's statements with reference to the weights of their ships relative to the strength, these were made before the proper method of calculating strength was understood, and having in view the enormous reduction of transverse strength which is not allowed for in any way in the calculations, it would appear that no useful inference can be drawn. I believe the modified longitudinal system Professor Welch reminded us of as used in battleships, especially in the double bottom, is the same as I referred to in the third paragraph of my paper.

Mr. Hinchliffe, in his very suggestive and lucid remarks, gives us some very valuable criticisms on the subject. I am quite prepared to accept his first definition of our new system of framing, and I may take it that his second definition is not quite consistent with the first; it is merely an outburst of humour. I would point out, however, that the main objection to the well known web frame system is removed, seeing that the several tiers of intercostal stringers are dispensed with. Mr. Hinchliffe is right when he says that there is a tendency for the weakest part of the longitudinals to be co-existent with the greatest bending moment. The need for brackets, however, is overcome by keeping up the section of the longitudinal and closing up the riveting in the immediate vicinity of the transverse frames. I hardly agree with Mr. Hinchliffe that docking stresses are not, generally speaking, capable of investigation. Professor Jenkins, in several able lectures given in 1887 and 1888 shews how these can be exhaustively considered. Grounding stresses depend so much upon the nature of the ground selected for stranding purposes that such can hardly come within the scope of this paper. When Mr. Hinchliffe mentions racking stresses, I must confess I fail to understand what he means. In the fully rigged wooden sailing ships, where the strakes of planking were separated by caulking, I can understand such stresses in the neighbourhood of the chain plates, but in the case of a steamer, which is a floating girder free to take any position in a frictionless fluid, there does not appear to be any question of racking stresses. Momentary lateral variations in the locus of the centre of buoyancy along the length of the vessel of her various sections, caused by unusual surface unevenness, can easily be shown to be immaterial and not productive of any serious trouble.

Mr. Hinchliffe will be pleased to hear that the tank testing of our oil ship which has been rigorously carried out afforded ample proof of the sufficiency of transverse strength in way of the oil tanks, and it should follow from this that cargo vessels, with the additional advantage of double bottoms, should be at least equally efficient in this respect.

Mr. Hogg's methods of calculating strength are rather difficult to follow, and do not in any way appear to agree with recognised methods. I quite agree with Mr. Hogg when, in describing the weakness of the transverse system, he points out that the plating requires thickening, and I have no doubt that his own experience has led him to this conclusion.

Mr. James E. Scott has given us some excerpts from a paper he read before the Naval Architects in 1872 in reference to longitudinal framing. He points out how in the sides of the ship he used longitudinal framing, and in the decks entirely transverse framing without efficient means of connecting the whole. I therefore do not think it necessary to go further into these proposals, as they were obviously foredoomed to failure.

I must thank Mr. Isherwood for his interesting contribution to the discussion. I hope his suggestions in regard to section 41, paragraph 13, of Lloyd's Rules, will not be allowed to drop. In listening to Mr. Isherwood's remarks on wood middle decks, I was strongly reminded of Scott Russell's words when he indicated that the structural value of such a wooden platform was about the same as that of a carpet.

I thank Mr. Burgess for his short but very interesting contribution. I cannot quite agree with him, however, on one point, and that is that the difference between two classification societies in vessels of the same dimensions on the ordinary system often amounts to 10 per cent. in weight of material. I think he puts this figure altogether too high.

Dealing next with Dr. Bruhn's remarks, I am very glad to have his support in regard to the influence of wood shipbuilding practice. I do not think, however, he does himself justice in his dissertation upon the application of mathematics for comparing the strength of vessels in which the structural arrangements essentially differ; neither do I think he makes his arguments any clearer by the manner in which he confuses stowage efficiency with strength efficiency by endeavouring to consider them at one and the same time. I have already explained how in cases where it is economically possible to supply the same clear length and breadth of unobstructed hold space in any two vessels under consideration, the exact structural arrangement of the obstructions merits no further consideration. The problem is therefore reduced to the strength comparison. Dr. Bruhn, however, does not give us much assistance in this direction, for, after laying down, very properly, that in transferring the experience gained in existing structures to new and untried arrangements of material, mathematical methods must be employed, he proceeds, "This method fails where there are radical changes in the structural arrangements." Amidst such self-contradictory statements he asks us to look on the question from a broader point of view and to employ the more general methods which we may or may not be able to put into mathematical formulæ. Personally, if the broader point of view recommended by Dr. Bruhn can only lead us to such a hopeless attitude of doubt and uncertainty I prefer to retain a method of reliable figures and recognised terms of measurement.

In turning from the consideration of one arrangement of material to another, I do not think it necessary to take fright and run away into vaguity as suggested. A few moments of unbiassed consideration should be sufficient to observe whether the new arrangement of material lends itself in a simpler manner or a more complex manner to mathematical investigation. In the transverse system it is sometimes difficult to really know what part is doing the work, and in cases of failure it has often been known to ascribe to transverse weakness the injury that has been distinctly caused by longitudinal weakness. Moreover, the effective length of every girder in the new system can be found by inspection, and whether its work lies in the transverse or the longitudinal direction is as clear on the drawings as though every part had been labelled, and I would venture to say that as a natural consequence of what I have said, it follows that a more useful and complete investigation can be made as regards riveting.

I have already pointed out that investigation into the strength of the "Isherwood" system has thrown light upon the investigation of oil ships' riveting generally, and I venture to predict that the introduction of the "Isherwood" system will be an incentive rather than a hindrance to classifying bodies to legislate upon sound and well known mathematical principles.

After what I have said we cannot wonder when Dr. Bruhn finds himself confronted with his own inference in the form of a paradox that "it is not necessary to adopt the longitudinal system for the sake of obtaining longitudinal strength." It is impossible to prove such a general statement as this, and in fact the assertion is often incorrect, and in cases that have recently come before my notice, the necessary longitudinal strength is not by any means to be obtained except by the assistance of longitudinal stiffening.

Coming also to the development of vessels of very extreme length, it is obvious that a length of vessel could be safely built on a longitudinal system greater than on the transverse system. Influenced, I presume, by the same inclination to vaguity, Dr. Bruhn objects to my using the term "factor of safety." It has become the fashion among men occupying such positions as Dr. Bruhn, when other people than themselves essay to make calculations in regard to the strength of ships, to point out that all such calculations are purely comparative and that no exact formulæ can be reached. Notwithstanding this, they trust themselves without hesitation to use these methods in order to make the strength calculations for such an enormous departure as the "Mauretania." In other words, they would tell us that the factor of safety of the "Mauretania" is altogether unknown, and the actual stresses in doubt. I have purposely used in a modified and restricted sense the term "factor of safety," because I have strong objections to this kind of vaguity and indefiniteness. I assert most positively that there is an approximate idea among those accustomed to calculate the strength of vessels as to the factor of safety they are aiming at under various assumed and reasonable conditions, and where collapse has occurred investigation has shewn that such factors of safety have not existed, and that if the usual investigation had been made before the ship was built the collapse would not have occurred. As a most important instance, I would refer to the calculations made in the case of the loss of the paddle steamer "Marie" in the Bay of Biscay by Mr. John of Lloyd's Register and given in the *Transactions* of the Naval Architects.

Referring to Mr. Twaddell's written contribution, I am happy to find that he gives the weight of his valued opinion in favour of Mr. Isherwood's calculations of the comparative longitudinal stresses. He raises some question, however, as to the size of frame panel and its ability to withstand water pressure. Mr. Hinchliffe in his remarks has shewn that an increased size of panel is admissible with the greater length in the horizontal direction, and it is not necessary for me to add much to what has been said. I am inclined to think that rather too much attention has been paid by Mr. Twaddell to what he terms "area of unsupported plating," but what might perhaps be more correctly termed dimensions of supporting panel. Besides this, it must be remembered the longitudinal stringers he refers to are not fitted to give local strength to resist water pressure, but are fitted for other reasons. He will observe by reference to Table 86 of Lloyd's Rules that intercostal stringers are fitted in vessels of extreme proportions, clearly shewing that they are required to provide for increased longitudinal strength. Side stringers are fitted in order to prevent the frames from tripping when under stress. It is well known that much thinner plating than is usually fitted in steamers is able to successfully withstand water pressure. I might refer to a notable example in the case of the "Great Eastern," where in the vicinity of the bottom of a vessel of about 30 feet mean draft the supporting frame panel measures *60 feet in length and 6 feet in width* on the skin plating which is substantially thinner than would be required in these days for a vessel of the same dimensions if built on the transverse system, and the seams were only single riveted and the butts double riveted. Mr. Twaddell is not correct in stating that the plating of our new oil steamer is $\frac{1}{20}$ inch less in thickness than required by Lloyd's Rules. At the same time, I am glad to have this opportunity of explaining to Mr. Twaddell that I have stated myself as being in full agreement with Lloyd's Rules that if the frames in the transverse system are placed at wider intervals an addition to the thickness of plating is a necessity to prevent buckling between the frames under longitudinal stress. For water pressure alone the increased thickness is, of course, not necessary, and of this fact Mr. Twaddell has ample proof in his experience gained during the tank testing of a number of oil ships built at his shipyard.

I cannot agree with Mr. Twaddell that the weight of framing material now in general use, that is required by the classification societies, is excessive. In many cases the side frames are unduly stressed, especially at the fore end, where there is a greater length of frame girder than amidships, and the section of material is reduced, and this weakness, as Mr. Twaddell is no doubt aware, has been partly met by the introduction of panting beams and stringer plates, forming serious obstructions, and which are not necessary in the new system.

The PRESIDENT said—I am sure you will all accord Mr. Craggs a most hearty and cordial vote of thanks for having brought this subject before us. It is most interesting, and forms a most valuable contribution to our *Transactions*.

The proposal was carried by acclamation.

CLOSING BUSINESS.

RE-ELECTION OF AUDITORS.

Colonel R. SAXTON WHITE proposed that Messrs. R. W. and J. A. SISSON be re-appointed auditors for the ensuing year.

Professor R. L. WEIGHTON seconded the motion, which was unanimously carried.

ALTERATION OF BYE-LAW 35.

The PRESIDENT, on behalf of the Council, moved an addition in Bye-law No. 35, as follows:—

(*The addition is printed in italics.*)

35.—Copies of papers to be read during any Session will be sent seven days before the date of reading to members who shall have applied to the Secretary for them, in writing, at the commencement of the Session. The discussion on a paper shall not be considered closed on the evening on which it is read, but shall be open for renewal at a subsequent meeting, prior to *or after* the reading of the paper set down for that date.

The proposal was agreed to.

ELECTION OF OFFICERS.

The PRESIDENT announced that the following gentlemen had been elected to fill the vacancies on the Council list, and that they would take office on August 1st, 1908:—

President—Mr. Summers Hunter.

Vice-Presidents—Major George J. Carter, Messrs. Alfred Harrison, and R. Home Muir.

Hon. Treasurer—Mr. G. E. Macarthy (re-elected).

Ordinary Members of Council—Messrs. Cecil T. Adams, John T. Batey, Albert E. Doxford, Andrew Laing, and Harold Thomson.

The Council has elected Col. R. Saxton White to take the place of Mr. Summers Hunter as Vice-President, and Prof. J. J. Welch to take the place of Col. Saxton White as Member of Council.

VOTE OF THANKS TO RETIRING COUNCILLORS.

The PRESIDENT said—I would now like to propose a vote of thanks to those gentlemen who retire from the Council. I assure you that they have worked most laboriously, and done their utmost to forward the interests of the Institution. They have attended regularly, and the Council has benefited very much by their assistance at the various meetings. Therefore I have very great pleasure in proposing that a very hearty vote of thanks be accorded to the retiring Members of Council.

The proposition was carried by acclamation.

PRESIDENT'S CLOSING REMARKS.

The PRESIDENT said—I am glad to say that this session has been a very successful one, and I congratulate you upon it. We have had an increase of something like 80 members, so that our total now is about 1,125. I think you will all admit we have not only had exceedingly good papers, but we have had good attendances and discussions. Last session I had to complain several times about the small attendances, but this session our average has been somewhere about 80. It has ranged from 65 to over 90, and therefore I very sincerely hope, on behalf of my successor, that the attendance will be still further increased next session, because, after all, the success of this or any other Institution depends upon the individual members, and the interest the individual members take in it, and not solely upon your Council or your President, although they do all they can; but it is no encouragement to our members or friends to come and contribute papers if the other members will not take the trouble—if you do not mind my saying so—to come and listen to them and take part in the discussions. This session we have been very fortunate. Therefore I hope, on behalf of my successor, and the Institution generally, that the attendances will be as large, or larger, next session. I would also ask you to induce some of the younger members, and our graduates, to attend. It is quite true they have their own sectional meetings, but there is no earthly reason why they should not come here and take part in our discussion. I am sure we always welcome them, and it often happens that papers are read here which are useful to them, and which have not arrived at the text-book stage. As regards next session, we have very little in prospect at the moment, except that I have every hope that Professor Weighton will give a further contribution upon his research work, and I have every reason to believe that my friend, Professor Welch, who promised me a paper, will give it to my successor. So that during the interim I hope you will think the matter over and get some papers ready for the next session. There is only one other point. The members of this and other engineering institutions having identified themselves with the naval engineer question, and as great general interest is still taken in the matter, I have during my term of office kept you informed of any progress made, and must again report that the solution of this national question still remains blocked by the intense prejudice on the part of a section of the executive branch towards engineers. The action of the Admiralty with regard to naval re-organisation entirely ignores the urgent necessity of improvement in the present engineer branch. They are, however, apparently attempting to assimilate the duties of the present specialist officers of the military branch with those of the new scheme of training who will eventually succeed them, and they seem to be doing this at the expense of naval efficiency. The recent withdrawal of the care and management of gunnery and torpedo machinery from the existing engineer officers and transferring such care, etc., to the gunnery and torpedo lieutenants who have no special mechanical training, has so far only produced inefficiency, and has increased the mechanical complements of various ships, until it still leaves the engineer officers with the ultimate duty of keeping this machinery in efficient repair and of making good the errors of non-mechanical officers.

As yet the Admiralty do not appear to recognize the evident danger of entrusting the officers of the existing engineer branch with great responsibilities and refusing these officers the authority and position which will alone enable them to carry out their various duties with maximum efficiency. The matter has, however, been warmly discussed in the Parliamentary debates in the Navy Estimates which have recently taken place in the House of Commons.

The only effect so far appears to be that some small concessions in pay have been made, which, however, still leave the Admiralty promises of 1902 to be redeemed, and a new scheme of retirement, framed on lines somewhat similar to those governing the retirement of officers of the military branch, has been published. Nothing has, however, yet been stated of the intentions of the Admiralty to reform the status of the existing engineer officers; and to bring them into line with the military position which the young engineer officers now being trained under the new scheme will occupy. This, the most important point in the whole matter, and the very crux of the subject, becomes more pressing as the advent of the officers of the new scheme comes nearer and nearer. The necessity for incorporating the existing engineer branch with the military organization of the Navy has been long realised by the engineering profession and by public opinion, and nothing but the prejudice and opposition of a section of the military branch of the navy officers stop the way.

In replying to the discussions on this important matter which took place on the Navy Estimates' debate recently in the House of Commons, Mr. Robertson, the then Parliamentary Secretary to the Admiralty, in announcing the concessions in pay and retirement to which reference has been previously made, said he did not mention these concessions in order to stave off the much larger question of status. He did not hesitate to express his sympathy with the question, and he admitted that the new condition of things necessitated a reconsideration of the relations between the officers of the existing engineer and military branches of the Navy, and stated that he would report to the Admiralty the strong arguments advanced. Here, then, is an admission of the Parliamentary mouthpiece of the Admiralty of the necessity for the reforms so long advocated, and the engineering institutions of the country will have to continue their exertions until this national question is satisfactorily solved.

The session then closed and the meeting dissolved.

REPORT OF THE WORK OF THE CONSULTATIVE COMMITTEE APPOINTED TO CONFER WITH THE MARINE DEPARTMENT OF THE BOARD OF TRADE, FOR THE YEAR ENDED 5TH MARCH, 1908.

In the last Report which ends with the 5th of March, 1907, the Committee explained the steps which they had taken in connection with the proposal of Mr. Lloyd-George, to form a Grand Committee or several Divisional Committees, to advise the Board of Trade on matters relating to Shipbuilding, Marine Engineering and Shipping.

Since then a General Advisory Committee has been formed by the Board of Trade, and on the nomination of the Institution of Naval Architects, at the request of the Board of Trade, two Naval Architects or Shipbuilders, viz.:—Dr. Elgar and Dr. Inglis were appointed thereon. To the choice of those two gentlemen no objection can of course be taken, but this Committee did take exception to the method of selection, and further, were of opinion that Marine Engineers as well as Naval Architects or Shipbuilders should be represented on the Advisory Committee to the Board of Trade, and that it is desirable that such members of the Advisory Committee should also be members of this Committee, in order that they may be in touch with the Marine Engineering and Shipbuilding Industries and those controlling them.

The Committee accordingly, after very carefully considering the matter, embodied their views briefly in the following resolution, viz.:—

> "The Committee consider it desirable that the three Scientific Institutions in the Country, viz.:—The Institution of Naval Architects, London; The Institution of Engineers and Shipbuilders in Scotland (incorporated), Glasgow; and the North East Coast Institution of Engineers and Shipbuilders, Newcastle-on-Tyne; should be represented on the Advisory Committee of the Board of Trade constituted under section 79 of the Merchant Shipping Act of 1906.

> "That if the gentlemen so appointed are not members of this, the Consultative Committee, arrangements should be made whereby they may become members, and that copies of this Resolution be sent to the three Institutions."

which they sent to the three Scientific Institutions with a covering letter in which the Committee stated that by section 79 of the Merchant Shipping Act of 1906, power was given to the Board of Trade to appoint Advisory Committees for the purposes therein specified, consisting of such persons as the Board of Trade might appoint representing the interests affected, or having special knowledge of the subject matter to be dealt with by the Committee, and that in the best interests of the Industries, the Scientific Institutions (which elect the members of the Consultative Committee) should each be asked to nominate a Representative on the Advisory Committee, so that mutual assistance might be given, and uniformity of decision on all technical matters secured, and pointing out that in the case of the Naval Architects Institution, it was composed of members from all parts of the world, many of whom are from foreign countries, while in the cases of the Institution of Engineers and Shipbuilders in Scotland (Glasgow), and the North East Coast Institution of Engineers and Shipbuilders, Newcastle-on-Tyne, they are largely composed of members resident and working in these two districts, and hence might be assumed to be the sources from which representatives directly in touch with the various practices of the two districts would best be drawn.

The Institution of Naval Architects, however, have suggested that in their opinion, the matter would be best dealt with by a Joint Committee of the three Scientific Institutions, and in this opinion the Committee most heartily acquiesce. A Joint Committee of the three Scientific Institutions is accordingly at present being formed, and the subject will then receive consideration and the matter will probably be dealt with without delay.

The Committee are pleased to state that copies of all Instructions which have been issued by the Board of Trade to Surveyors during 1906, 1907 and 1908, have been sent to the Secretary of this Committee, with the intimation that copies of instructions

A question raised by a Firm on the North East Coast, as to the preparation, alterations on and passing of Grain Cargoes Plans by the Board of Trade, was considered by the Sub-Committee on Tonnage, when it was directed that Shipbuilders should be warned that grain feeders should measure two per cent. of cargo space clear of all obstructions in them such as fore and afters, shifting Boards, etc., in hatches, as trouble has arisen owing to the Board of Trade deducting these obstructions and feeder space falling below the two per cent. Meantime, the Firm in question propose to deal themselves with the question as to the passing of Grain Cargoes Plans by the Board of Trade.

A letter stating that one of the members of the North West Engineering Trades Employers Association had been asked by the Board of Trade to submit for approval a plan, showing the arrangement and detail of main steam piping proposed for a passenger steamer, was considered, and while the Committee generally deprecate sending plans to the Board of Trade, they must leave it to each member to do as he thinks fit, but they are of opinion that if plans are sent, it should be on condition that the Board of Trade give a decisive reply either approving or the reverse of such plans, in writing.

The subject of the Training of Seagoing Engineers has again been under consideration.

In connection with this matter, the difficulty of arranging a satisfactory scheme of apprenticeship has also been under consideration, and as the matter has assumed serious proportions it has been resolved that it should be dealt with by a Joint Committee appointed from the North East and North West Coasts.

With regard to Lloyd's and Board of Trade requirements the matters dependent thereon under the consideration of this Committee are being arranged in accordance with the general reports of the Standardisation Committee.

The question of the sizes of test pieces required by the Board of Trade (which should be brought into line with the Engineering Standards) has been considered, and the Committee are pleased to state that active steps are being taken by the Board of Trade and Lloyd's Surveyors with a view to establishing a standard size of test piece.

The question raised by a Scottish Firm of Shipbuilders as to the inclusion in tonnage of Hopper Barges and like vessels, of Buoyancy for compartments in side wings, and exemption of peak ballast tanks, has received further consideration by the Committee as well as by the Sub-Committee on tonnage, and the Committee have been in correspondence with the Board of Trade and with the firm referred to, and have arrived at the conclusion that unless the spaces referred to are treated and fitted up as water ballast tanks, the matter could not be taken up by the Committee with the Board of Trade with advantage to the firm, and this having been duly communicated to them no further movement has been made.

Questions as to Ventilators, Deck Lights, etc., have also received consideration by this Committee, but at the request of the firm by whom the matters were brought under their notice, further consideration of these matters was in the meantime deferred.

Questions relating to the Measurement of Tonnage in the 'tween decks of vessels have received much attention from this Committee and from their Sub-Committee on tonnage, but such information as the Committee could get in the cases submitted to them has not been sufficient to enable them to make out a good case with which to approach the Board of Trade.

The Committee were of opinion, and communicated it to the Board of Trade, that the rating of Steam Tugs engaged in towing and attending on vessels and not having a Board of Trade Certificate for the carrying of passengers should not be of less registered tonnage than 18 per cent. of the gross, or on the lines of the new Tonnage Bill the deduction for Engine Space should not be more than 78 per cent. of the tonnage arrived at by deducting from the gross tonnage, the tonnage of the space occupied by officers and crew, etc., and they duly communicated this opinion to the President of the Board of Trade, and it will be observed that Sub-Section A of Section I. provides that this Section shall not apply to Steamships constructed for the purpose of towing vessels, so long as they are exclusively employed as tugs, but when employed for the carriage of passengers or goods, etc., etc., the Register Tonnage on which dues are based shall be ascertained in manner provided by the Merchant Shipping Acts 1894 to 1906 as amended by said Tonnage Act.

A question having arisen as to submitting other boiler drawings for examination, etc., to the Board of Trade, the same as is done when a passenger certificate for a ship is to be taken out, it has been elicited that if such a certificate is wished there will apparently be no difficulty in obtaining it, if it be arranged with the local Surveyor, and the Board of Trade fees are paid.

It may be stated in conclusion that the Finances of the Committee continue to be satisfactory.

The Institution is represented on this Committee by the following gentlemen:—

Shipbuilders—Mr. W. H. Dugdale and Mr. George Jones.
Engineers—Mr. J. H. Irwin and Mr. D. B. Morison.

MEMOIRS.

MR. THOMAS WILLIAM BAGNALL.

Mr. Thomas William Bagnall was born at Winlaton on May 27th, 1861. He was educated at The College, Harrogate. In his youth he became connected with the firm of R. S. Bagnall and Sons, Ltd., forgemasters, engineers, etc., of the Winlaton Ironworks, Blaydon-on-Tyne, and South Hylton Forge and Engineering Works, near Sunderland, and eventually became managing director of the Company, a position he held at the time of his death, which took place at Ayr, N.B., on July 14th, 1907. He took a keen interest in local affairs and also in the Volunteer movement, in which he held the post of Major in the 5th V.B.D.L.I. (now 9th D.L.I.)., but retired shortly after receiving that rank. He joined the North-East Coast Institution of Engineers and Shipbuilders in 1893.

MR. JOHN DICKINSON, J.P.

Mr. John Dickinson was born at Hebburn-on-Tyne on July 4th, 1825, and died on July 3rd, 1908, within one day of his 83rd birthday. He went to work at the early age of twelve years, and in 1841 he went to Sunderland, where he was placed in the works of Messrs. John Clark & Co. as an apprentice, and while there was employed on the construction and erection of colliery engines. The works changed hands shortly after he went, but he remained until 1846, when they were finally closed. After this he went to Consett to work at the mills which were ten in the course of construction, but this class of work not pealing to him, he soon had an opportunity of giving it up, d went to Houghton-le-Spring, where he was again employed colliery work. After being there for a short while, he urned to Sunderland, and was employed by Mr. Burlinson, and Mr. George Clark, on repair work of various kinds. After shing with these gentlemen, he started a small repairing establishment of his own in 1852. This repair work was confined principally to the tugs and small colliers and traders then coming to the port, and was the foundation of the present marine engine and boiler works. The work so increased in volume that extensions had to be made, and a move was made to a more commodious site on the top of Palmer's Hill. Gradually the whole of the hill was acquired, extending down to the river, and was cut into terraces on which the present shops were erected. The works now occupy an area of about 5 acres, with a quay frontage of 600 feet, and when in full swing about 1,200 men are employed. In 1895 the business was converted into a limited liability company with the deceased gentleman as chairman of the directorate, and his sons occupying positions on the board. Mr. Dickinson was the inventor of "Dickinson's Patent Crankshaft," which is well known to engineers in connection with marine work. He was a member of the River Wear Commissioners, having been appointed in 1891 as a representative of the landowners, and he was a justice of the peace for the county of Durham. The deceased gentleman was a connoisseur in art, and he made picture collecting one of his chief interests outside his business concerns. His collections include some interesting and costly works by old as well as modern masters. He was of a kindly and beneficent nature, and the charities of the town by his death have lost a good friend. He was a life governor of the Sunderland Infirmary, and his association with the Monkwearmouth Hospital was equally beneficent. He was one of the first members of the Institute and took considerable interest in its work, having for many years occupied the position of vice-president.

MR. J. WIGHAM RICHARDSON, J.P.*

Mr. Wigham Richardson was born in January, 1837, being descended from an old Yorkshire Quaker family hailing from Whitby, and dating back to the fourteenth century. His first school was the famous academy of the late Dr. Collingwood Bruce, at Newcastle, and he afterwards went to the well-known Friends' School at York. He himself, however, always ascribed

* See *The Shipbuilder*, vol. iii., page 31.

his love of study to the instruction of his elder sister, she to whose memory he dedicated the west window in Christ Church at Wallcar, or, as it is now more usually written, Walker. At sixteen years of age he went for a short time to Liverpool to study naval architecture under a ship surveyor named Senhouse Martindale. Returning to Newcastle, his father, acting upon the advice of the late Robert Hawthorn, apprenticed him for three years to the late Jonathan Robson, a builder of paddle and screw-tug steamers, at Gateshead. On the completion of his apprenticeship he continued his education at University College, London, and subsequently at Tuebingen University in Wuertemberg. He returned to Newcastle in 1858 and entered the service of the eminent engineers, R. and W. Hawthorn.

It was in the year 1860 that Mr. Wigham Richardson, then in his twenty-third year, purchased a shipyard on the Tyne, and founded the firm of Wigham Richardson & Co., the name of which for upwards of forty years was to be a household word in the North of England. It is interesting (says *The Mid-Tyne Link*, now issued as *The Shipbuilder*) to recall that the shipbuilding branch of the Neptune Works is the oldest iron shipyard on the Tyne. It was started by Mr. Coutts, the pioneer of the industry on the river. The first iron vessel ever built on Tyneside, the "Prince Albert," was launched from the original part of this yard on the 23rd September, 1842. The premises afterwards passed into the hands of a London firm, Messrs. Miller, Ravenhill, & Co., prior to be taken over by Mr. Wigham Richardson. The works covered only four acres with a river frontage of 107 yards, and they had three building berths, the longest being 320 feet. The Neptune Works gradually increased in size and importance; the small passenger vessels, tugs and barges built at first were followed by merchant ships of almost every type constructed for practically every maritime nation in the world and engine and boilerworks were added in 1879. In 1899 the business was turned into a limited liability company, and in 1903 was amalgamated with the shipbuilding firm of C. S. Swan & Hunter, Ltd., and the Tyne Pontoons and Dry Docks Company, Ltd., the premises of the combined firms having an area of 78 acres and a building capacity of some 150,000 gross tons per annum.

Mr. Wigham Richardson's name has always been associated with the North-East Coast Institution of Engineers and Shipbuilders since its formation in 1884. In 1890 he was elected fourth President of the Institution, his predecessor being the late Mr. F. C. Marshall. His inaugural address took the form of a review of recent engineering, scientific and general progress. Vast as was the field covered in the address, the universality and depth of the President's knowledge must have come as a revelation even to many who had known him a lifetime; and as one reads again the printed report of the address in the *Transactions* of the Institution, one is struck with the graceful and scholarly language with which he clothed his thoughts and the constant activity of mind which kept him ever in touch with the various phases of the world's progress. Civil engineering, the merits of compound engines on land and sea, economy of fuel, the planting of trees in towns, the importance of a pure water supply and scientific sanitation—all these and many other interesting topics were reviewed by Mr. Richardson in his presidential address, and were put into new lights for the benefit of the expert and novice.

Business often took Mr. Richardson abroad, and he was familiar with every country of importance in Europe, besides parts of Canada and of the United States of North America. He made the most of these journeys, enriching his store of knowledge by studying local habits and conditions of living, visiting neighbouring places of historic interest and filling many a book with charming water-colour sketches. Other interesting journeys were made to Cape Colony, the West Indies and North Africa.

His energies and tastes were not limited by the scope of his profession as shipbuilder and engineer. He was for years a member of the County Council of Northumberland, devoting much time to the work of the Education Committee, and a Justice of the Peace for the county of Northumberland since 1892. He was well known as a student of political economy, sociology and history. He was also a practical architect and a patron of art. Many institutions and places in his native district and elsewhere benefited by his gifts and advice always generously given, for he was ever a warm supporter of schemes for the improvement of his fellow-beings. His wide experience his rest after a life well spent. His lamented death took place unexpectedly in London on the 15th of April, 1908, and long will his memory be cherished, not only by a large circle of friends in this country, but by many others on the Continent and in more distant lands.

MR. GEORGE ROBSON.

Mr. George Robson was born at Marske-by-the-Sea on December 1st, 1844. He was educated in London and Hanover. He came to the Tyne to serve his apprenticeship in engineering, after which he spent some time in the Egyptian Navy, and later he joined the Merchant Service as a sea-going engineer. About thirty years ago he started business with Mr. James Duncan in South Shields as ship repairers and engineers. Mr. Duncan retired and went to London, Mr. Robson took over the business and carried it on up to the time of his decease, which occurred on May 14th, 1908, after a lingering illness. He was a man of sterling character, and being of a kindly and generous disposition he was greatly esteemed by all who had the privilege of his friendship. He was identified with many of the local institutions and took a keen interest in the Volunteer Life Brigade. He was a member of the Institution of Naval Architects, the Newcastle and Gateshead Chamber of Commerce, and an honorary member of the Newcastle and District Association of Foremen Engineers and Draughtsmen. He joined the North-East Coast Institution of Engineers and Shipbuilders in 1889.

MR. J. C. STIRZAKER.

Mr. James Cleland Stirzaker was born on January 14th, 1849. He was educated at the Kingswood School, Bath, and as a student he was most successful. On leaving school he went to Liverpool to serve his apprenticeship with Messrs. George Forrester & Company, of Vauxhall Foundry. He left Liverpool to take the management of an engineering works in Belfast. In 1880 he removed from Belfast to the Elswick Ordnance Works, Newcastle-upon-Tyne, where he remained for the rest of his life. Mr. Stirzaker was one of the very earliest members of the Institution, and as Member of Council did much valuable work in connection with the founding of the Institution and arranging its Constitution and Bye-laws. In his profession he was a thoroughly sound and well-trained engineer, being looked upon as an authority in connection with his work of designing heavy gun mountings. In private life he was of a quiet and retiring nature, and much liked by his intimate friends. He was a keen churchman, and as one of the Newcastle Cathedral sidesmen was a well-known figure and did much work in a silent and unobtrusive way. His death occurred on November 24th, 1907, suddenly, when in London on business for Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited, he being then in his 59th year.

COLONEL HENRY F. SWAN, C.B.*

By the death of Colonel HENRY FREDERICK SWAN, C.B., V.D., High Sheriff of Northumberland, which took place suddenly at his residence, Prudhoe Hall, Prudhoe, on the 25th March, the Tyne loses one who, by his technical and administrative abilities, has been prominent for the last forty years in the development of the shipbuilding and engineering industries of the river. The deceased gentleman had suffered from a heart affection for some time, but appeared in his usual health on the evening before his death, and was expected at the Walker Shipyard on the following day.

Colonel Swan was born at Walker in the same month in 1842 in which the first iron steamer built on the Tyne—the "Prince Albert"—was launched at Low Walker, and to recount the changes wrought in marine construction during his long career would indeed be to tell the history of iron shipbuilding. Commencing his apprenticeship in 1858 with the late firm of C. Mitchell & Company, shipbuilders, of Walker, he was all his working life associated with that firm, now merged into the great company known as Sir W. G. Armstrong, Whitworth & Co., Limited. In 1862 Messrs. Mitchell were entrusted by the Russian Government with the stupendous task

* Excerpt, *The Shipbuilder*, vol. ii., page 238.

of commencing the construction of iron war vessels in the land of the Czar, and Mr. Swan took up his residence in St. Petersburg as the representative of the Tyneside firm. One of the Government's wooden dockyards was handed over to Messrs. Mitchell, who converted it into an establishment for the building of iron warships and here they constructed five armour-clads for the Russian Navy. In recognition of his services in this connection, the Czar presented Mr. Swan, on leaving Russia in 1865, with a valuable diamond snuff-box. Returning to England he took charge of the Walker Shipyard of his firm, Mr. Charles Mitchell, the senior partner, having been compelled by ill-health to temporarily take up his residence in the South of England. Under the energetic and sound commercial management of Mr. Swan, the works were greatly developed, new and improved machinery was introduced, and the vessels built correspondingly increased in number and importance.

In the year 1882, the shipbuilding firm of C. Mitchell & Co. amalgamated with the Elswick firm of Armstrong, under the style of Sir W. G. Armstrong, Mitchell & Co. This fusion of interests was followed, in 1897, by the Tyneside company amalgamating with Messrs. Whitworth, of Manchester, and since then the company has been known as Sir W. G. Armstrong, Whitworth & Company. Colonel Swan was one of the managing directors of this great concern from 1882 until his death. Under his guidance, steamers of every description were built at the Walker Yard, from plain cargo carriers of moderate tonnage, to high-class, speedy mail and passenger steamers, large cruisers for Japan and other countries, and quite a fleet of ice-breakers, of which perhaps the "Ermack" is the most notable. But possibly Colonel Swan was most widely known throughout the shipping world as one closely identified with the carriage of petroleum oversea in bulk. Much of the success with which this trade has been carried on is due to the masterly manner in which he grappled with, and successfully solved, the naval architectural problems involved in the construction of vessels suitable for the safe conveyance in bulk over the Atlantic of liquid cargoes of so inflammable a nature as petroleum. Undoubtedly one of our greatest authorities on oil carriers, he took out many patents in connection with this type of steamship. The first oil tank steamer to convey a bulk cargo of petroleum from

America to this country, the "Gluckauf," which crossed in 1886, was built in accordance with Colonel Swan's system. Nearly half of the total number of ocean oil carriers now afloat have been constructed at the Walker Yard, including the new vessels "Buyo Maru" and "Derbent." It is interesting to note that the latest and most approved designs on which oil steamers are being constructed are substantially the same as those on which Colonel Swan's original vessels were built.

It is not so generally known that, in addition to being so long associated with the great shipbuilding companies of C. Mitchell & Company and Armstrong, Whitworth & Co., Colonel Swan, together with Mr. Charles Mitchell, was closely connected with the commencement of the two other famous Tyneside businesses which have made Wallsend a large and populous town, and have greatly contributed to the reputation and fame of the River Tyne as a centre of shipbuilding and marine engineering. It was in association with Mr. Charles Mitchell and Colonel H. F. Swan that the brother of the latter, the late Mr. Charles S. Swan, commenced shipbuilding at Wallsend under the style of C. S. Swan & Company. On Mr. C. S. Swan's death, the firm became C. S. Swan and Hunter, and is now known as Swan, Hunter & Wigham Richardson, Limited. Mr. C. Mitchell and Colonel Swan, with some shipowning friends, also formed the Wallsend Slipway and Engineering Company, and for many years the latter gentleman was chairman of this company and he remained a director until his death.

Colonel Swan was a member of the North-East Coast Institution of Engineers and Shipbuilders from its formation in 1884 and from 1896 to 1898 he occupied the Presidential Chair, being the seventh on the list. He was a member of Council of the Institution of Naval Architects and a member of the Institution of Civil Engineers, Iron and Steel Institute, and North of England Institute of Mining and Mechanical Engineers. He joined the Volunteer forces in 1859, and for twenty-seven years commanded the 2nd V.B.N.F., being created a Companion of the Bath on his retirement. Only a few weeks prior to his death he was appointed High Sheriff of Northumberland.

ROBERT THOMPSON, J.P.

Mr. Robert Thompson was the principal partner and chairman of directors of the old established and well-known firm of Joseph L. Thompson & Sons, Limited, of the North Sands Shipbuilding Yard and Manor Quay Repairing Works, Sunderland. He was the eldest son of the late Joseph L. Thompson, and was educated at Gainford School. Having been actively engaged in the shipbuilding industry since the year 1865, his experience was very varied, and there was probably no more popular business man in the Wearside borough. From 1875 up till a year or two ago, when on account of ill-health he was obliged to take less active interest in business, the fortunes of the shipbuilding business were under his control and direction. Commencing his outside management of the shipyard in 1870, when the plant and ground were altered to suit iron shipbuilding, all the efforts of Mr. Thompson, who was impressed with the possibilities in the change from wood to iron shipbuilding, were directed towards the equipment of the establishment with the most modern requirements. The enterprise and foresight then shown were displayed throughout his career until to-day the North Sands Yard is reckoned one of the best equipped on the North-East Coast. The firm has, on a great many occasions, held the record of having launched the largest amount of tonnage on the Wear, and held high positions in the world's annual output of tonnage, being fourth on three successive occasions, and a great deal of the credit for this is due to the untiring energy and business ability of Mr. Thompson. Besides directing the affairs of the shipbuilding and repairing business, Mr. Thompson was an active partner in The Sunderland Forge & Engineering Company, Limited; he was one of the founders of the Wearmouth Foundry Company, Limited; Chairman of Directors of the Skinninggrove Iron Company, Limited, Yorkshire, and was connected with various other business enterprises. He was a County Justice of the Peace, a Freeman of the Worshipful Company of Shipwrights, a Governor and Member of Council of the Durham College of Science, Newcastle-on-Tyne, and was one of the founders of The North East Coast Institution of Engineers and Shipbuilders, in which he took considerable interest and proved himself a popular occupant of the presidential chair during the two sessions 1891-1892 and 1892-1893; he also contributed several valuable papers to the *Transactions*. Mr. Thompson was also a member of the Council of the Institution of Naval Architects, the Iron and Steel Institute, and other learned societies, and for a number of years was one of the North-East Coast representatives on the Committee of Lloyd's Register of British and Foreign Shipping, and acted as a member of the Technical Sub-Committee. He was also for a number of years a member of the River Wear Commission and of the Borough Council, and was also connected with various charities in the borough, being a member of the Infirmary Committee, and for a number of years Chairman of the Monkwearmouth and Southwick Hospital. He died on January 1st, 1908, in the 57th year of his age.

Illustrating Mr. J. H. Heck's Paper on "Notes on the Effect of Work and Time on the Properties of Mild Steel and Iron."

DAMAGED SHIP PLATE FROM S.S. "ROTTERDAM."

Illustrating Mr. J. H. Heck's Paper on "Notes on the Effect of Work and Time on the Properties of Mild Steel and Iron."

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Proceedings N.E.C.I. of E. & S., 1907-1908. *Session XXIV.*

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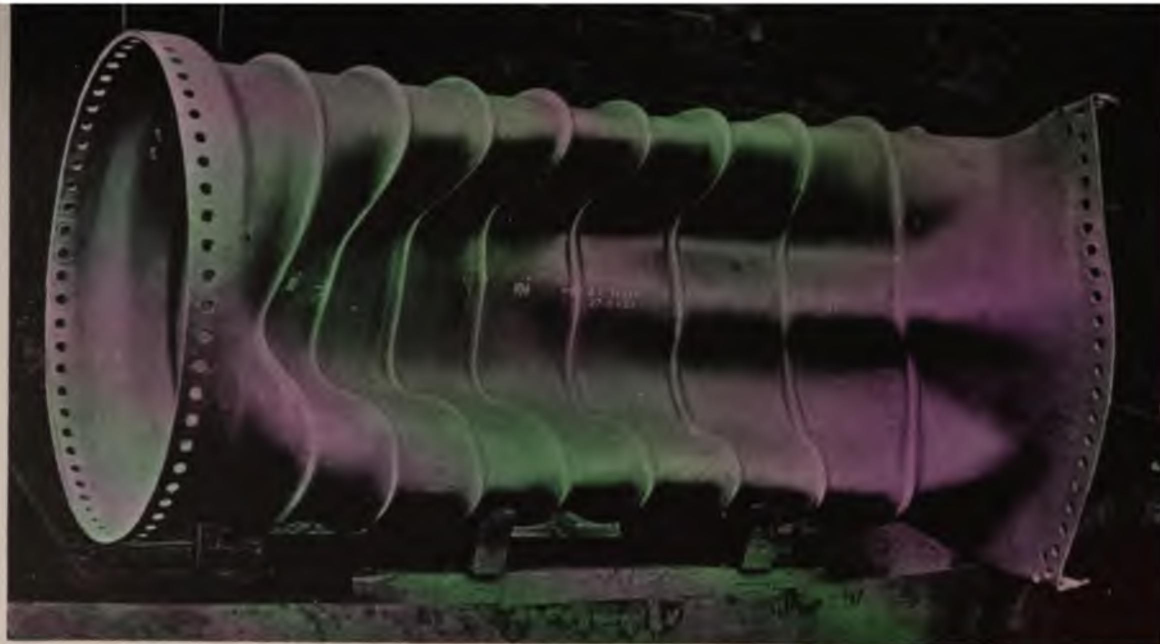
Illustrating Mr. J. H. Heck's Paper on "Notes on the Effect of Work and Time on the Properties of Mild Steel and Iron."

OVERHEATED BOILER FURNACE.



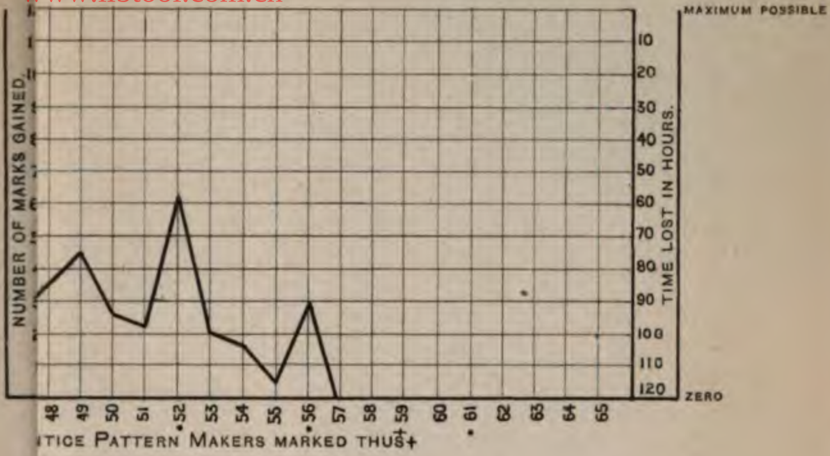
Overheated Boiler Furnace.

Proceedings N.E.C.I. of E. & S., 1907-1908. *Session XXIV.*

Illustrating Mr. J. H. Heck's Paper on "Notes on the Effect of Work and Time on the Properties of Mild Steel and Iron."

Damaged Ship Plate from S.S. "Rotterdam."

TTOM OF A STRANDED SHIP.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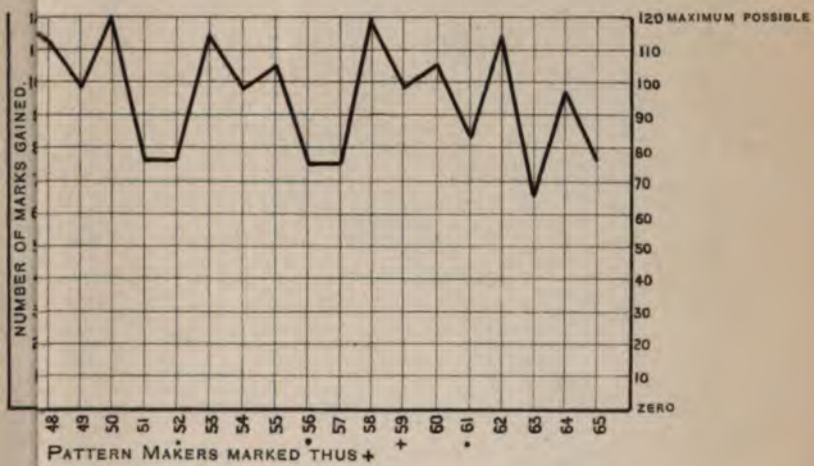
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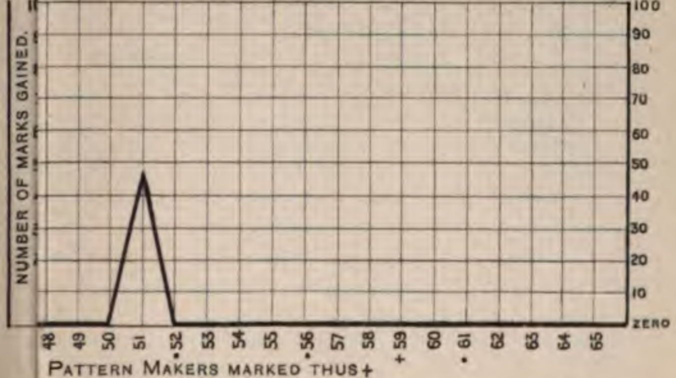
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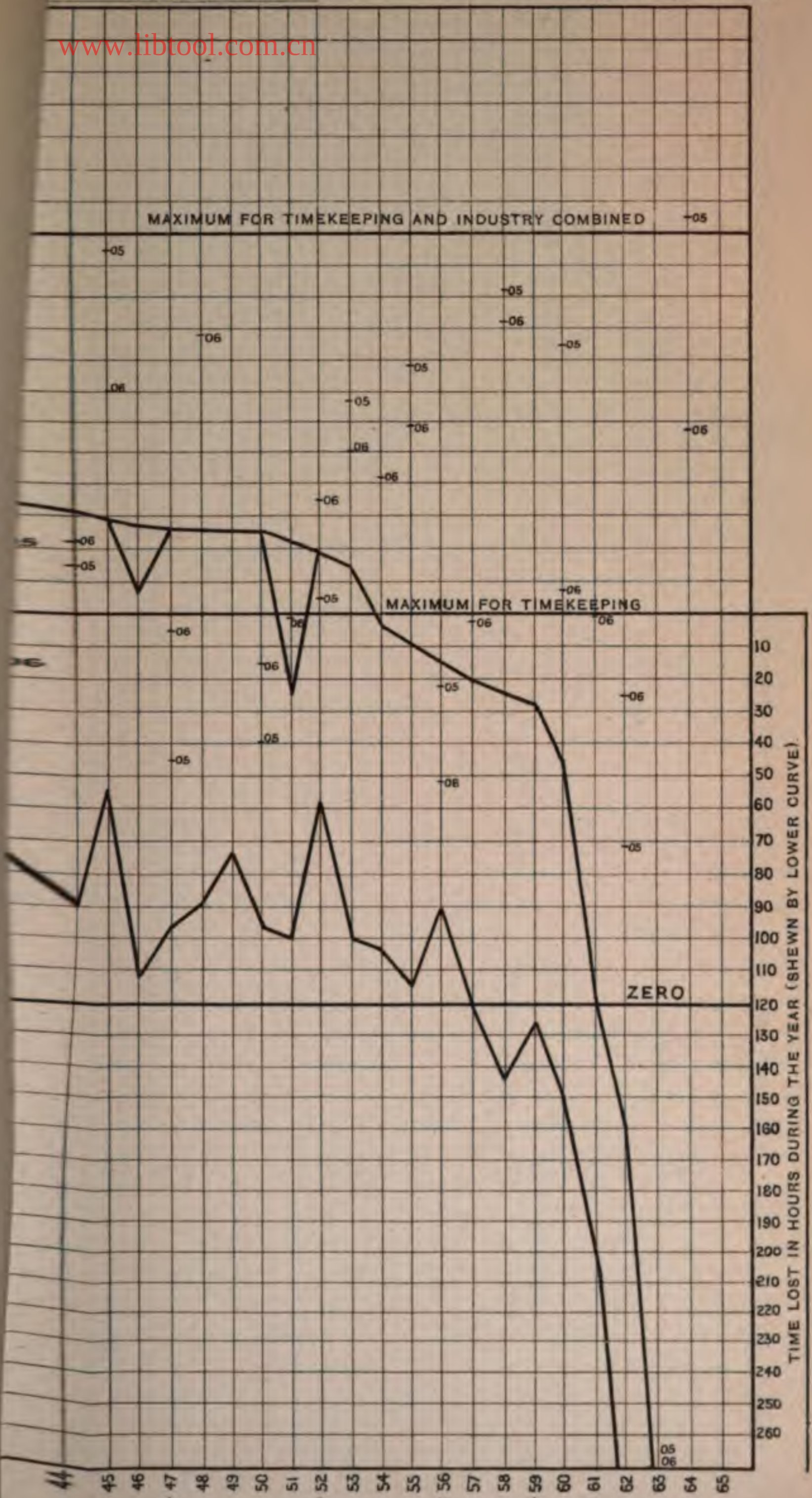

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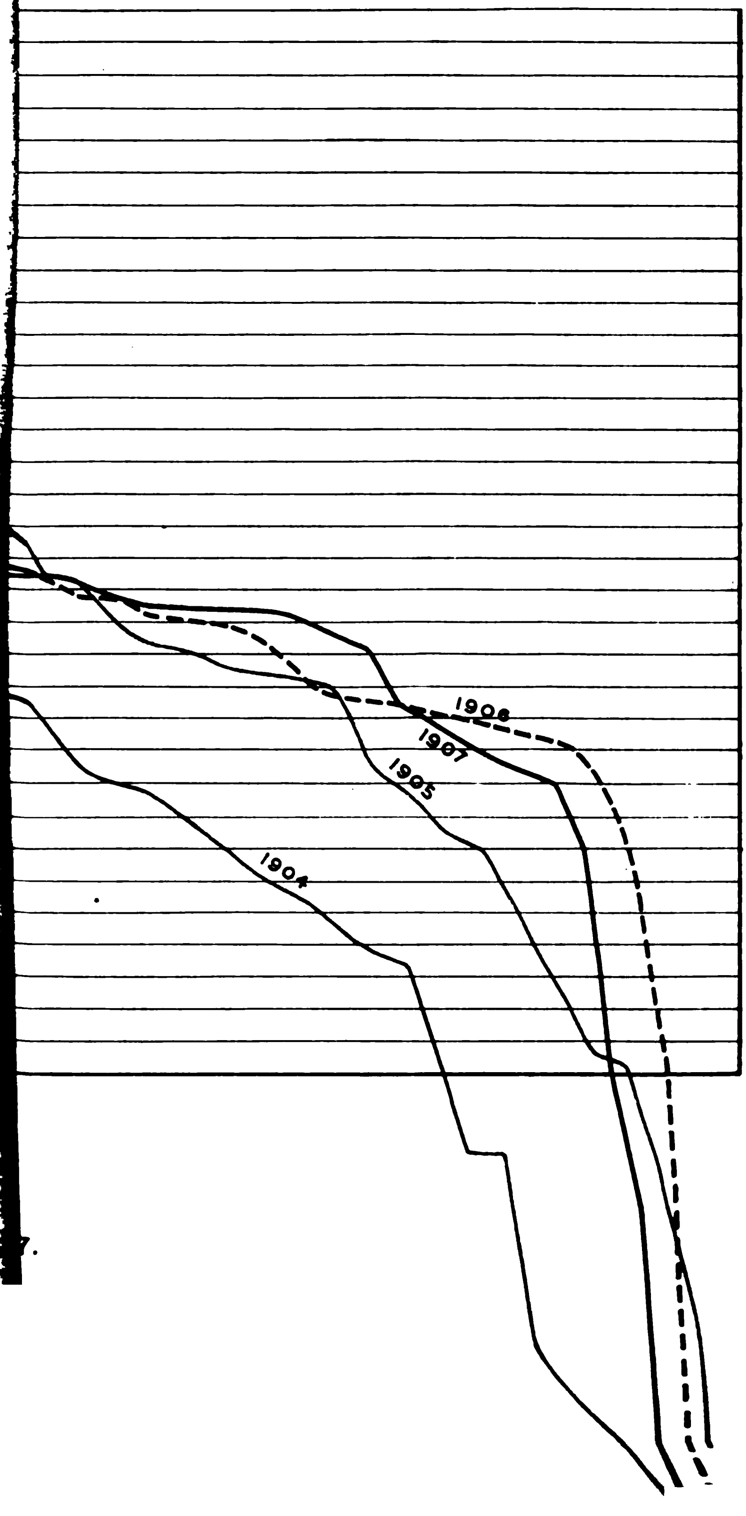
Andw. Reid & Compy. Ltd. Newcastle upon Tyne



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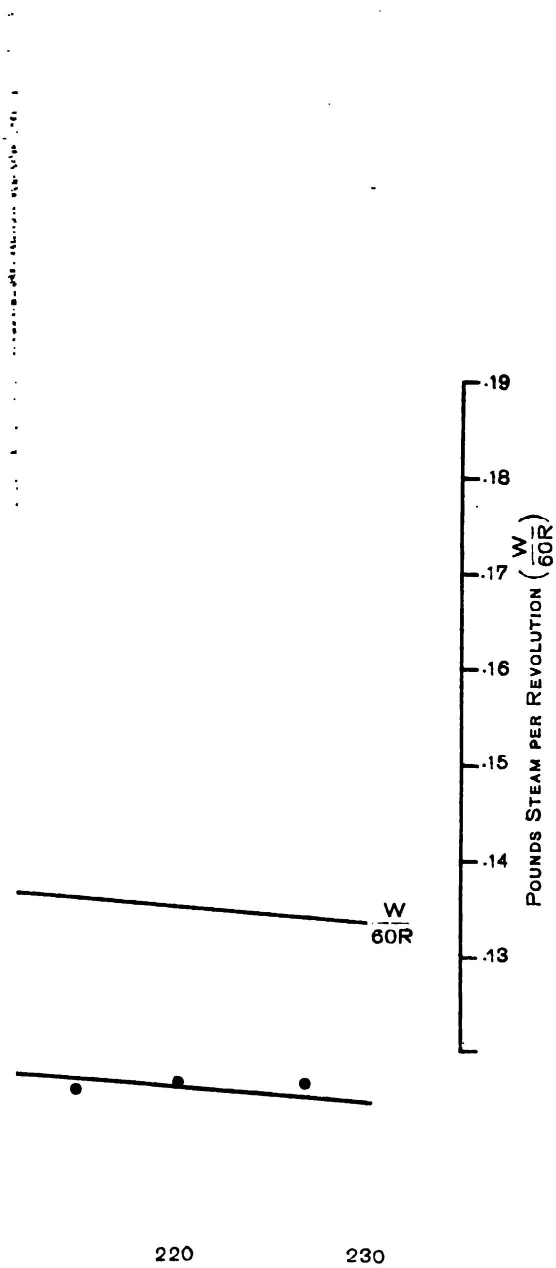
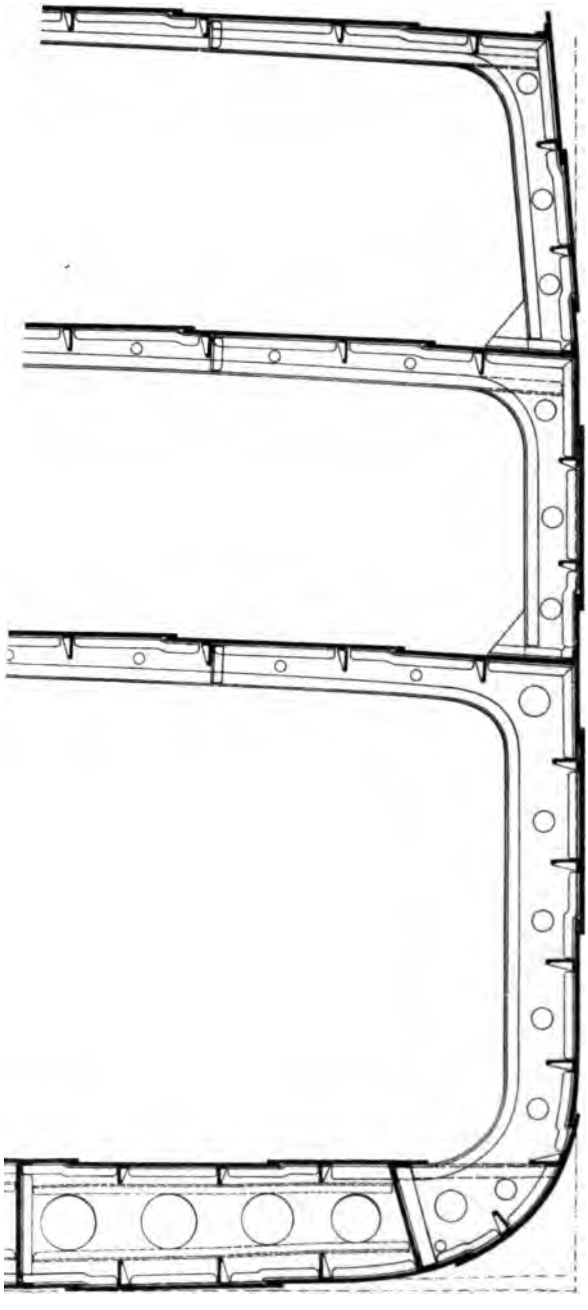
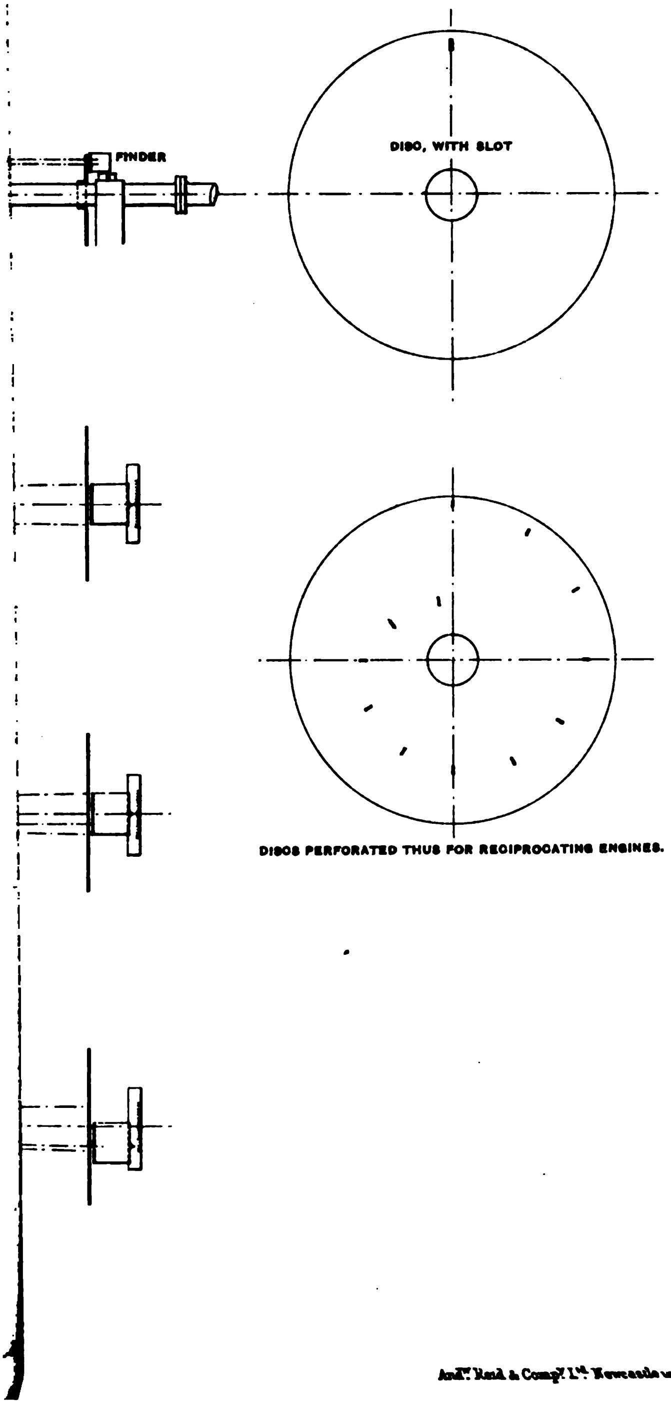


And^w Reid & Comp^y L^{td} Newcastle upon Tyne



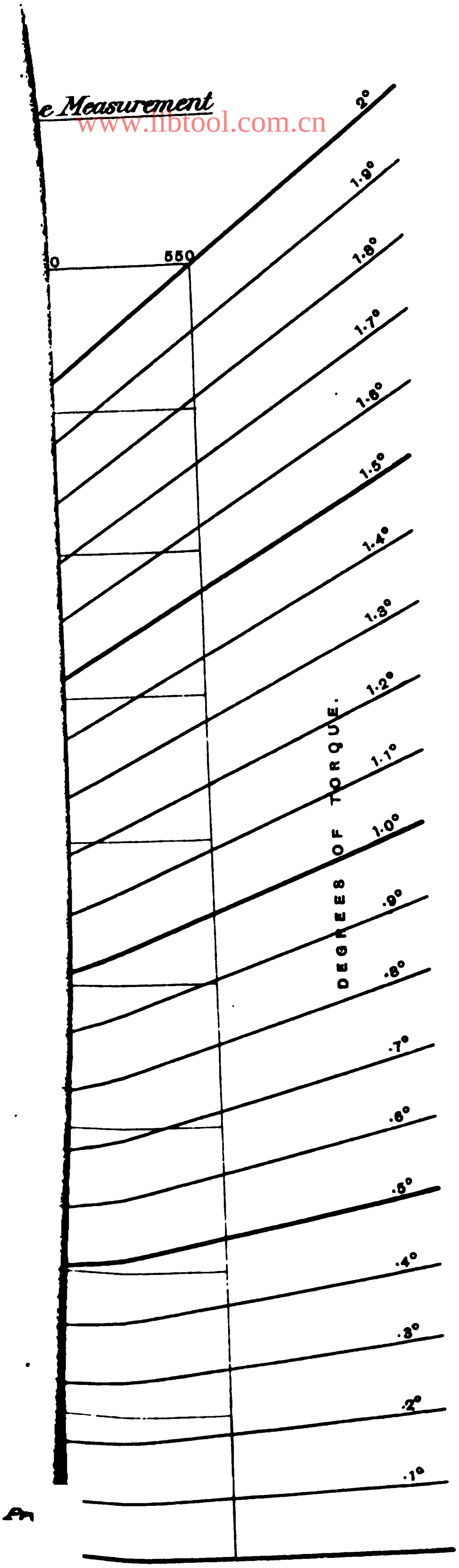
And^w Reid & Comp^y L^td Newcastle upon Tyne.

"...he Horse-power of Marine Steam Turbines."



Andw. Reid & Compy. Ltd. Newcastle upon Tyne

e Measurement



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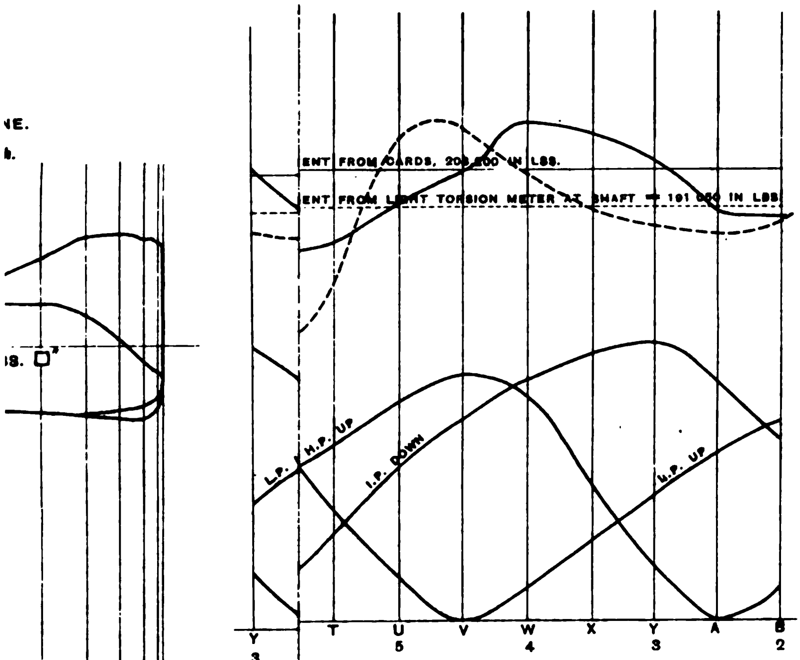
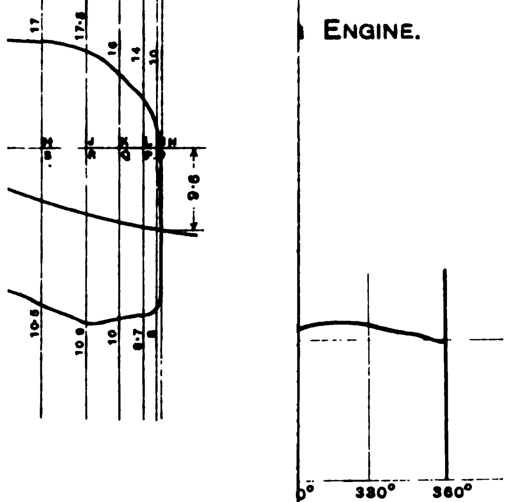
...RANK EFFORT AND T...



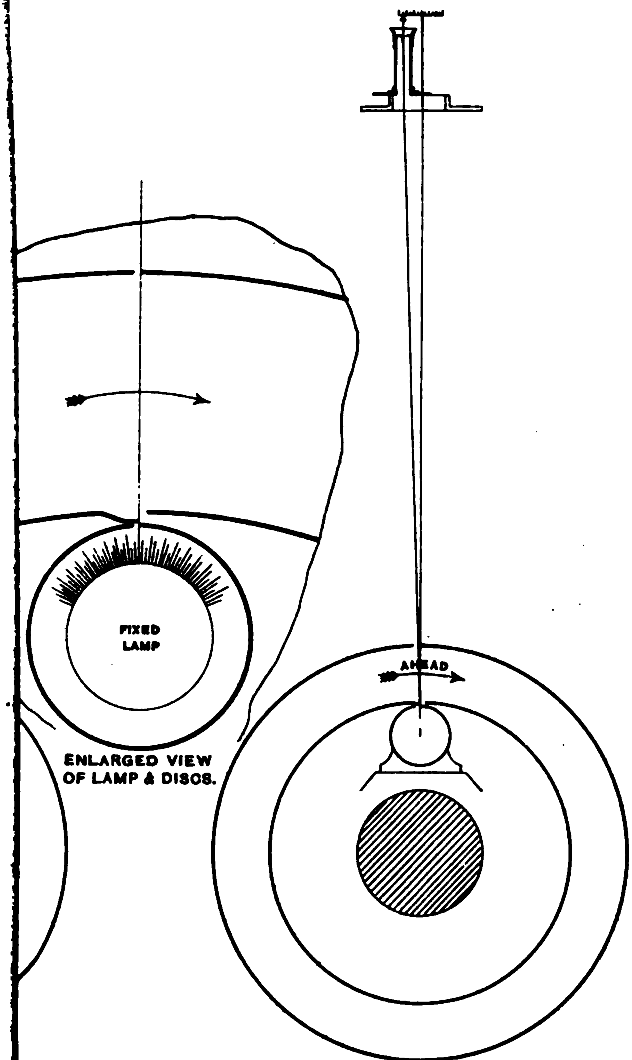
FUL... LETTERS CORRESPONDING TO POSITION OF H.P. CRANK.
DOT... NUMBERS „ „ SLOTS IN TORSION METER DISC.

... ENGINE.



Andw. Reid & Compy. Ltd. Newcastle upon Tyne

of the Horse-power of Marine Steam Turbines."



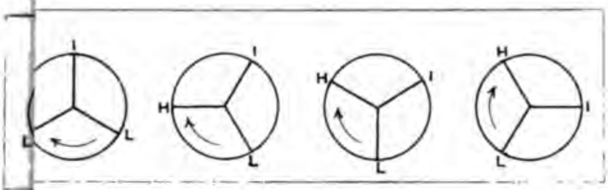
ENLARGED VIEW
OF LAMP & DISCS.

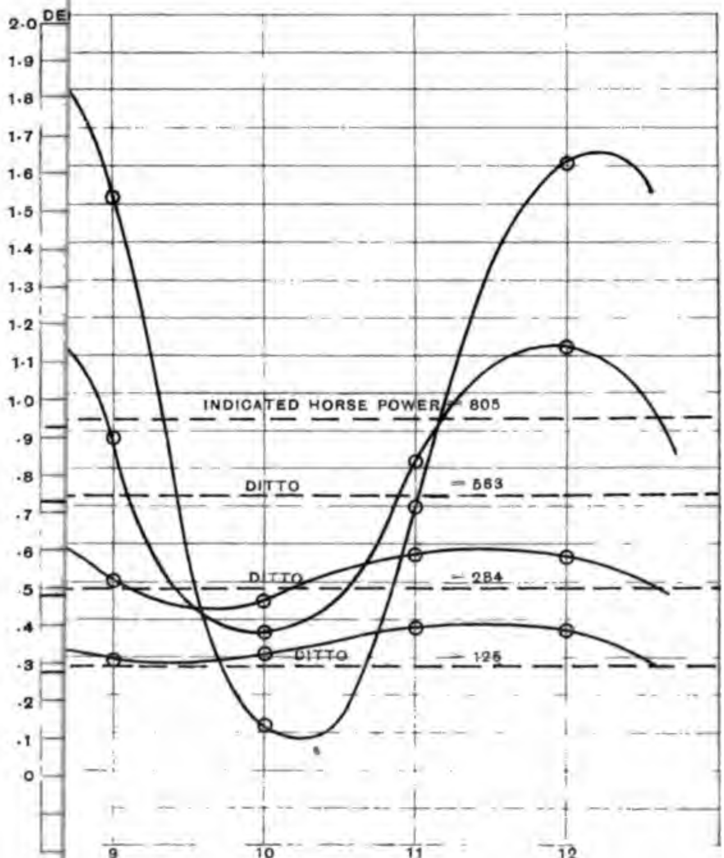
VIEW LOOKING AFT,
SHOWING TORQUE.

Andw. Reid & Compy. Ld. Newcastle upon Tyne.

"...f the Horse-power of Marine Steam Turbines."

...OGRESSIVE TRIAL



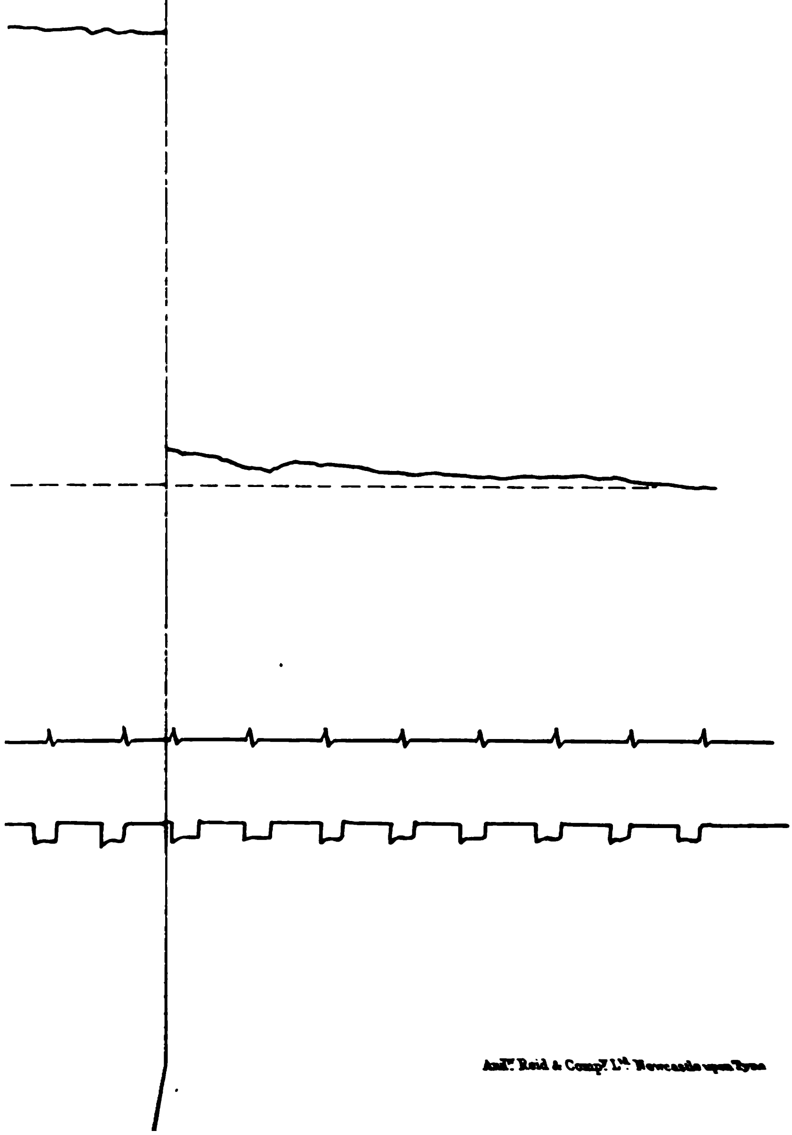


Press...

Andw Reid & Compy Ld Newcastle upon Tyne

IAFT, BY MEA

ERATION.



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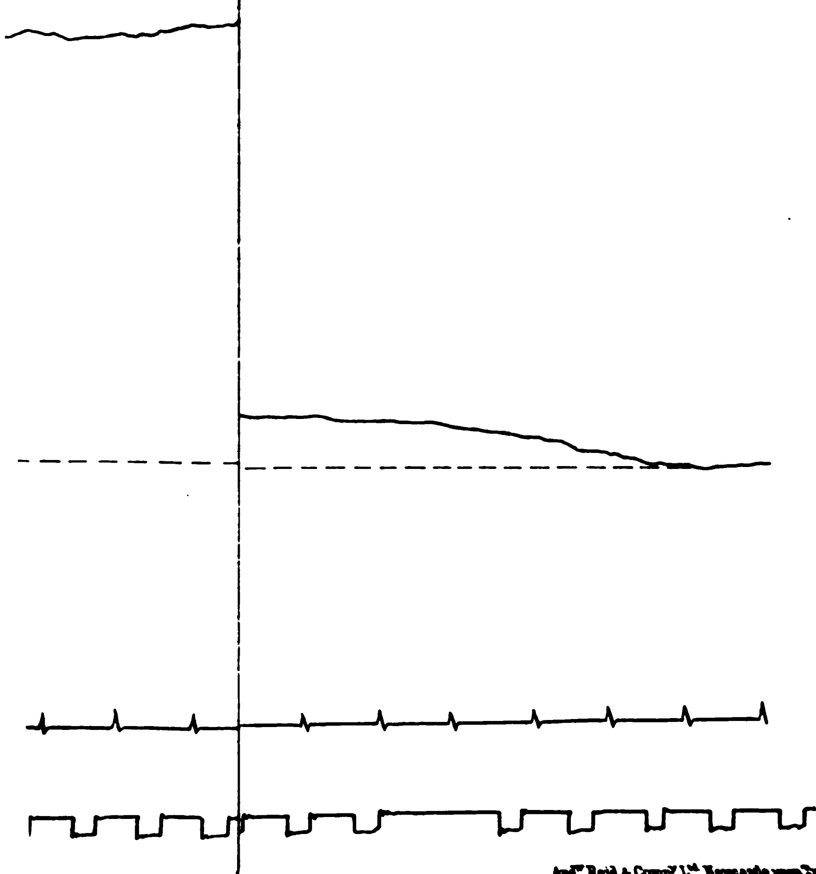
M A ROLLING MILL S

Two Mills in Operatio



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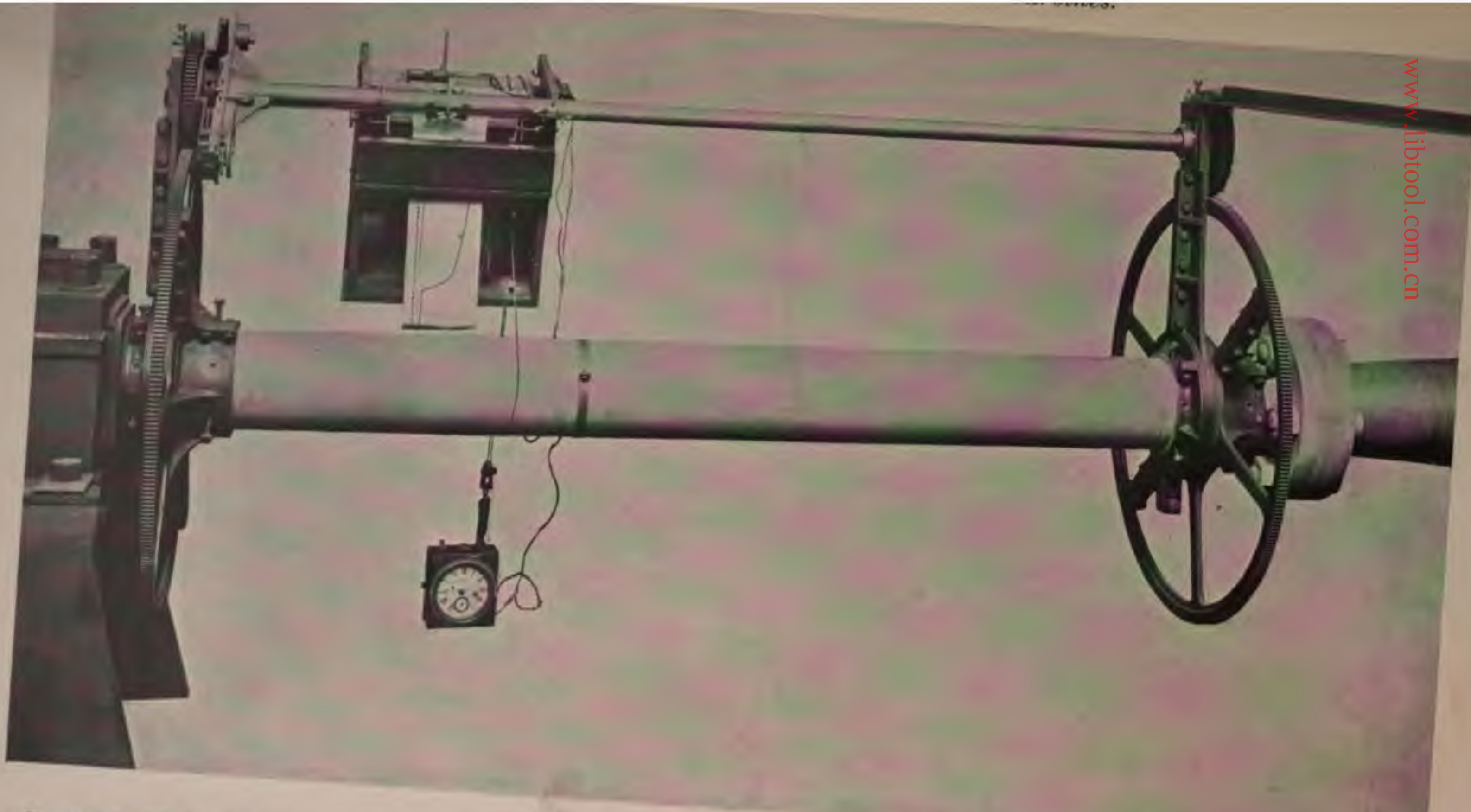
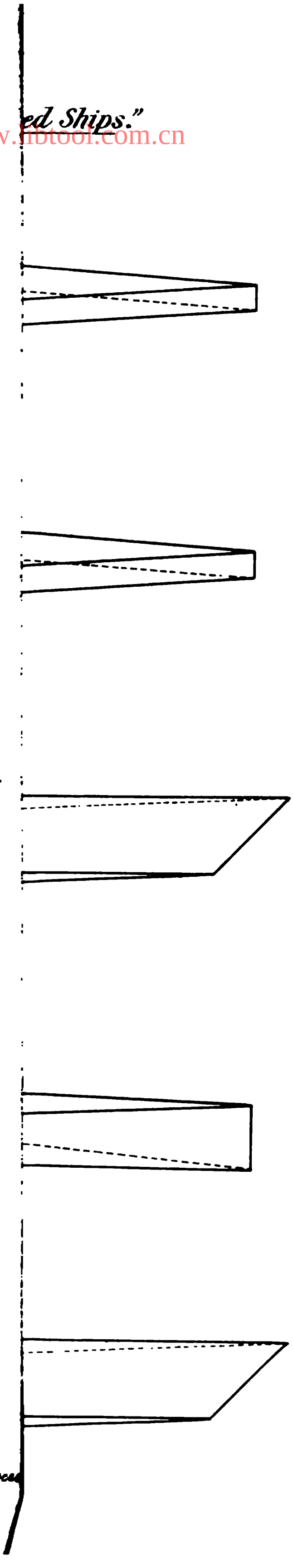


DENNY-EDGECOMBE TORSION-INDI



Proce

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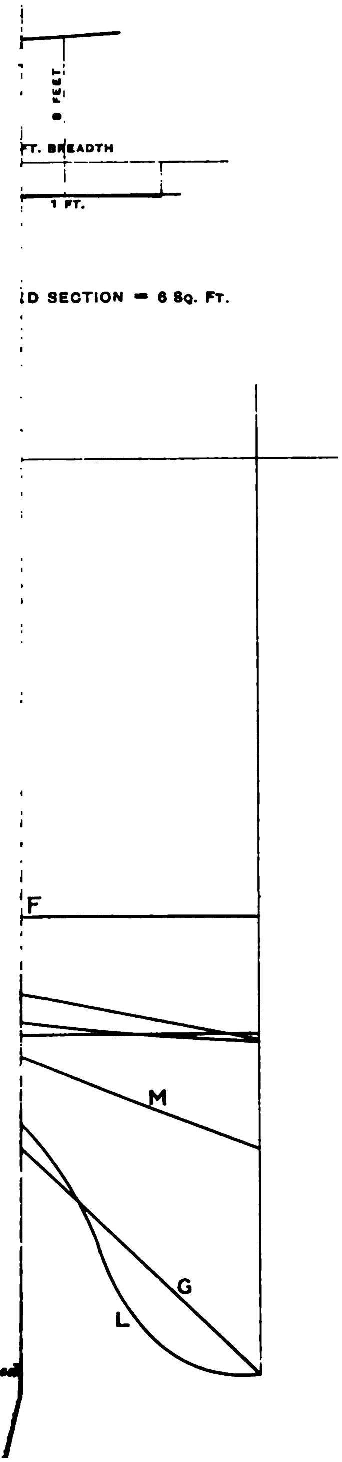
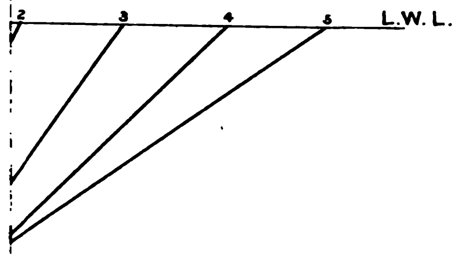
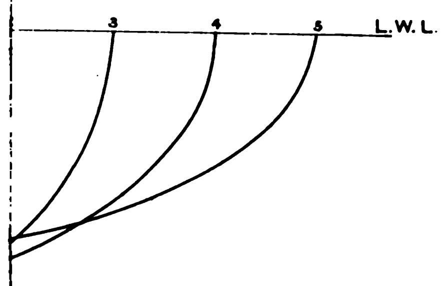


Andw. Reid & Compy. Ltd. Newcastle upon Tyne





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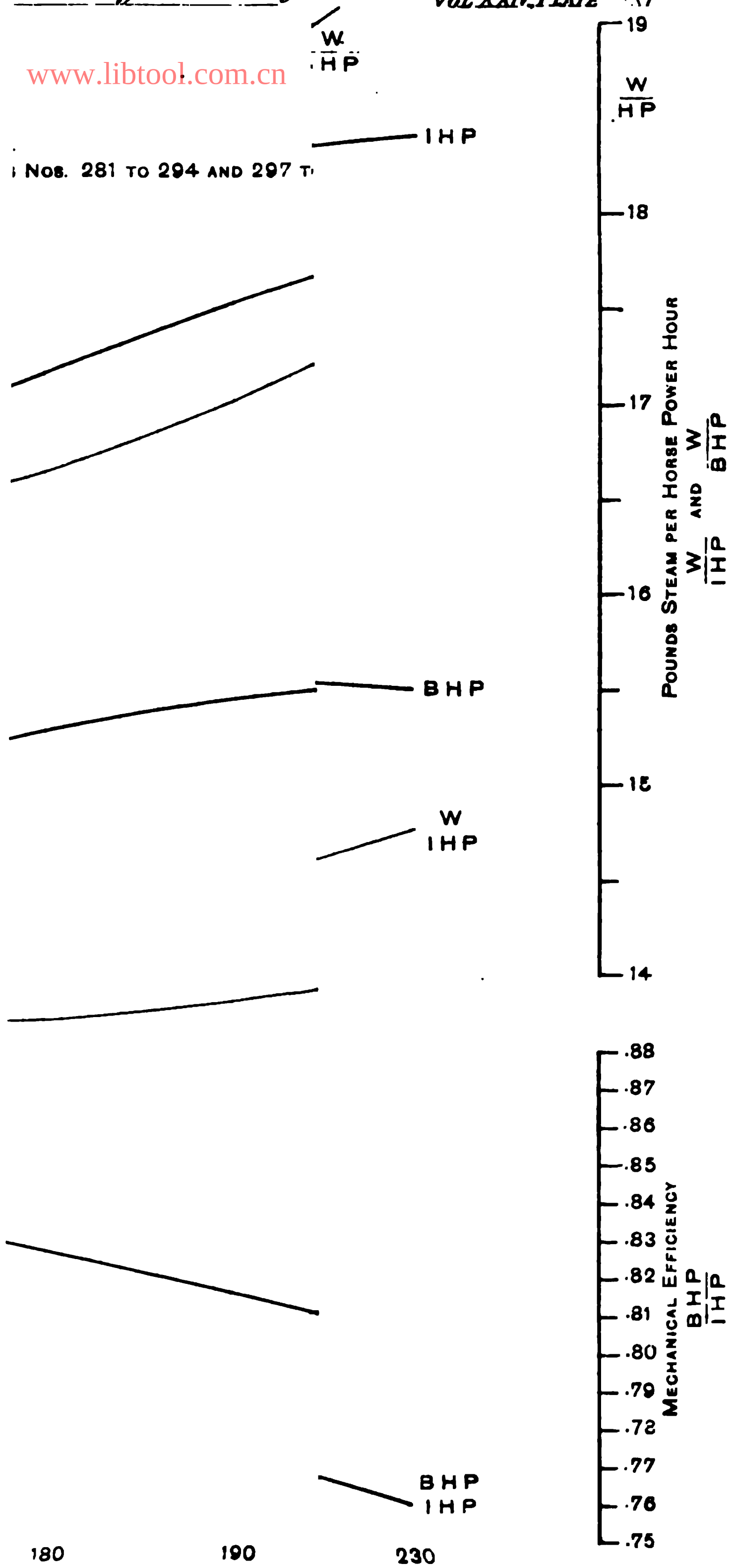


Andw Reid & Compy Ltd Newcastle upon Tyne

M III.

23". 18" Stroke.

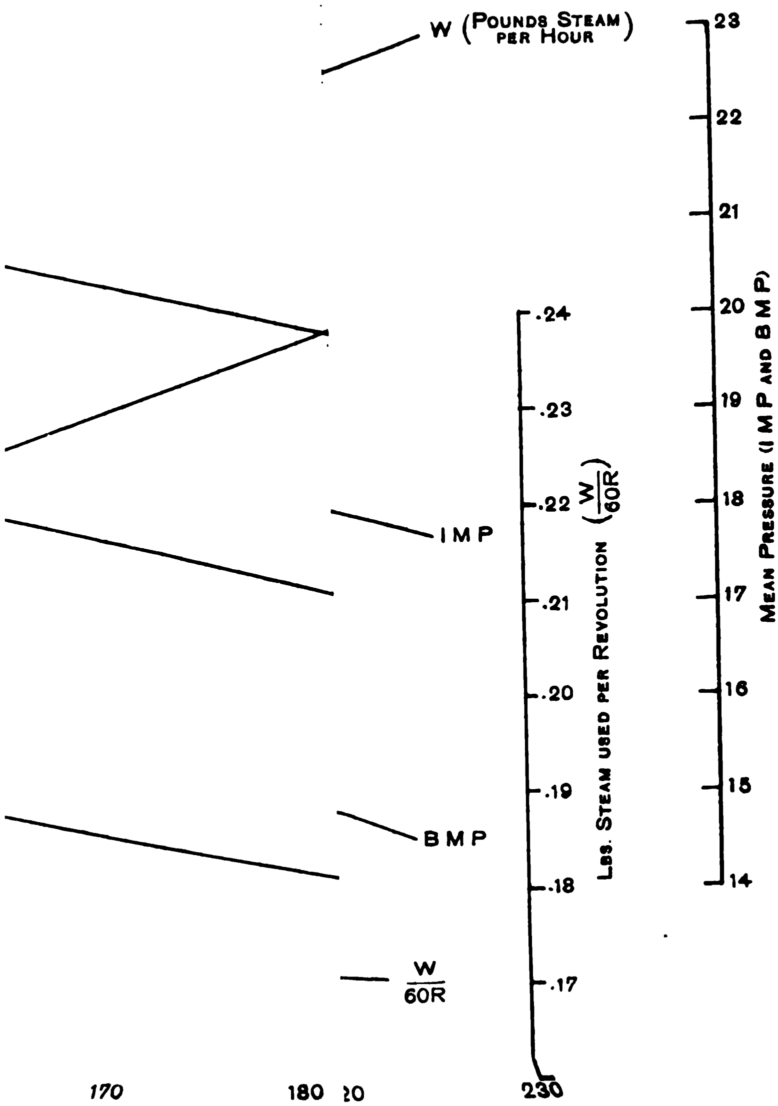
Lbs. absolute. Trials Nos.

Pounds = 7·16R + 678. W at

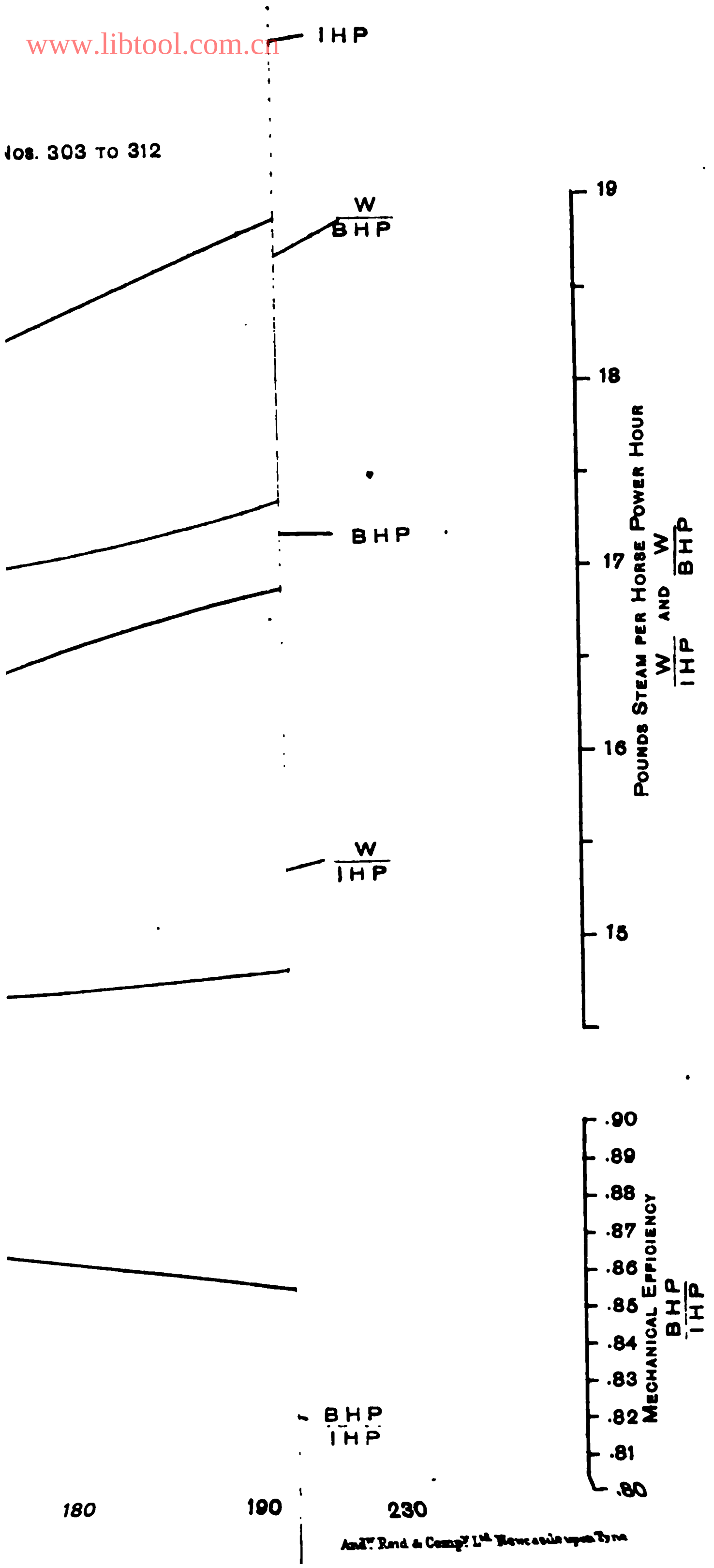
educed to Low Pressure Cyli

Pressure equivalent to Brak

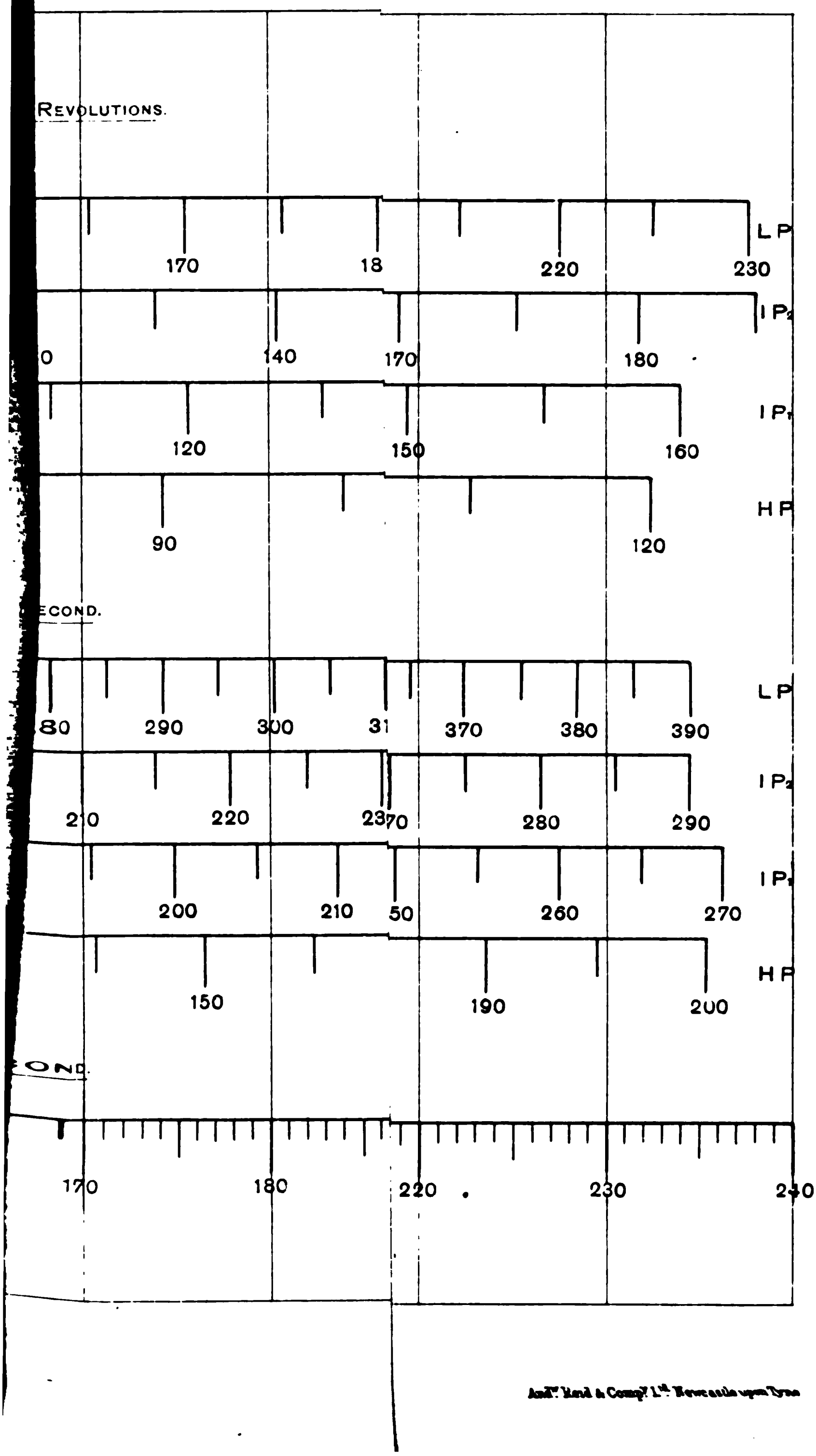
ion.



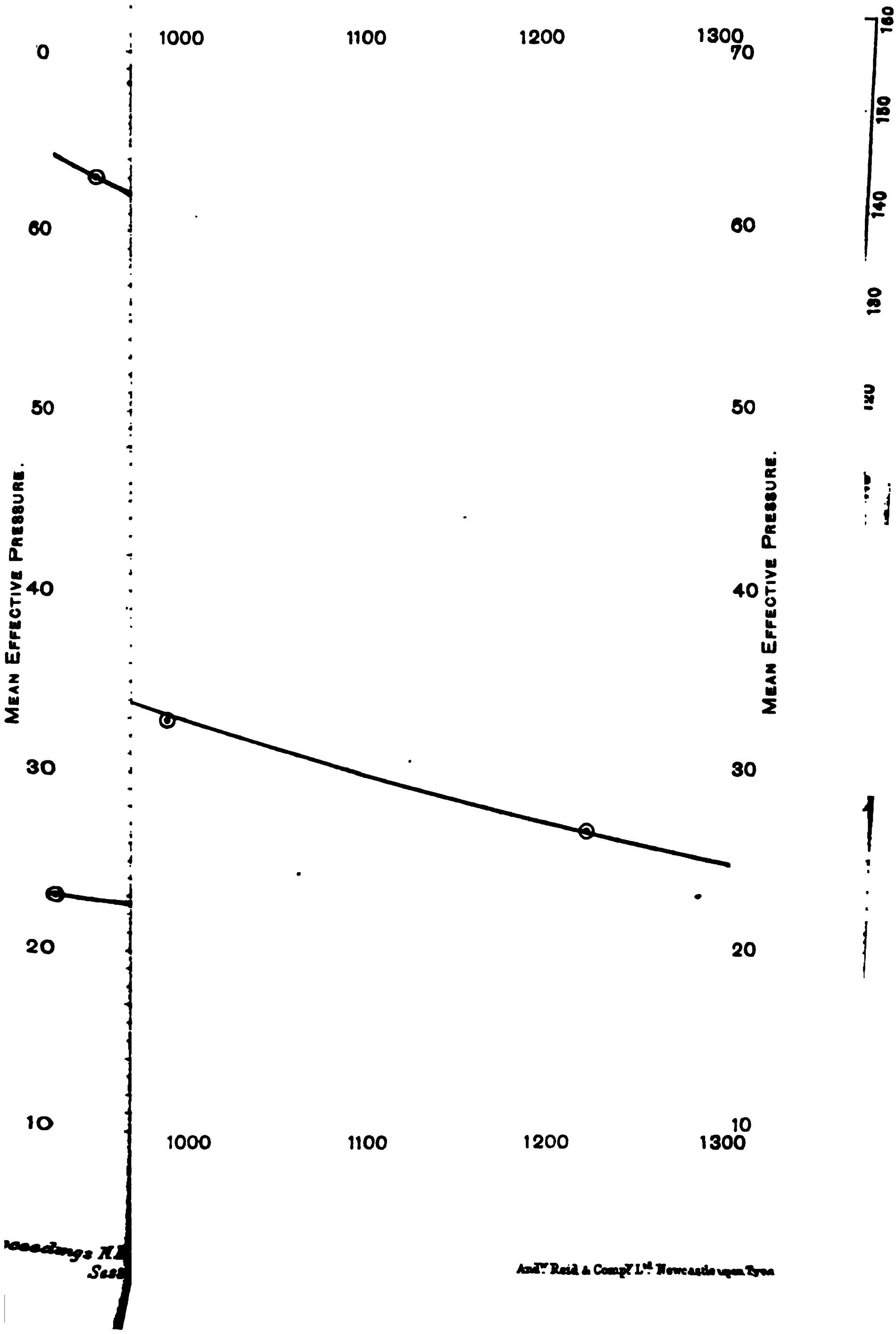
Andw Reid & Compy Ltd Newcastle upon Tyne



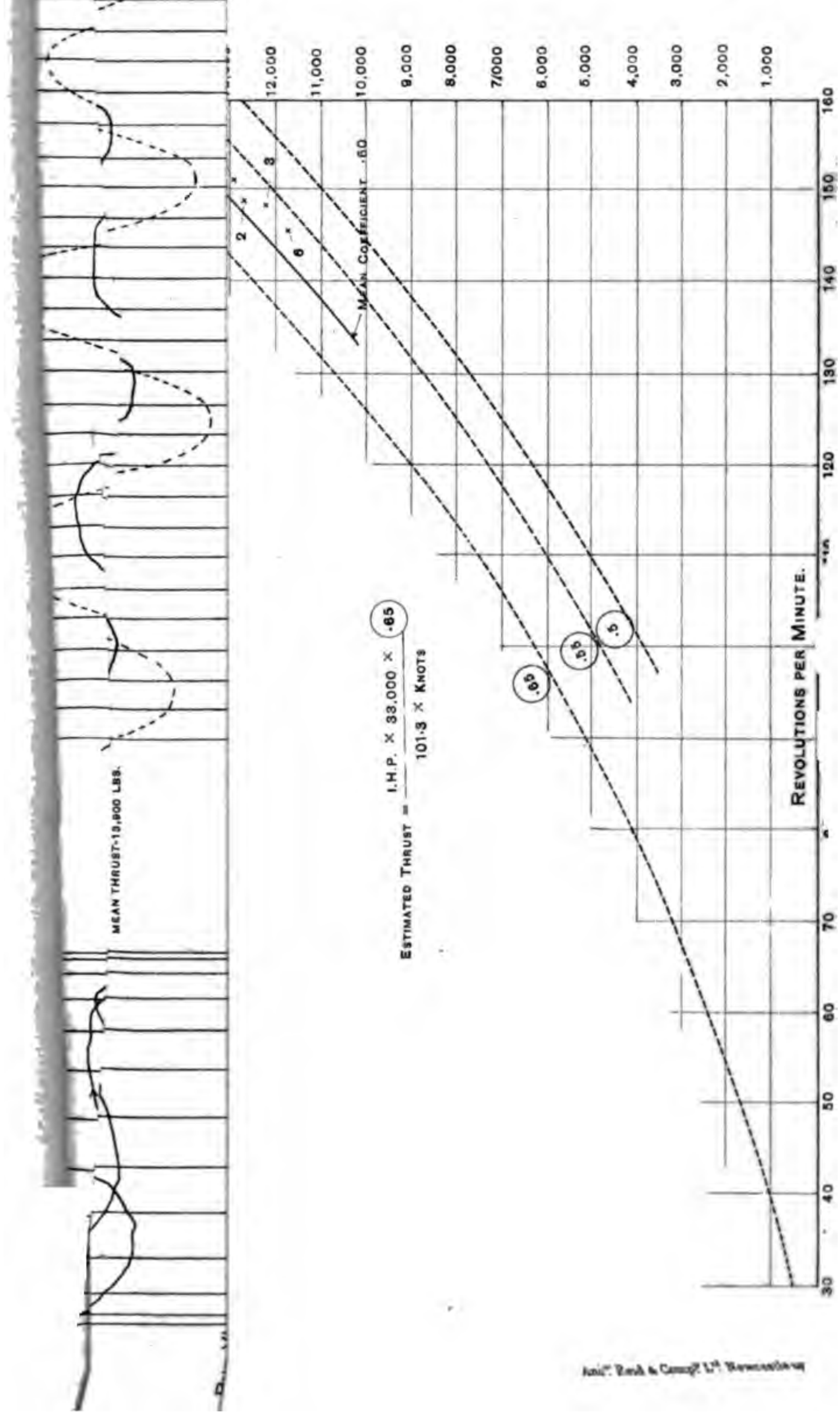
Andw. Reid & Compy. Ltd. Newcastle upon Tyne

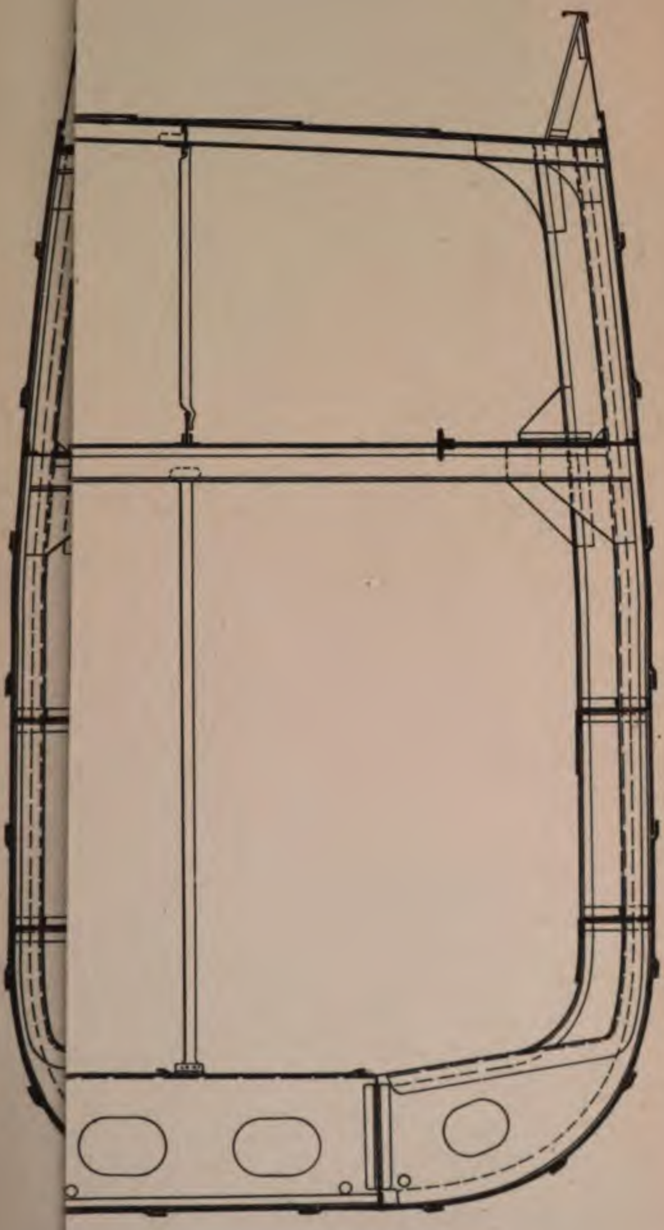


Andw Reid & Compy Ld Newcastle upon Tyne

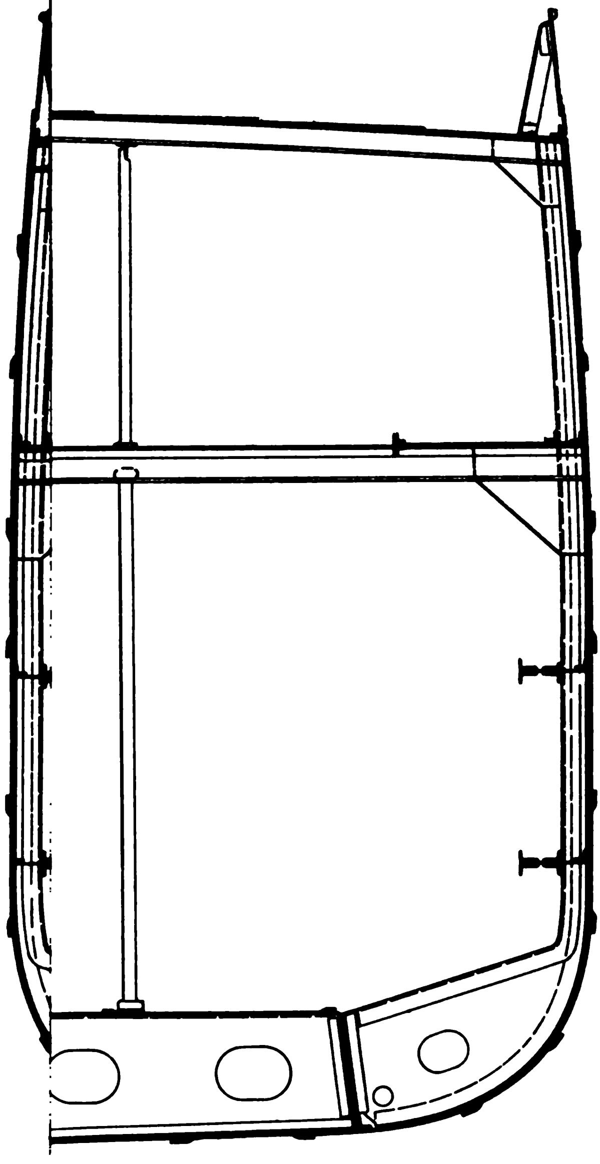


Andw. Reid & Compy. Ld. Newcastle upon Tyne

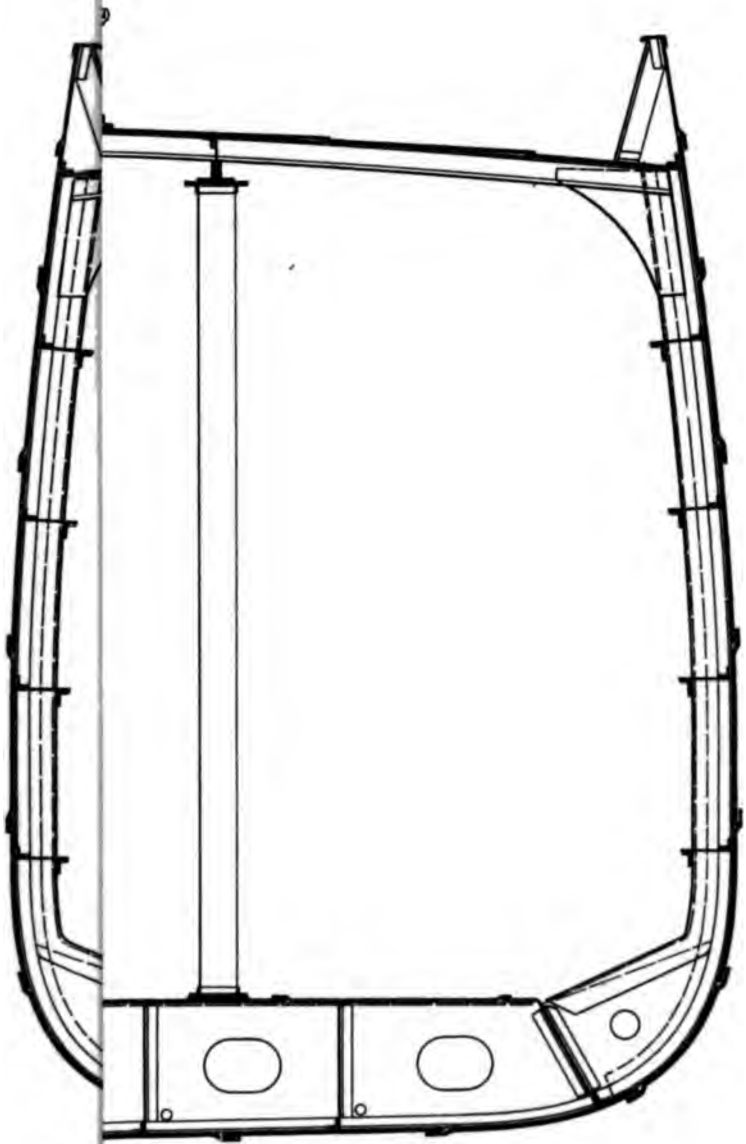

MEAN THRUST-13,900 LBS.
12,000
11,000
10,000
9,000
8,000
7/000
6,000
5,000
4,000
3,000
2,000
1,000
MEAN COEFFICIENT .60
ESTIMATED THRUST = I.H.P. × 33,000 × .65 / 101·3 × KNOTS
.65
.55
.5
REVOLUTIONS PER MINUTE.
160
150
140
130
120
70
60
50
40
30



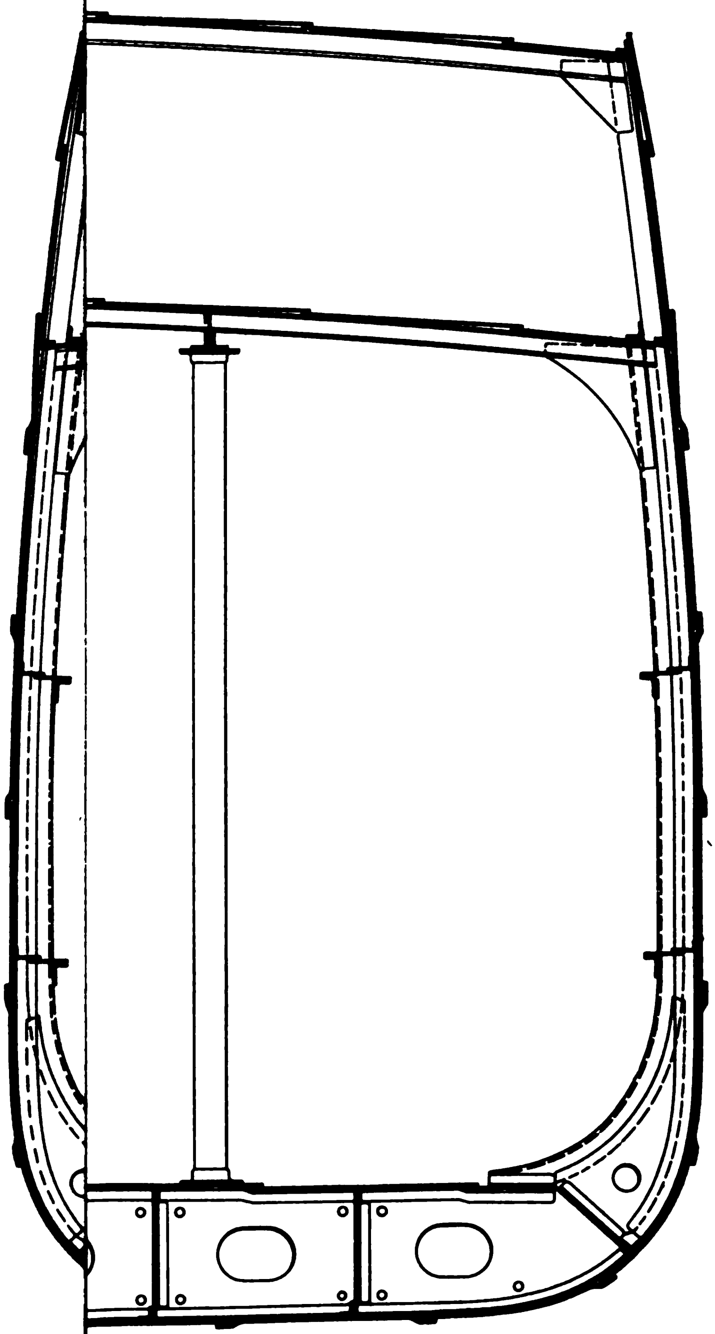
And.w Reid & Comp.y L.td Newcastle upon Tyne



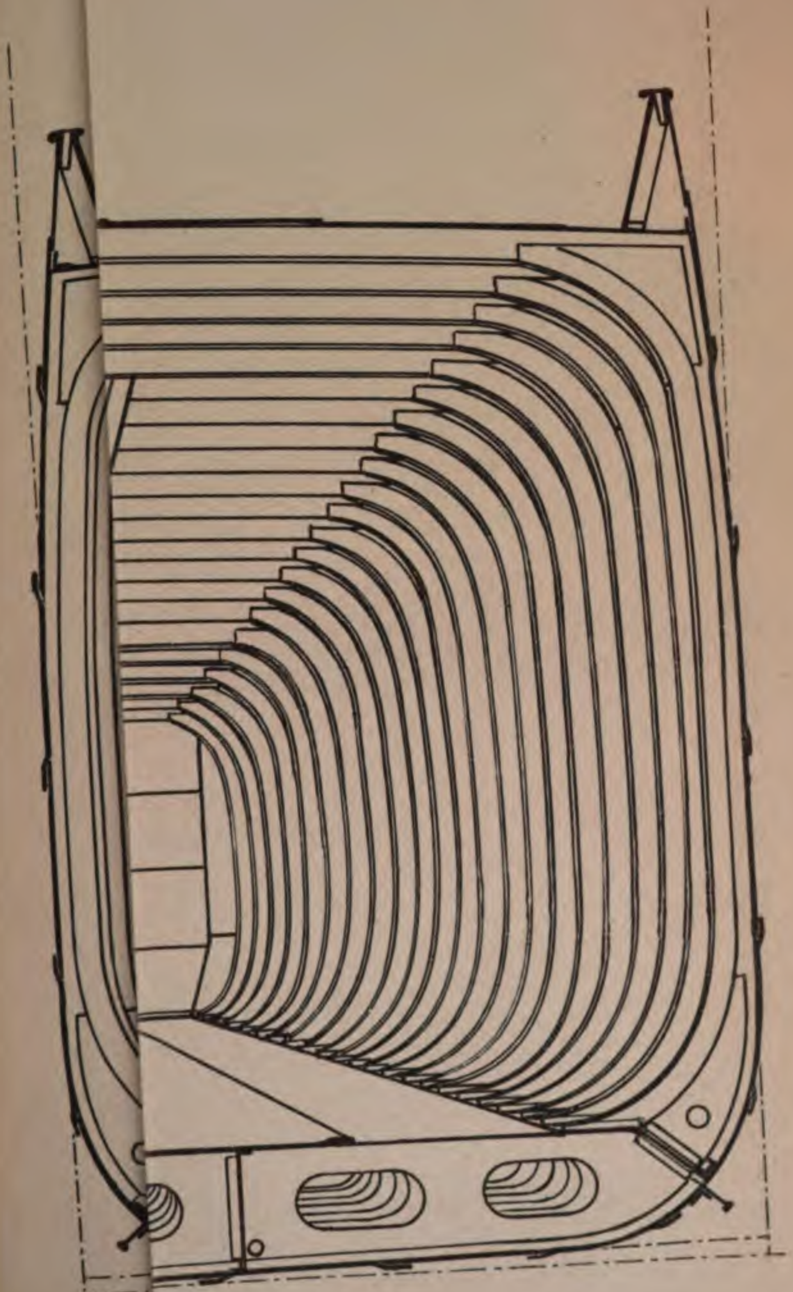
Andw Reid & Compy Ltd Newcastle upon Tyne



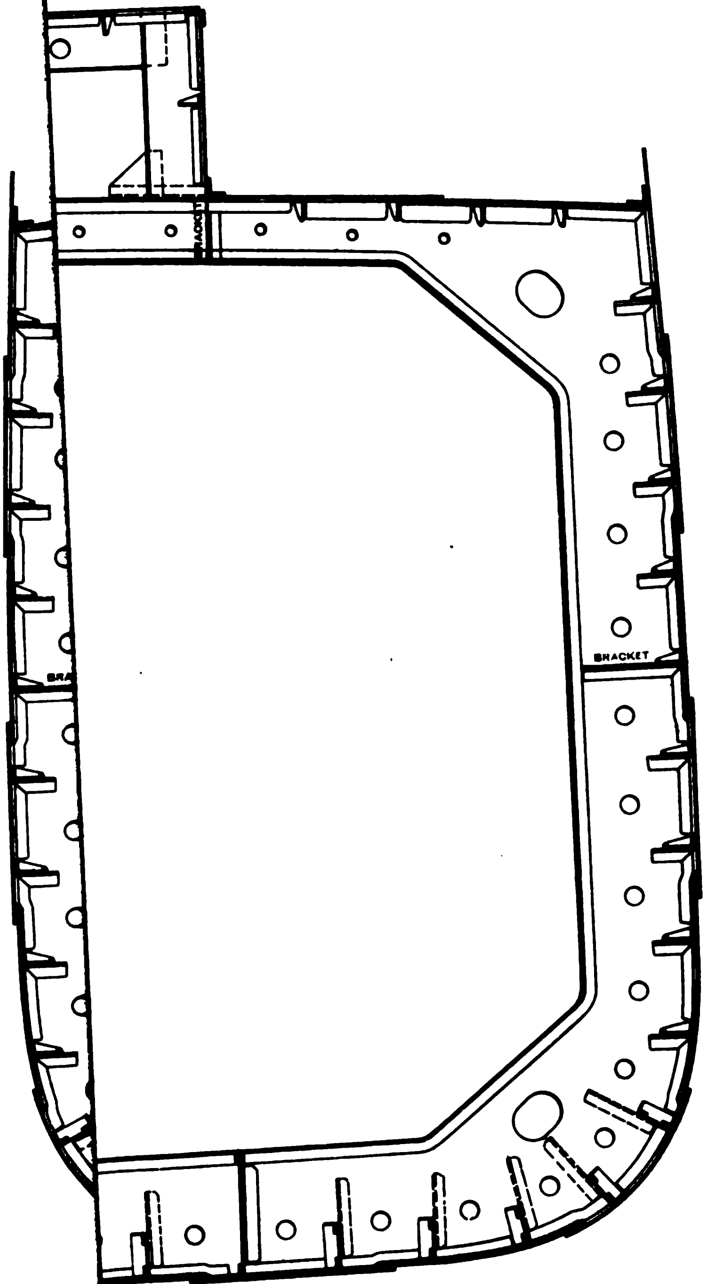
Andw. Reid & Compy. Ltd. Newcastle upon Tyne.



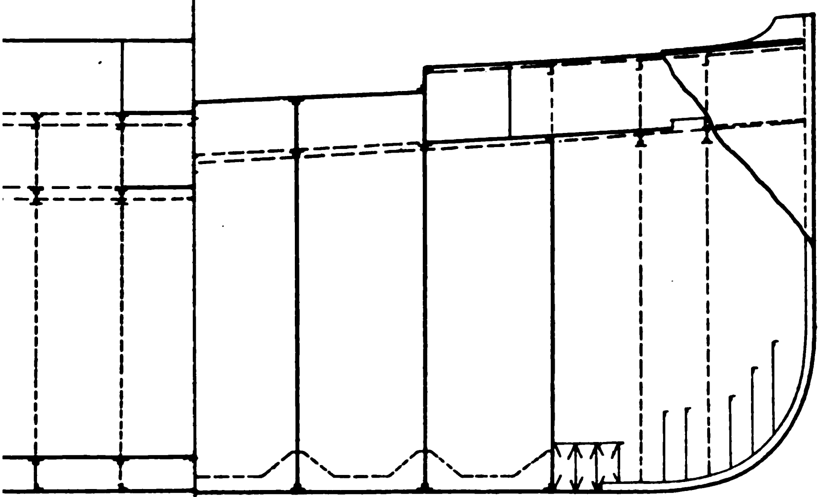
Andw. Reid & Compy. Ltd. Newcastle upon Tyne



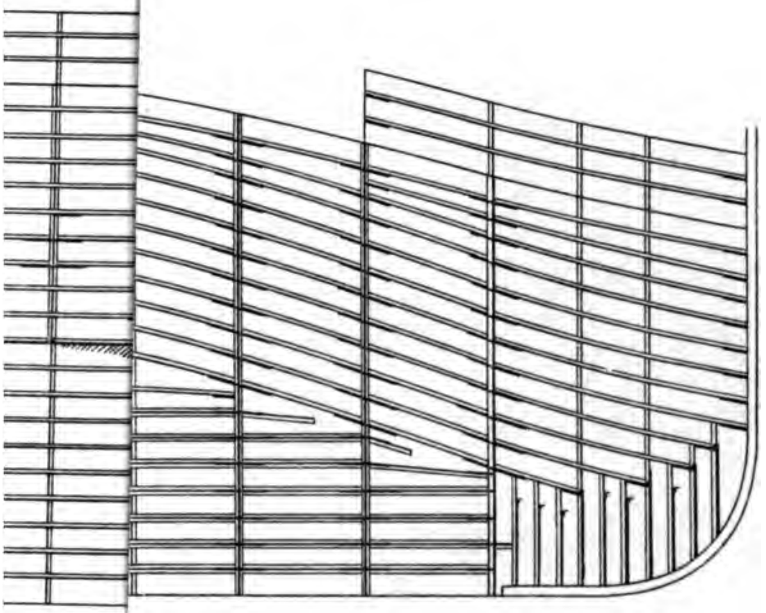
And^w Reid & Comp^y L^td Newcastle upon Tyne



And^w Reid & Comp^y L^td Newcastle upon Tyne



Andw. Reid & Compy. Ltd. Newcastle upon Tyne.



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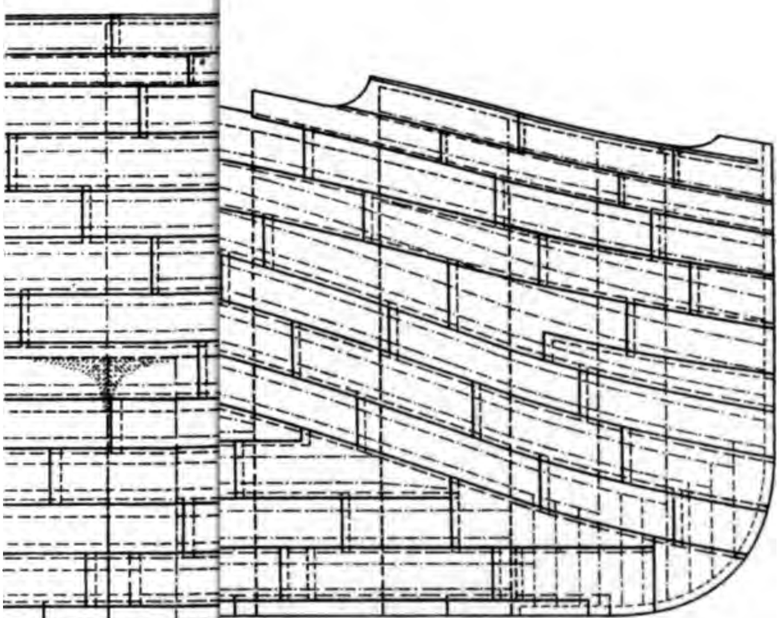
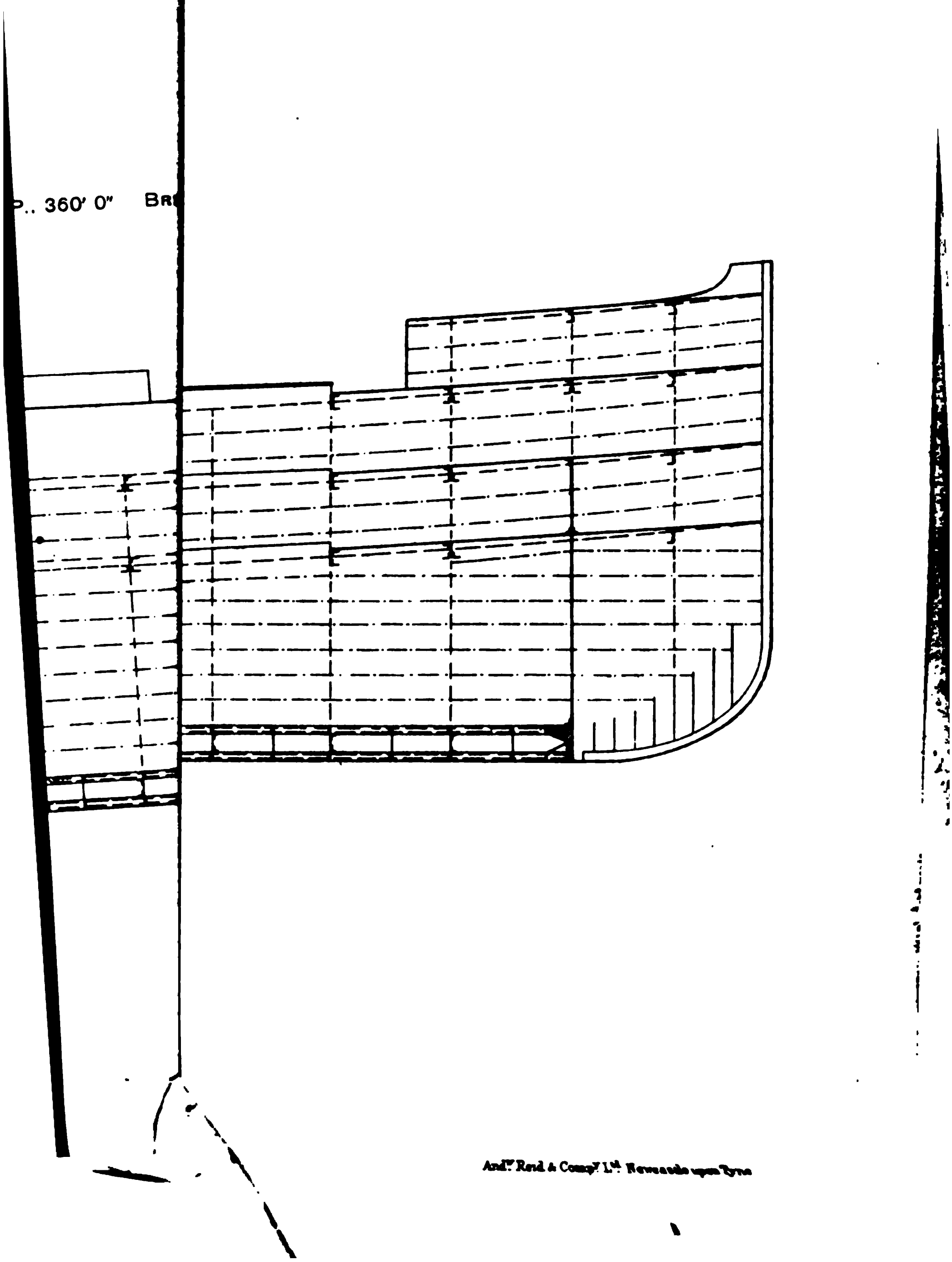


Andw Reid & Compy Ltd Newcastle upon Tyne

E. Hall Grayg



Andw Reid & Compy Ld Newcastle upon Tyne