NORTH OF ENGLAND INSTITUTE OF MINING
AND MECHANICAL ENGINEERS.

TRANSACTIONS.

VOL. XXX.

1880-81.

NEWCASTLE-UPON-TYNE: A. REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

1881.

NEWCASTLE-UPON-TYNE:
ANDREW REID, PRINTING COURT BUILDINGS, AKENSIDE HILL.

CONTENTS OF VOL. XXX.

GENERAL MEETINGS.

Report.

Perhaps at no time in the history of mining has a larger quantity of mineral been brought to the surface than during the year 1880–81, and it would naturally be thought from this circumstance that the profession of mining was in a prosperous condition, whereas, unfortunately, the reverse is the fact, and never has the pressure of adverse times been so severely felt.

The Institute has suffered from this condition of things, but not to the extent that might have been anticipated. The total number of members has decreased by 36, but the income from all sources has increased. This is attributable to the larger amount of arrears that has been collected.

The accumulation of arrears has seriously occupied the attention of the Council for some time past, and although the evil is great as regards the Institute, it is one that is not confined to it alone, for it forms a serious item in the balance sheets of other Societies.

After mature consideration the Council recommend that the most stringent measures provided by the rules for compelling payment of the outstanding subscriptions be applied in all cases, and that in future all those who have not complied with the provisions contained in Form H be taken off the List of Members.

The Report of the Finance Committee appears to be in every way satisfactory, and the fact that there is a balance of a thousand pounds which can be invested, shows that the financial position of the Institute is sound. The Council recommend that the advice of the Finance Committee be adopted, and that this sum be invested in some suitable security. This is the more necessary as the number of life members continues to increase.

There have been no excursions during the past year. A courteous invitation was received in April from the Association des Ingenieurs sortis de l'Ecole de Liège to view the collieries and manufactories of interest in the neighbourhood of Liège; but owing to the lateness of the date at which the invitation was received, most of the members had already made their arrangements for the summer, and there was not a sufficient number of persons who could avail themselves of the invitation to properly represent the Institute before so important a body.

By the kind invitation of Mr. John Daglish a very instructive and enjoyable visit was made to the Whitburn Colliery, to inspect the sinking operations carried on by the Kind-Chaudron process.

The papers read before the Institute during the year have fully equalled those of former years. The contribution of Dr. Saise, on "The Coal-Field of Kurhurballee," gives a most interesting description of the mode of working coal in our Imperial possessions. Mr. J. D. Kendall has added two more geological papers, one on "The Hematite Deposits of West Cumberland," and the other on "The Iron Ores of Antrim," to his previous contributions. Mr. Edwin Gilpin has given a paper on "The Gypsum of Nova Scotia," and Mr. Lebour one on "The Mineral Resources of Central Northumberland."

Some of the more mechanical branches of the profession of the miner have been ably illustrated by Mr. T. J. Bewick in his paper on "Diamond Rock Boring," and by Mr. Charles Parkin in his remarks on "The Treatment of Ores."

That most important question, the Lighting of Mines, has always occupied the attention of the Council, and hearing that Mr. J. W. Swan had invented a mode by which mines could be, partially at least, lighted by electricity, that gentleman was asked to explain his views to the members. Mr. Swan kindly responded to the request, and exhibited the lamp, a description of which has appeared in the Transactions. Most certainly the beautiful mode by which Mr. Swan has succeeded in dividing the light produced by passing an electric current through a thin filament of carbon, has rendered the lighting of collieries by this means even in the most remote workings possible and safe, although much seems yet to be done before that amount of simplicity is attained which will bring the process into general use. The suggestion, however, is a most valuable one, and, in the hands of a gentleman possessed of the practical knowledge of Mr. Swan, is likely to result in a most important change in the present mode of working coal; for increased light means also increased safety, facility for the use of mechanical contrivances underground, and an increased amount of care in the separation of band, impure coal, stone, and other matters, which it is now extremely difficult to distinguish from the pure coal.

However advantageous electricity under control may be in a mine, the "Report of the Committee on the Descent of Lightning in Tanfield Moor Colliery" plainly demonstrates that when not under such control it may be extremely dangerous. From Mr. John Daglish's paper on "The Effects of Lightning at Kimblesworth," and from the discussions which followed, it would appear that occurrences such as are there described may be looked for as constantly likely to happen, with the certainty of exploding gas if there should be any present; and, further, when it is known that sparks from a horse's hoof, or, in fact, sparks caused by any circumstance whatever will fire gas, the wonder is that so few explosions have hitherto occurred in coal mines, and shows how much there is yet to be done to make life and property secure.

Mr. Lindsay Wood's paper on "The Pressure and Quantity of Gas in the Solid Coal," read about twelve months since, has occupied more time than was anticipated in bringing the series of experiments which had been undertaken to a close, but it will now be issued to the members very shortly. This paper will be found unique of its kind, and will no doubt cause more extended inquiry into this very important subject.

The Council has at different times considered whether the Students could not be made more directly interested in the working of the Institute with advantage to both themselves and the members generally. A student has more time for research than a professional man, and has more need perhaps to exchange the results of his experience; but a natural diffidence often prevents him from stating the results he has arrived at before those standing above him in his profession, and it is possible that some scheme might be adopted which would enable the students to have meetings of their own under the presidency of officers chosen from amongst themselves, who might recommend to the Council such papers read at their meetings as they might consider fit to submit to the members and suitable for publication in the Proceedings. Such an arrangement might be the means of bringing the students more together, increasing their professional knowledge, and giving them such additional interest in the Proceedings of the Institute as would probably remain with them for life. The Council consider this a suitable time for bringing the subject forward, as it is probable that the Society of British Students, which has done really good work during the few years it has been in existence, will be dissolved, and as the young men connected with the profession have shown a desire to improve themselves by mutual instruction, it is thought that nothing could possibly be of more service to them than affording them the means of doing so in the way they themselves have pointed out as being the most suitable to their inclinations.

Finance Report.

The Finance Committee have to report that they have minutely examined the finances of the Institute during the last few years, and think that the members have every reason to congratulate themselves upon their position. The highest income the Institute ever realized was in the year 1876–77, when it reached £2,168 16s. 4d. It now stands at £1,993 1s., or only £175 15s. 4d. less, and this in spite of the long period of depression that has been passed through, and which is probably not even now ended. The fact that the amount of income is reduced might seem discouraging were it not that the past year's income shows an increase of £50 9s. 9d. over that of the preceding year.

Although every possible effort has been made to obtain the payment of arrears, there is still a large amount outstanding, and it will be for the Council to decide as to the advisability of rigorously taking the names off the List of Members of all persons not paying their subscriptions in accordance with the rules.

The expenditure of the Institute has been £130 4s. 4d. less than last year, and £504 10s. 7d. less than the income, leaving a balance at the bankers of £1,029 13s. 10d., out of which there is a sum due to the Treasurer of £10 10s. 6d. One thousand pounds of this amount the Committee recommend should be invested.

The Institute continues to hold 134 shares in the Institute and Coal Trade Chambers Company, Limited, of the value of £2,680, and had there been any shares of this Company procurable, the Committee would have recommended that the above-mentioned sum of one thousand pounds should have been invested in this security; but having ascertained that the River Tyne Commissioners are paying 4 per cent. for loans for seven or ten years, the Committee recommend that the money should be invested with that Body for seven years.

G. C. GREENWELL.
WM. COCHRANE.
JOHN B. SIMPSON.

ADVERTISEMENT.

The Institute is not, as a body, responsible for the facts and opinions advanced in the Papers read, and in the Abstracts of the Conversations which occurred at the Meetings during the Session.

DR. THE TREASURER IN ACCOUNT

		£	s.	d.
To 651 Original Members, as per List, 1880-81, 11 of which are Life Members.				
640 at £2 2s.		1,344	0	0
To 22 Ordinary Members, as per List, 1880-81, 1 paid, as Life Member		25	0	0
21 = 1 at £2 2s., 20 at £3 3s.		65	2	0
To 52 Associate Members, as per List, 1880-81, at £2 2s.		109	4	0
To 136 Students, as per List, 1880-81, 2 having paid as Members...		4	4	0
134 at £1 1s.		140	14	0
To 13 Subscribing Collieries		65	2	0
To 4 New Ordinary Members, at £3 3s.		12	12	0
To 12 New Associate Members, at £2 2s.		25	4	0
To 12 New Students, at £1 1s.		12	12	0
		1,803	14	0
To Arrears, as per last Balance Sheet	£598 10 0			
Deduct—				
Irrecoverable Arrears not inserted in 1880-81 List, Dead, Resigned, &c.	148 1 0			
		450	9	0
To Arrears considered as irrecoverable, but since paid		2	2	0
		£2,256	5	0

WITH SUBSCRIPTIONS, 1880-81. Cr.

	PAID. £	s.	d.	UNPAID. £	s.	d.
By 517 Original Members paid	1,085	14	0			
By 93 do. unpaid				195	6	0
By 7 do. dead, unpaid				14	14	0
By 14 do. resigned, unpaid				29	8	0
By 9 do. gone, no address				18	18	0
640						
By 1 Ordinary Member paid as Life Member	25	0	0			
By 16 Ordinary Members paid, at £3 3s.	50	8	0			
By 3 do. unpaid, 1 at £2 2s., 2 at £3 3s. ...				8	8	0
By 2 do. resigned, at £3 3s.				6	6	0
21						
By 42 Associate Members paid, at £2 2s.	88	4	0			
By 9 do. unpaid, at £2 2s.				18	18	0
By 1 do. gone, no address, at £2 2s. ...				2	2	0
52						
By 2 Students paid as Members	4	4	0			
By 105 do. paid, at £1 1s....	110	5	0			
By 26 do. unpaid, at £1 1s.				27	6	0
By 1 do. resigned, unpaid, at £1 1s.				1	1	0
By 2 do. gone, no address, at £1 1s.				2	2	0
134						
By 13 Subscribing Collieries paid	65	2	0			
By 3 New Ordinary Members paid, at £3 3s.	9	9	0			
By 1 do. do. resigned, at £3 3s.				3	3	0
4						
By 11 New Associate Members paid, at £2 2s.	23	2	0			
By 1 do. do. unpaid, at £2 2s.				2	2	0
12						
By 12 New Students, at £1 1s.	12	12	0			
	1,474	0	0	329	14	0
By Members' Arrears	201	12	0	216	6	0
By Students' do.	9	9	0	23	2	0
By Arrears considered irrecoverable, but since paid	2	2	0			
	1,687	3	0	569	2	0
				1,687	3	0
				£2,256	5	0

Audited and Certified,
JOHN G. BENSON & Co.,
Fellows of the Institute of Chartered Accountants.

Newcastle-upon-Tyne, August 4th, 1881.

TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND

Dr. *For the Year ending*

							£	s.	d.
To Balance at Bankers							469	12	6
To Balance in hands of Treasurer							45	0	3
To Dividend of 8 per cent. on 134 Shares of £20 each = £2.680							214	8	0
To Rent of College Class Rooms, less Borough Rates							48	15	6
							777	16	3
To Subscriptions for 1880-81 from 517 Original Members				£1.085	14	0			
Do. do. 16 Ordinary Members				50	8	0			
Do. do. 1 do. paid, as Life Member				25	0	0			
Do. do. 42 Associate Members				88	4	0			
Do. do. 105 Students				110	5	0			
Do. do. 2 do. paid, as Members				4	4	0			
Do. do. 3 New Ordinary Members				9	9	0			
Do. do. 11 New Associate Members				23	2	0			
Do. do. 12 New Students				12	12	0			
To Subscribing Collieries:—									
Ashington	£2	2	0						
Haswell	4	4	0						
Hetton	10	10	0						
Lambton	10	10	0						
North Hetton	6	6	0						
Londonderry	10	10	0						
Ryhope	4	4	0						
Seghill	2	2	0						
South Hetton	4	4	0						
Stella	2	2	0						
Throckley	2	2	0						
Wearmouth	4	4	0						
Whitworth	2	2	0						
				65	2	0			
				1,474	0	0			
To Members' Arrears	201	12	0						
To Students' do.	9	9	0						
To Arrears considered as irrecoverable, but since paid	2	2	0						
				213	3	0			
							1,687	3	0
To Sale of Publications, per A. Reid				42	4	6			
Less 10 per cent. Commission				4	4	6			
				38	0	0			
To Sale of Publications, per Secretary				4	14	6			
							42	14	6
To Balance due Treasurer							10	10	6
							£2,518	4	3

INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

August, 1881. Cr.

	£	s.	d.	£	s.	d.
By Paid A. Reid, Publishing Account	271	5	0			
Do. Covers for Parts and Stitching	33	9	6			
Do. Binding and Sewing Volumes	37	17	0			
Do. Postage	32	10	7			
Do. Stationery and Circulars	148	2	1			
Do. Library	23	13	2			
Do. Borings	33	0	0			
				579	17	4
By other Printing and Stationery				4	7	4
By Secretary's Incidental Expenses and Postage				154	10	3
By Sundry Accounts				73	12	5
By Travelling Expenses				15	6	8
By Secretary's Salary				300	0	0
By Assistant's do.				75	0	0
By Reporter's do.				12	12	0
By Payments on account of Furnishing				5	4	4
By Rent				73	8	4
By Rates and Taxes				14	11	4
By Fire Insurance				9	0	6
By Water, Coals, and Gas				20	11	10
By Subscription to the Natural History Society				20	0	0
By Books for Library, in addition to amount paid A. Reid				51	1	4
By Instruments				”	”	”
By Expenses in connection with Ventilator Experiments				9	18	11
By Awards for Papers				3	7	10
By Snowguard and Repair of Windows, &c., Wood Memorial Hall				66	0	0
				1,488	10	5
By Balance at Bankers				1,029	13	10
By Balance in hands of Treasurer				”	”	”
				£2,518	4	3

Audited and Certified,
JOHN G. BENSON & Co.,
Fellows of the Institute of Chartered Accountants.

Newcastle-upon-Tyne, August 4th, 1881.

DR. GENERAL STATEMENT, AUGUST, 1881. CR.

Liabilities.	£	s.	d.
None	”	”	”
Capital	9,527	18	4
	£9,527	18	4

Assets.	£	s.	d.	£	s.	d.
Balance of Account at Bankers	1,029	13	10			
Less—Balance due Treasurer ...	10	10	6			
				1,019	3	4
134 Shares of £20 each in the Institute and Coal Trade Chambers Company, Limited				2,680	0	0
Arrears of Subscriptions				569	2	0
Value of 397 Bound Volumes of Transactions, @ 11s. 6d.				228	5	6
Value of 4,008 Sewn Copies of Transactions, @ 9s. ...				1,803	12	0
Value of sundry Sheets and Plates belonging to Vol. XXX., unfinished at this date				200	0	0
Value of 37 Copies of Mr. T. F. Brown's Map of the South Wales Coal-Field, @ 5s.				9	5	0
Value of 481 Copies of General Index, @ 3s.				72	3	0
Value of 815 Copies of Fossil Illustrations, @ 12s. 6d.				509	7	6
Value of 908 Copies of Fossil Catalogues, @ 5s. ...				227	0	0
Value of 400 Copies of Borings and Sinkings, Vol. I., @ 5s.				100	0	0
Value of 1,500 Vols. of Borings and Sinkings in Sheets				300	0	0
Value of sundry Sheets belonging to Vol. II. of Borings and Sinkings, unfinished at this date				110	0	0
Value of Furniture and Office Fittings				300	0	0
Value of Books and Maps in Library				1,400	0	0
				£9,527	18	4

Audited and Certified (Share Certificates produced),

JOHN G. BENSON & Co.,

CHARTERED ACCOUNTANTS.

Newcastle-on-Tyne, 4th August, 1881.

Patrons.

His Grace the DUKE OF NORTHUMBERLAND.
His Grace the DUKE OF CLEVELAND.
The Most Noble the MARQUESS OF LONDONDERRY.
The Right Honourable the EARL OF LONSDALE.
The Right Honourable the EARL OF DURHAM.
The Right Honourable the EARL GREY.
The Right Honourable the EARL OF RAVENSWORTH.
The Right Honourable the LORD WHARNCLIFFE.
The Right Reverend the LORD BISHOP OF DURHAM.
The Very Reverend the DEAN AND CHAPTER OF DURHAM.
WENTWORTH B. BEAUMONT, Esq., M.P.

Honorary Members.

	Elected.	
	Orig.	Hon
The Right Honourable the EARL OF RAVENSWORTH		1877
WILLIAM ALEXANDER, Esq., Inspector of Mines, Glasgow		1863
* JAMES P. BAKER, Esq., Inspector of Mines, Wolverhampton	1853	1866
JOSEPH DICKINSON, Esq., Inspector of Mines, Manchester		1853
THOMAS EVANS, Esq., Inspector of Mines, Pen-y-Bryn, Duffield Road, Derby		1855
* HENRY HALL, Esq., Inspector of Mines, Rainhill, Prescott		1876
* RALPH MOORE, Esq., Inspector of Mines, Glasgow		1866
CHARLES MORTON, Esq., The Grange, St. Paul's, Southport		1853
* THOMAS E. WALES, Esq., Inspector of Mines, Swansea	1855	1866
* FRANK N. WARDELL, Esq., Inspector of Mines, Wath-on-Dearne, near Rotherham	1864	1868
* JAMES WILLIS, Esq., Inspector of Mines, 14, Portland Terrace, Newcastle-on-Tyne	1857	1871
THOMAS WYNNE, Esq., Inspector of Mines, Manor House, Gnosall, Stafford		1853
WARINGTON W. SMYTH, Esq., 28, Jermyn Street, London		1869
THE VERY REV. DR. LAKE, Dean of Durham		1872
* PROF. W. S. ALDIS, M.A., Principal of the Col. of Phys. Sc., N'castle		1872
* „ G. S. BRADY, M.D., F.L.S. do. do.		1875
* „ A. FREIRE-MARRECO, M.A. do. do.		1872
* „ A. S. HERSCHEL, M.A., F.R.A.S. do. do.		1872
* „ G. A. LEBOUR, M.A., F.G.S. do. do.	1873	1879
M. DE BOUREUILLE, Commandeur de la Légion d'Honneur, Conseiller d'état, Inspecteur General des Mines, Paris		1853
DR. H. VON DECHEN, Berghauptmann, Ritter, etc., Bon-am-Rhine, Prussia		1853
M. THEOPHILE GUIBAL. School of Mines, Mons, Belgium		1870
M. E. VUILLEMIN, Mines d'Aniche (Nord), France		1878

Life Members.

	Orig.	Life.
C. W. BARTHOLOMEW, Esq., Blakesley Hall, near Towcester		1875
DAVID BURNS, Esq., C.E., Brookside, Haltwhistle		1877
E. B. COXE, Esq., Drifton, Jeddo, P.O., Luzerne Co., Penns., U.S.	1873	1874
JAMES S. DIXON, Esq., 170, Hope Street, Glasgow	1878	1880
ERNEST HAGUE, Esq., Castle Dyke, Sheffield	1872	1876
G. C. HEWITT, Esq., Coalpit Heath Colliery, near Bristol	1871	1879
HENRY LAPORTE, Esq., M.E., 80, Rue Royale, Brussels		1877
NATHAN MILLER, Esq., Kurhurballee Collieries, East Indian Railway, Chord Line, Bengal		1878
H. J. MORTON, Esq., 4, Royal Crescent, Scarborough	1856	1861
RUDOLPH NASSE, Konigl Bergwerks Director, Louisenthal, Saarbrücken	1869	1880
W. A. POTTER, Esq., Cramlington House, Northumberland	1853	1874
R CLIFFORD SMITH, Esq., Parkfield, Swinton, Manchester		1874

* Honorary Members during term of office only.

OFFICERS, 1881-82.

President.

GEORGE BAKER FORSTER, Esq., M.A., Backworth House, Newcastle-on-Tyne.

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WM. ARMSTRONG, Sen., Esq., Pelaw House, Chester-le-Street.
CUTHBERT BERKLEY, Esq., Marley Hill, Gateshead.
T. J. BEWICK, Esq., Haydon Bridge, Northumberland.
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THOMAS DOUGLAS, Esq., West Lodge, Crook, Darlington.
J. B. SIMPSON, Esq., Hedgefield House, Blaydon-on-Tyne.

Council.

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E. BAINBRIDGE, Esq., Nunnery Colliery Offices, Sheffield.
T. W. BENSON, Esq , 11, Newgate Street, Newcastle-on-Tyne.
R. F. BOYD, Esq., Moor House, Fence Houses.
V. W. CORBETT, Esq., Chilton Moor, Fence Houses.
S. B. COXON, Esq., Usworth Hall, Washington Station, Co. Durham.
S. C. CRONE, Esq., Killingworth Hall, Newcastle-on-Tyne.
W. GREEN, Jun., Esq., Thornelly House, Lintz Green.
W. H. HEDLEY, Esq., Medomsley, Newcastle-on-Tyne.
THOS. HEPPELL, Esq., Leafield House, Chester-le-Street.
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GEO. MAY, Esq., Harton Colliery Offices, Tyne Docks, South Shields.
R. S. NEWALL, Esq., Ferndene, Gateshead.
A. M. POTTER, Esq., Shire Moor Colliery, Newcastle-on-Tyne.
J. G. WEEKS, Esq., Bedlington Colliery, Bedlington.
JAMES WILLIS, Esq., 14, Portland Terrace, Newcastle-on-Tyne.
W. O. WOOD, Esq., Trimdon Grange Colliery, Co. Durham.

Ex-officio	SIR W. G. ARMSTRONG, C.B., LL.D., F.R.S., Jesmond, Newcastle-on-Tyne.	Past Presidents.
	E. F. BOYD, Esq., Moor House, Fence Houses.	
	SIR GEORGE ELLIOT, Bart., Houghton Hall, Fence Houses.	
	G. C. GREENWELL, Esq., F.G.S., Tynemouth.	
	LINDSAY WOOD, Esq., Southill, Chester-le-Street.	
	WM. COCHRANE, Esq., Grainger Street West, Newcastle-on-Tyne.	Retiring Vice-Presidents.
	JOHN MARLEY, Esq., Mining Offices, Darlington.	
	A. L. STEAVENSON, Esq., Durham.	

Secretary and Treasurer.

THEO. WOOD BUNNING, Neville Hall. Newcastle-on-Tyne

List of Members.

AUGUST, 1881.

Original Members.

	Marked (*) are Life Members.	ELECTED.
1	Adams, G. F., Guild Hall Chambers, Cardiff	Dec. 6, 1873
2	Adams, W., Cambridge House, Park Place, Cardiff	1854
3	Adamson, Daniel, Engineering Works, Dukinfield, near Manchester	Aug. 7, 1875
4	Addy, W. F., Marehay Main Colliery, Ripley, near Derby	May 6, 1876
5	Aitkin, Henry, Falkirk, N.B.	Mar. 2, 1865
6	Allison, T., Belmont Mines, Guisbro'	Feb. 1, 1868
7	Anderson, C. W., Sea View, South Shields	Aug. 21, 1852
8	Anderson, William, Rainton Colliery, Fence Houses	Aug. 21, 1852
9	Andrews, Hugh, Felton Park, Felton, Northumberland	Oct. 5, 1872
10	Appleby, C. E., Charing Cross Chambers, Duke St., Adelphi, London	Aug. 1, 1861
11	Archer, T., Dunston Engine Works, Gateshead	July 2, 1872
12	Armstrong, Sir W. G., C.B., LL.D., F.R.S., Jesmond, Newcastle-upon-Tyne (Past President, *Member of Council*)	May 3, 1866
13	Armstrong, Wm., Sen., Pelaw House, Chester-le-St. (Vice-President)	Aug. 21, 1852
14	Armstrong, W., Junior, Wingate, Co. Durham *(Member of Council)*	April 7, 1867
15	Armstrong, W. L., Kettlebrook Colliery, Tamworth	Mar. 3, 1864
16	Arthur, David, M. E., Accrington, near Manchester	Aug. 4, 1877
17	Ashworth, James, 56, Upper Duke Street, Southport	Feb. 5, 1876
18	Ashworth, John, Bryn Celyn, Llanferis, Mold	Sept. 2, 1876
19	Asquith, T. W., Seaton Delaval Colliery, Northumberland	Feb. 2, 1867
20	Atkinson, J. B., Ridley Mill, Stocksfield-on-Tyne	Mar. 5, 1870
21	Atkinson, W. N., Shincliffe Hall, Durham	June 6, 1868
22	Aubrey, R. C., Wigan Coal & Iron Co. Ld., Standish, near Wigan	Feb. 5, 1870
23	Austine, John, Cadzow Coal Co., Glasgow	Nov. 4, 1876
24	Aynsley, Wm., Brynkinalt Collieries, Chirk, Ruabon	Mar. 3, 1873
25	Bagley, Chas. John, Tees Bridge Iron Co., Stockton	June 5, 1875
26	Bailes, George, Murton Colliery, Sunderland	Feb. 3, 1877
27	Bailes, John, Wingate Colliery, Ferryhill	Sept. 5, 1868
28	Bailes, T., Junior, 41, Lovaine Place, Newcastle-on-Tyne	Oct. 7, 1858
29	Bailes, W., West Melton, Rotherham	April 7, 1877
30	Bailey, Samuel, Perry Barr, Birmingham	June 2, 1859
31	Bain, R. Donald, Newport, Monmouthshire	Mar. 3, 1873

		ELECTED.
32	Bainbridge, E., Nunnery Colliery Offices, Sheffield *(Mem. of Council)*	Dec. 3, 1863
33	Banks, Thomas, Leigh, near Manchester	Aug. 4, 1877
34	Barclay, A., Caledonia Foundry, Kilmarnock	Dec. 6, 1866
35	Barkus, Wm.	Aug. 21, 1852
36	Barnes, T., Seaton Delaval Office, Quay, Newcastle-on-Tyne	Oct. 7, 1871
37	Barrat, A. J., Ruabon Coal Co., Ruabon	Sept. 11, 1875
38	Bartholomew, C., Castle Hill House, Ealing, London, W.	Aug. 5, 1853
39*	Bartholomew, C. W., Blakesley Hall, near Towcester	Dec. 4, 1875
40	Bassett, A., Tredegar Mineral Estate Office, Cardiff	1854
41	Bates, Matthew, Bews Hill, Blaydon-on-Tyne	Mar. 3, 1873
42	Bates, Thomas, Heddon, Wylam, Northumberland	Mar. 3, 1873
43	Bates, W. J., Old Axwell, Whickham, Gateshead-on-Tyne	Mar. 3, 1873
44	Batey, John, Newbury Collieries, Coleford, Bath	Dec. 5, 1868
45	Beanlands, A., M.A., North Bailey, Durham	Mar. 7, 1867
46	Beaumont, James, M.E., Nanaimo, Vancouver's Island	Nov. 7, 1874
47	Bell, I. L., Rounton Grange, Northallerton	July 6, 1854
48	Bell, John (Messrs. Bell Brothers), Middlesbro'-on-Tees	Oct. 1, 1857
49	Bell, Thomas, Crosby Court, Northallerton	Sept. 3, 1870
50	Bell, T., Jun. (Messrs. Bell Brothers), Middlesbro'-on-Tees	Mar. 7, 1867
51	Benson, J. G., Accountant, Newcastle-on-Tyne	Nov. 7, 1874
52	Benson, T. W., 11, Newgate Street, Newcastle *(Member of Council)*	Aug. 2, 1866
53	Berkley, C., Marley Hill Colliery, Gateshead ... (Vice-President)	Aug. 21, 1852
54	Beswicke, Wm., South Parade, Rochdale	Sept. 11, 1875
55	Bewick, T. J., M. Inst. C.E., F.G.S., Haydon Bridge, Northumberland (Vice-President)	April 5, 1860
56	Bidder, B. P., c/o C. J. Ryland, 3, Small Street, Bristol	May 2, 1867
57	Bigland, J., Bedford Lodge, Bishop Auckland	June 4, 1857
58	Binns, C., Claycross, Derbyshire	July 6, 1854
59	Biram, B., Peaseley Cross Collieries, St. Helen's, Lancashire	1856
60	Black, James, Jun., Portobello Foundry, Sunderland	Sept. 2, 1871
61	Black, W., Hedworth Villa, South Shields	April 2, 1870
62	Bolam, H. G., Little Ingestre, Stafford	Mar. 6, 1875
63	Bolton, H. H., Newchurch Collieries, near Manchester	Dec. 5, 1868
64	Booth, R. L., Ashington Colliery, near Morpeth	1864
65	Bourne, Peter, 39, Rodney Street, Liverpool	1854
66	Bourne, Thos. W., Broseley, Salop	Sept. 11, 1875
67	Boyd, E. F., Moor House, Fence Houses (Past Pres., *Mem. of Council*)	Aug. 21, 1852
68	Boyd, R. F., Moor House, Fence Houses ... *(Member of Council)*	Nov. 6, 1869
69	Boyd, Wm., 74, Jesmond Road, Newcastle-on-Tyne	Feb. 2, 1867
70	Bradford, Geo., Etherley, Bishop Auckland	Oct. 11, 1873
71	Breckon, J. R., Park Place, Sunderland	Sept. 3, 1864
72	Brettell, T., Mine Agent, Dudley, Worcestershire	Nov. 3, 1866
73	Bromilow, Wm., 18, Leicester Street, Southport, Lancashire	Sept. 2, 1876
74	Brown, E., 79, Clayton Street, Newcastle-on-Tyne	Mar. 7, 1874
75	Brown, John, The Hawthorns, 3, Lozell's Road, Birmingham	Oct. 5, 1854
76	Brown, J. N., 56, Union Passage, New Street, Birmingham	1861
77	Brown, Thos. Forster, Guild Hall Chambers, Cardiff	1861

		ELECTED.
78	Browne, B. C., M.I.C.E., No. 2, Granville Road, Jesmond, Newcastle	Oct. 1, 1870
79	Bruton, W., 32, High Street, Rotherham, Yorkshire	Feb. 6, 1869
80	Bryham, William, Rosebridge Colliery, Wigan	Aug. 1, 1861
81	Bryham, W., Jun., Douglas Bank Collieries, Wigan	Aug. 3, 1865
82	Bunning, Theo. Wood, Neville Hall, Newcastle-on-Tyne *(Secretary and Treasurer)*	1864
83*	Burns, David, C.E., Brookside, Haltwhistle	May 5, 1877
84	Burrows, J. S., Howe Bridge, Atherton, near Manchester	Oct. 11, 1873
85	Caldwell, Geo., The Grove, West Houghton, nr. Bolton, Lancashire	Mar. 6, 1869
86	Campbell, W. B., Consulting Engineer, Grey Street, Newcastle	Oct. 7, 1876
87	Carr, Wm. Cochran, South Benwell, Newcastle-on-Tyne	Dec. 3, 1857
88	Carrington, T., Jun., Endcliffe Court, Sheffield	Aug. 1, 1861
89	Catron, J., Brotton Hall, Saltburn-by-the-Sea	Nov. 3, 1866
90	Chadborn, B. T., Pinxton Collieries, Alfreton, Derbyshire	1864
91	Chambers, A. M., Thorncliffe Iron Works, near Sheffield	Mar. 6, 1869
92	Chapman, M., Plashetts Colliery, Northumberland	Aug. 1, 1868
93	Charlton, George, Washington Colliery, Co. Durham	Feb. 6, 1875
94	Checkley, Thomas, M.E., Lichfield Street, Walsall	Aug. 7, 1869
95	Cheesman, I., Throckley Colliery, Newcastle-on-Tyne	Feb. 1, 1873
96	Cheesman, W. T., Wire Rope Manufacturer, Hartlepool	Feb. 5, 1876
97	Childe, Rowland, Wakefield, Yorkshire	May 15, 1862
98	Clarence, Thomas, Elswick Colliery, Newcastle-on-Tyne	Dec. 4, 1875
99	Clark, C. F., Garswood Coal and Iron Co., near Wigan	Aug. 2, 1866
100	Clark, G., Newton-le-Willows, Lancashire	Dec. 7, 1867
101	Clark, R. B., Marley Hill, near Gateshead	May 3, 1873
102	Clark, W., M.E., The Grange, Teversall, near Mansfield	April 7, 1866
103	Clarke, William, Victoria Engine Works, Gateshead	Dec. 7, 1867
104	Cochrane, B., Aldin Grange, Durham	Dec. 6, 1866
105	Cochrane, C., The Grange, Stourbridge	June 3, 1857
106	Cochrane, W., St. John's Chambers, Grainger Street West, Newcastle *(Member of Council)*	1859
107	Cockburn, G., 8, Summerhill Grove, Newcastle-on-Tyne	Dec. 6, 1866
108	Cole, Richard, Walker Colliery, near Newcastle-on-Tyne	April 5, 1873
109	Cole, Robert Heath, Scholar Green, Stoke-upon-Trent	Feb. 5, 1876
110	Cole, W. R., Broomfield, Jesmond, Newcastle-on-Tyne	Oct. 1, 1857
111	Collis, W. B., Swinford House, Stourbridge, Worcestershire	June 6, 1861
112	Cook, J., Jun., Washington Iron Works, Gateshead	May 8, 1869
113	Cooke, John, Langley Old Hall, near Durham	Nov. 1, 1860
114	Cooksey, Joseph, West Bromwich, Staffordshire	Aug. 3, 1865
115	Cooper, P., Thornley Colliery Office, Ferryhill	Dec. 3, 1857
116	Cooper, R. E., C.E., 1, Westminster Chambers, Victoria Street, London	Mar. 4, 1871
117	Cooper, T., Rosehill, Rotherham, Yorkshire	April 2, 1863
118	Cope, James, Port Vale, Longport, Staffordshire	Oct. 5, 1872
119	Corbett, V. W., Chilton Moor, Fence Houses *(Member of Council)*	Sept. 3, 1870
120	Corbitt, M., Wire Rope Manufacturer, Teams, Gateshead	Dec. 4, 1875
121	Coulson, F., 10, Victoria Terrace, Durham	Aug. 1, 1868

		ELECTED.
122	Coulson, W., 32, Crossgate, Durham	Oct. 1, 1852
123	Cowen, Jos., M.P., Blaydon Burn, Newcastle-on-Tyne	Oct. 5, 1854
124	Cowey, John, Wearmouth Colliery, Sunderland	Nov. 2, 1872
125	Cowlishaw, J., Thorncliffe, &c., Collieries, near Sheffield	Mar. 7. 1867
126	Cox, John H., 10, St. George's Square, Sunderland	Feb. 6, 1875
127*	Coxe, E. B., Drifton, Jeddo, P. O. Luzerne Co., Penns., U.S.	Feb. 1, 1873
128	Coxon, S. B., Usworth Colliery, Washington Station, Co. Durham *(Member of Council)*	June 5, 1856
129	Craig, W. Y., Palace Chambers, St. Stephen's, Westminster, London	Nov. 3, 1866
130	Crawford, T., Littletown Colliery, near Durham	Aug. 21, 1852
131	Crawford, T., 3, Grasmere Street, Gateshead-on-Tyne	Sept. 3, 1864
132	Crawford, T., Jun. Littletown Colliery, near Durham	Aug. 7, 1869
133	Crawshay, E., Gateshead-on-Tyne	Dec. 4, 1869
134	Crawshay, G., Gateshead-on-Tyne	Dec. 4, 1869
135	Crone, E. W., Killingworth Hall, near Newcastle-on-Tyne	Mar. 5, 1870
136	Crone, J. R., Tow Law, *via* Darlington	Feb. 1, 1868
137	Crone, S. C., Killingworth Colliery, Newcastle *(Member of Council)*	1853
138	Cross, John, 71, King Street, Manchester	June 5, 1869
139	Croudace, C. J., The Laurels, Newton, by Chester	Nov. 2, 1872
140	Croudace, John, West House, Haltwhistle	June 7, 1873
141	Croudace, Thomas, Lambton Lodge, New South Wales	1862
142	Daglish, John, Marsden, South Shields (Vice-President)	Aug. 21, 1852
143	Daglish, W. S., Solicitor, Newcastle-on-Tyne	July 2, 1872
144	Dakers, J., Chilton Colliery, Ferryhill	April 11, 1874
145	Dale, David, West Lodge, Darlington	Feb. 5, 1870
146	D'Andrimont, T., Liége, Belgium	Sept. 3, 1870
147	Daniel, W., Steam Plough Works, Leeds	June 4, 1870
148	Darling, Fenwick, South Durham Colliery, Darlington	Nov. 6, 1875
149	Darlington, John, 2, Coleman Street Buildings, Moorgate Street, Great Swan Alley, London	April 1, 1865
150	Darlington, J., Black Park Colliery Co. Limited, Ruabon	Nov. 7, 1874
151	Davey, Henry, C.E., Leeds	Oct. 11, 1873
152	Davis, David, Coal Owner, Maesyffynon, Aberdare	Nov. 7, 1874
153	Day, W. H., Eversley Garth, So. Milford	Mar. 6, 1869
154	Dees, R. R., Solicitor, Newcastle-on-Tyne	Oct. 7, 1871
155	Dickinson, G T., 14, Claremont Place, Newcastle-on-Tyne	July 2, 1872
156	Dickinson, R., Coal Owner, Shotley Bridge, Co. Durham	Mar. 4, 1871
157	Dixon, D. W., Brotton Mines, Saltburn-by-the-Sea	Nov. 2, 1872
158	Dixon, Nich., Dudley Colliery, Dudley, Northumberland	Sept. 1, 1877
159	Dixon, R., Wire Rope Manufacturer, Teams, Gateshead	June 5, 1875
160	Dodd, B., Bearpark Colliery, near Durham	May 3, 1866
161	Dodds, J., M.P., Stockton-on-Tees	Mar. 7, 1874
162	Douglas, C. P., Consett House, Consett, Co. Durham	Mar. 6, 1869
163	Douglas, T., Peases' West Collieries, Darlington (Vice-President)	Aug. 21, 1852
164	Douthwaite, T., Merthyr Vale Colliery, Merthyr Tydvil	June 5, 1869
165	Dove, G., Viewfield, Stanwix, Carlisle	July 2, 1872

		ELECTED.
166	Dowdeswell, H., Butterknowle Colliery, *via* Darlington	April 5, 1873
167	Dyson, George, Middlesborough	June 2, 1866
168	Dyson, O., Pooley Hall Colliery, near Tamworth	Mar. 2, 1872
169	Easton, J., Nest House, Gateshead	1853
170	Eddison, Robert W., Steam Plough Works, Leeds	Mar. 4, 1876
171	Elliot, Sir George, Bart., Houghton Hall, Fence Houses (Past President, *Member of Council*)	Aug. 21, 1852
172	Elsdon, Robert, 76, Manor Road, Upper New Cross, London	Nov. 4, 1876
173	Embleton, T. W., The Cedars, Methley, Leeds	Sept. 6, 1855
174	Embleton, T. W., Jun., The Cedars, Methley, Leeds	Sept. 2, 1865
175	Eminson, J. B., Londonderry Offices, Seaham Harbour	Mar. 2, 1872
176	Everard, I. B., M.E., 6, Millstone Lane, Leicester	Mar. 6, 1869
177	Farmer, A., South Durham Fitting Offices, West Hartlepool	Mar. 2, 1872
178	Farrar, James, Old Foundry, Barnsley	July 2, 1872
179	Favell, Thomas M., 14, Saville Street, North Shields	April 5, 1873
180	Fenwick, Barnabas, Team Colliery, Gateshead	Aug. 2, 1866
181	Fenwick, George, Banker, Newcastle-on-Tyne	Sept. 2, 1871
182	Fenwick, Thomas, East Pontop Colliery, by Lintz Green	April 5, 1873
183	Ferens, Robinson, Oswald Hall, near Durham	April 7, 1877
184	Fidler, E., Platt Lane Colliery, Wigan, Lancashire	Sept. 1, 1866
185	Fisher, R. C., 5, Picton Place, Swansea	July 2, 1872
186	Fletcher, Geo., Hamsteels Colliery, near Durham	Aug. 1, 1874
187	Fletcher, H., Ladyshore Coll., Little Lever, Bolton, Lancashire	Aug. 3, 1865
188	Fletcher, Jas., Manager Co-operative Collieries, Wallsend, near Newcastle, New South Wales	Sept. 11, 1875
189	Fletcher, J., Kelton House, Dumfries	July 2, 1872
190	Fletcher, W., Lansdowne House, Didsbury, Manchester	Feb. 4, 1871
191	Foggin, Wm., North Biddick Coll., Washington Station, Co. Durham	Mar. 6, 1875
192	Forrest, J., Assoc. Inst. C.E., Witley Coll., Halesowen, Birmingham	Mar. 5, 1870
193	Forster, G. B., M.A., Backworth House, near Newcastle-upon-Tyne (President)	Nov. 5, 1852
194	Forster, J. R., Water Company's Office, Newcastle-on-Tyne	July 2, 1872
195	Forster, J. T., Waldridge Colliery, Chester-le-Street	Aug. 1, 1868
196	Forster, Richard, 51, Quayside, Newcastle-on-Tyne	Oct. 5, 1872
197	Forster, R., South Hetton, Fence Houses	Sept. 5, 1868
198	Foster, George, Osmondthorpe Colliery, near Leeds	Mar. 7, 1874
199	France, Francis, St. Helen's Colliery Co. Ld., St. Helen's, Lancashire	Sept. 1, 1877
200	France, W., Lofthouse Mines, Saltburn-by-the-Sea	April 6, 1867
201	Franks, George, Victoria Garesfield, Lintz Green	Feb. 6, 1875
202	Frazier, Prof. B. W., Lehigh University, Bethlehem, Penns., U.S.	Nov. 2, 1872
203	Galloway, R. L., Ryton-on-Tyne	Dec. 6, 1873
204	Galloway, T. Lindsay, M.A., 28, Enoch Square, Glasgow	Sept. 2, 1876
205	Gerrard, John, Westgate, Wakefield	Mar. 5, 1870
206	Gillett, F. C., Midland Road, Derby	July 4, 1861

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207	Gilmour, D., Portland Colliery, Kilmarnock	Feb. 3, 1872
208	Gilpin, Edwin, 75, Birmingham Street, Halifax, Nova Scotia	April 5, 1873
209	Gilroy, G., Ince Hall Colliery, Wigan, Lancashire	Aug. 7, 1856
210	Gilroy, S. B., Mining Engineer, Crewe	Sept. 5, 1868
211	Gjers, John, Southfield Villas, Middlesbro'	June 7, 1873
212	Goddard, F. R., Accountant, Newcastle-on-Tyne	Nov. 7, 1874
213	Gooch, G. H., Lintz Colliery, Burnopfield, Gateshead	Oct. 3, 1856
214	Gordon, James N., c/o W. Nicolson, 5, Jeffrey's Square, St. Mary Axe, London, E.C.	Nov. 6, 1875
215	Grace, E. N., Dhadka, Assensole, Bengal, India	Feb. 1, 1868
216	Grant, J. H., District Engineer, Beerbhoon, Bengal, India	Sept. 4, 1869
217	Greaves, J. O., M.E., St. John's, Wakefield	Aug. 7, 1862
218	Green, J. T., Mining Engineer, Ty Celyn, Abercarn, Newport, Mon.	Dec. 3, 1870
219	Green, W., Jun., Thornelly House, Lintz Green *(Member of Council)*	Feb. 4 1853
220	Greener, John, General Manager, Vale Coll., Picton, Nova Scotia	Feb. 6, 1875
221	Greener, T., 76, Arlingford Road, Brixton, London, S.W.	Aug. 3, 1865
222	Greenwell, G. C., Tynemouth (Past President, *Mem. of Council)*	Aug. 21, 1852
223	Greenwell, G. C., Jun., Poynton, near Stockport	Mar. 6, 1869
224	Greig, D., Leeds	Aug. 2, 1866
225	Grey, C. G., 55, Parliament Street, London	May 4, 1872
226	Grieves, D., Brancepeth Colliery, Willington, County Durham	Nov. 7, 1874
227	Griffith, N. R., Wrexham	1866
228	Grimshaw, E. J., 23, Hardshaw Street, St. Helen's, Lancashire	Sept. 5, 1868
229	Grimshaw, W. J., Springfield House, Stand, near Manchester	Nov. 1, 1873
230	Guinotte, Lucien, Directeur des Charbonnages de Mariemont et de Bascoup, Mons, Belgium	Sept. 2, 1871
231	Haggie, D. H., Wearmouth Patent Rope Works, Sunderland	Mar. 4, 1876
232	Haggie, P., Gateshead	1854
233*	Hague, Ernest, Castle Dyke, Sheffield	Mar. 2, 1872
234	Haines, J. Richard, Adderley Green Colliery, near Longton	Nov. 7, 1874
235	Hales, C., Nerquis Cottage, Nerquis, near Mold, Flintshire	1865
236	Hall, F. W., 1, Eslington Terrace, Jesmond Road, Newcastle-on-Tyne	Aug. 7, 1869
237	Hall, George, South Garesfield Colliery, Lintz Green	Mar. 6, 1875
238	Hall, M., Lofthouse Station Collieries, near Wakefield	Sept. 5, 1868
239	Hall, M. S., M.E., Leasingthorne Colliery, near Bishop Auckland	Feb. 14, 1874
240	Hall, W., Spring Hill Mines, Cumberland County, Nova Scotia	Sept. 13, 1873
241	Hall, Wm., Thornley Colliery, County Durham	Dec. 4, 1875
242	Hall, William F., Haswell Colliery, Fence Houses	May 13, 1858
243	Hann, Edmund, Aberaman, Aberdare	Sept. 5, 1868
244	Harbottle, W. H., Orrell Colliery, near Wigan	Dec. 4, 1875
245	Hardy, Jos., Preston Colliery, North Shields	June 2, 1877
246	Hargreaves, William, Rothwell Haigh, Leeds	Sept. 5, 1868
247	Harle, Richard, Browney Colliery, Durham	April 7, 1877
248	Harle, William, Pagebank Colliery, near Durham	Oct. 7, 1876
249	Harrison, R., Eastwood, near Nottingham	1861
250	Harrison, T., Great Western Colliery, Pontypridd, Glamorganshire	Aug. 2, 1873

		ELECTED
251	Harrison, T. E., C.E., Central Station, Newcastle-on-Tyne	May 6, 1853
252	Harrison, W. B., Brownhills Collieries, near Walsall	April 6, 1867
253	Haswell, G. H., Messrs. Tangye Brothers, Birmingham	Mar. 2, 1872
254	Hay, J., Jun., Widdrington Colliery, Acklington	Sept. 4, 1869
255	Heckels, Matthew, Castle Eden Colliery, Co. Durham	April 11, 1874
256	Heckels, W. J., South Medomsley Colliery, Dipton, by Lintz Green	May 2, 1868
257	Hedley, Edw., 2, Church Street, London Road, Derby	Dec. 2, 1858
258	Hedley, J. J., Consett Collieries, Leadgate, County Durham ...	April 6, 1872
259	Hedley, J. L., Flooker's Brook, Chester	Feb. 5, 1870
260	Hedley, T. F., Valuer, Sunderland	Mar. 4, 1871
261	Hedley, W. H., Consett Collieries, Medomsley, Newcastle-on-Tyne *(Member of Council)*	1864
262	Henderson, H., Pelton Colliery, Chester-le-Street	Feb. 14, 1874
263	Heppell, T., Leafield House, Birtley, Fence Houses *(Mem. of Council)*	Aug. 6. 1863
264	Heppell, W., Brancepeth Colliery, Willington, County Durham ...	Mar. 2, 1872
265	Herdman, J., Park Crescent, Bridgend, Glamorganshire	Oct. 4, 1860
266	Heslop, C., Lingdale Mines, *via* Guisborough	Feb. 1, 1868
267	Heslop, Grainger, Whitwell Colliery, Sunderland	Oct. 5, 1872
268	Heslop, J., Hucknall Torkard Colliery, near Nottingham	Feb. 6, 1864
269	Hetherington, D., Coxlodge Colliery, Newcastle-on-Tyne	1859
270*	Hewitt, G. C., Coal Pit Heath Colliery, near Bristol	June 3, 1871
271	Hewlett, A., Haigh Colliery, Wigan, Lancashire	Mar. 7, 1861
272	Hick, G. W., 14, Blenheim Terrace, Leeds	May 4, 1872
273	Higson, Jacob, 94, Cross Street, Manchester	1861
274	Hill, Leslie C., Bartholomew House, London, E.C.	Nov. 6, 1875
275	Hilton, J., Standish and Shevington Collieries, near Wigan ...	Dec 7 1867
276	Hilton, T. W., Wigan Coal and Iron Co., Limited, Wigan	Aug. 3, 1865
277	Hindmarsh, Thomas, Cowpen Lodge, Blyth, Northumberland ...	Sept. 2, 1876
278	Hodgson, J. W., Dipton Colliery, *via* Lintz Green Station	Feb. 5, 1870
279	Holliday, Martin, M.E., Peases' West Collieries, Crook	May 1, 1875
280	Holmes, C., Grange Hill, near Bishop Auckland	April 11, 1874
281	Homer, Charles J., Mining Engineer, Stoke-on-Trent	Aug. 3, 1865
282	Hood, A., 6, Bute Crescent, Cardiff	April 18, 1861
283	Hope, George, Newbottle Colliery, Fence Houses	Feb. 3, 1877
284	Hornsby, H., Whitworth Terrace, *via* Spennymoor, Co. Durham ...	Aug. 1, 1874
285	Horsley, W., Whitehill Point, Percy Main	Mar. 5, 1857
286	Hoskold, H. D., C. and M.E., F.R.G.S., F.G.S., M. Soc. A., &c., Fonda de Oriente, Barcelona, Spain	April 1, 1871
287	Howard, W. F., 13, Cavendish Street, Chesterfield	Aug. 1, 1861
288	Hudson, James, Albion Mines, Pictou, Nova Scotia	1862
289	Hughes, H. E., The Hollies, Sedgley, near Dudley, Staffordshire ...	Nov. 6, 1869
290	Humble, John, West Pelton, Chester-le-Street	Mar. 4, 1871
291	Humble, Jos., Staveley Works, near Chesterfield	June 2, 1866
292	Hunter, J., Silkstone and Worsbro' Park Collieries, near Barnsley ...	Mar. 6, 1869
293	Hunter, W., Monk Bretton Colliery, near Barnsley	Oct. 3, 1861
294	Hunter, Wm., Ridley Hall, Bardon Mill, Northumberland	Aug. 21, 1852
295	Hunter, W. S., Moor Lodge, Newcastle-upon-Tyne	Feb. 1, 1868

		ELECTED
296	Hunting, Charles, Fence Houses	Dec. 6, 1866
297	Hurst, T. G., F.G.S., Lauder Grange, Corbridge-on-Tyne	Aug. 21, 1852
298	Jackson, C. G., Chamber Colliery Co.. Limited, Hollinwood	June 4, 1870
299	Jackson, W., Cannock Chase Collieries, Walsall	Feb. 14, 1874
300	Jackson, W. G., Loscoe Grange, Normanton, Yorkshire	June 7, 1873
301	Jarratt, J., Broomside Colliery Office, Durham	Nov. 2, 1867
302	Jeffcock, T. W., 18, Bank Street, Sheffield	Sept. 4, 1869
303	Jenkins, W., M.E., Ocean S.C. Colls., Ystrad, nr. Pontypridd, So. Wales	Dec. 6, 1862
304	Jenkins, Wm., Consett Iron Works, Consett, Durham	May 2, 1874
305	Johnasson, J., Leadenhall Street, London, E.C.	July 2, 1872
306	Johnson, Henry, Dudley, Worcestershire	Aug. 7, 1869
307	Johnson, John, M. Inst. C.E., F.G.S., 21, Victoria Square, Newcastle	Aug. 21, 1852
308	Johnson, J., Witley Colliery Co. Ld., Halesowen, nr. Birmingham	Mar. 7, 1874
309	Johnson, R. S., Sherburn Hall, Durham	Aug. 21, 1852
310	Joicey, J. G., Forth Banks West Factory, Newcastle-on-Tyne	April 10, 1869
311	Joicey, W. J., Tanfield Lea Colliery, Burnopfield	Mar. 6, 1869
312	Jordan, Robert, Ebbw Vale, South Wales	Nov. 7, 1874
313	Joseph, D. Davis, Ty Draw, Pontypridd, South Wales	April 6, 1872
314	Joseph, T., Ty Draw, near Pontypridd, South Wales	April 6, 1872
315	Kendall, John D., Roper Street, Whitehaven	Oct. 3, 1874
316	Kennedy, Myles, M.E., Hill Foot, Ulverstone	June 6, 1868
317	Kimpton, J. G., 40, St. Mary's Gate, Derby	Oct. 5, 1872
318	Kirkby, J. W., Ashgrove, Windygates, Fife	Feb. 1, 1873
319	Kirkwood, William, Larkhall Colliery, Hamilton	Aug. 7, 1869
320	Kirsopp, John, Team Colliery, Gateshead	April 5, 1873
321	Knowles, A., High Bank, Pendlebury, Manchester	Dec. 5, 1856
322	Knowles, John, Westwood, Pendlebury, Manchester	Dec. 5, 1856
323	Knowles, Thomas, Ince Hall, Wigan	Aug. 1, 1861
324	Kyrke, R. H. V., Westminster Chambers, Wrexham	Feb. 5, 1870
325	Laidler, W. J.	Mar. 4, 1876
326	Lamb, R., Cleator Moor Colliery, near Whitehaven	Sept. 2, 1865
327	Lamb, R. O., The Lawn, Ryton-on-Tyne	Aug. 2, 1866
328	Lamb, Richard W., Coal Owner, Newcastle-on-Tyne	Nov. 2, 1872
329	Lambert, M. W., 9, Queen Street, Newcastle-on-Tyne	July 2, 1872
330	Lancaster, John, Bilton Grange, Rugby	July 4, 1861
331	Lancaster, J., Jun., Anfield House, Willes Road, Leamington	Mar. 2, 1865
332	Lancaster, S., Nantyglo & Blaina Steam Coal Collieries, Blaina, Mon.	Aug. 3, 1865
333	Landale, A., Lochgelly Iron Works, Fifeshire, N.B.	Dec. 2, 1858
334*	Laporte, Henry, M.E., 80, Rue Royale, Brussels	May 5, 1877
335	Laverick, Robt., West Rainton, Fence Houses	Sept. 2, 1876
336	Lawrence, Henry, Grange Iron Works, Durham	Aug. 1, 1868
337	Laws, H., Grainger Street West, Newcastle-on-Tyne	Feb. 6, 1869
338	Laws, John, Blyth, Northumberland	1854

		ELECTED.
339	Lawson, Rev. E., Longhirst Hall, Morpeth	Dec. 3, 1870
340	Lebour, G. A., M.A., F.G.S., College of Physical Science, Newcastle *(Member of Council)*	Feb. 1, 1873
341	Lee, George, North Ormesby, Middlesbro'	June 4, 1870
342	Leslie, Andrew, Hebburn, Gateshead-on-Tyne	Sept. 7, 1867
343	Lever, Ellis, Bowdon, Cheshire	1861
344	Lewis, Henry, Annesley Colliery, near Nottingham	Aug. 2, 1866
345	Lewis, W. H., 3, Bute Crescent, Cardiff	Aug. 4, 1877
346	Lewis, William Thomas, Mardy, Aberdare	1864
347	Liddell, G. H., Somerset House, Whitehaven	Sept. 4, 1869
348	Liddell, M., Prudhoe Hall, Prudhoe-on-Tyne	Oct. 1, 1852
349	Lindop, James, Bloxwich, Walsall, Staffordshire	Aug. 1, 1861
350	Linsley, R., Cramlington Colliery, Northumberland	July 2, 1872
351	Linsley, S. W., Whitburn Colliery, Sunderland	Sept. 4, 1869
352	Lishman, T., Jun., Hetton Colliery, Fence Houses	Nov. 5, 1870
353	Lishman, Wm., Witton-le-Wear	1857
354	Lishman, Wm., Bunker Hill, Fence Houses *(Member of Council)*	Mar. 7, 1861
355	Livesey, C., Bradford Colliery, near Manchester	Aug. 3, 1865
356	Livesey, T., Bradford Colliery, Manchester	Nov. 7, 1874
357	Llewelyn, L., c/o W. P. James, Abersychan Iron Works, nr. Pontypool	May 4, 1872
358	Logan, William, Langley Park Colliery, Durham	Sept. 7, 1867
359	Longbotham, J., Norley Collieries, near Wigan	May 2, 1868
360	Longridge, J. A., 15, Great George Street, Westminster, London, S.W.	Aug. 21, 1852
361	Low, W., Vron Colliery, Wrexham, Denbighshire	Sept. 6, 1855
362	Lupton, A., F.G.S., Crossgates, near Leeds	Nov. 6, 1869
363	Mackenzie, J., Ashgrove Villa, Ibroxholm, Paisley Road, Glasgow	Mar. 5, 1870
364	Maddison, Henry, The Lindens, Darlington	Nov. 6, 1875
365	Maling, C. T., Ford Pottery, Newcastle-on-Tyne	Oct. 5, 1872
366	Mammatt, J. E., C.E., St. Andrew's Chambers, Leeds	1864
367	Marley, John, 7, Bondgate, Darlington *(Member of Council)*	Aug. 21, 1852
368	Marley, J. W., 7, Bondgate, Darlington	Aug. 1, 1868
369	Marshall, F. C., Messrs. Hawthorn & Co., Newcastle	Aug. 2, 1866
370	Marston, W. B., Leeswood Vale Oil Works, Mold	Oct. 3, 1868
371	Marten, E. B., C.E., Pedmore, near Stourbridge	July 2, 1872
372	Martin, R. F., Mount Sorrel, Loughborough	April 11, 1874
373	Matthews, R. F., Hardwicke, Sedgefield	Mar. 5, 1857
374	Maughan, J. A., Nerbudda Coal and Iron Co. Limited, Garrawarra, Central Provinces, India	Nov. 7, 1863
375	Maughan, J. D., Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876
376	May, George, Harton Colliery Offices, Tyne Docks, South Shields *(Member of Council)*	Mar. 6, 1862
377	McCreath, J., 95, Bath Street, Glasgow	Mar. 5, 1870
378	McCulloch, David, Beech Grove, Kilmarnock, N.B.	Dec. 4, 1875
379	McCulloch, H. J., Horton House, 277, Camden Road, London, N.	Oct. 1, 1863
380	McCulloch, W., 178, Gresham House, Old Broad Street, London, E.C.	Nov. 7, 1874
381	McGhie, T., Cannock, Staffordshire	Oct. 1, 1857

		ELECTED
382	McMurtrie, J., Radstock Colliery, Bath	Nov. 7, 1863
383	Meik, Thomas, C.E., 6, York Place, Edinburgh	June 4, 1870
384	Merivale, J. H., 2, Victoria Villas, Newcastle	May 5, 1877
385	Miller, Robert, Strafford Collieries, near Barnsley	Mar. 2, 1865
386	Mills, M. H., Duckmanton Lodge, Chesterfield	Feb. 4, 1871
387	Mitchell, Chas., Jesmond, Newcastle-on-Tyne	April 11, 1874
388	Mitchell, Joseph, Worsbro' Dale, near Barnsley	Feb, 14, 1874
389	Mitchinson, R., Jun., Pontop Coll., Lintz Green Station, Co. Durham	Feb. 4, 1865
390	Moffat, T., Montreal Iron Ore Works, Whitehaven	Sept. 4, 1869
391	Monkhouse, Jos., Yeat House, Frizington, Whitehaven	June 4, 1863
392	Moor, T., Cambois Colliery, Blyth	Oct. 3, 1868
393	Moor, Wm., Jun., Hetton Colliery, Fence Houses	July 2, 1872
394	Moore, R. W., Colliery Office, Whitehaven	Nov. 5, 1870
395	Morison, D. P., 21, Collingwood Street, Newcastle	1861
396	Morrell, John, Darlington	Oct. 7, 1876
397	Morris, W., Waldridge Colliery, Chester-le-Street, Fence Houses	1858
398*	Morton, H. J., 4, Royal Crescent, Scarborough	1861
399	Morton, H. T., Lambton, Fence Houses	Aug. 21, 1852
400	Moses, Wm., Lumley Colliery, Fence Houses	Mar. 2, 1872
401	Muckle, John, Monk Bretton, Barnsley	Mar. 7, 1861
402	Mulcaster, W., Jun., M.E., Croft House, Aspatria, near Carlisle	Dec. 3, 1870
403	Mulvany, W. T., Pêmpêlfort, Dusseldorf-on-the-Rhine	Dec. 3, 1857
404	Mundle, Arthur, 7, Collingwood Street, Newcastle-on-Tyne	June 5, 1875
405	Mundle, W., Redesdale Mines, Bellingham	Aug. 2, 1873
406*	Nasse, Rudolph, Konigl Bergwerks Director, Louisenthal, Saarbrucken, Prussia	1869
407	Naylor, J. T., 10, West Clayton Street, Newcastle-on-Tyne	Dec. 6, 1866
408	Nelson, J., C.E., Marine and Stationary Engine Works, Gateshead	Oct. 4, 1866
409	Nevin, John, Mirfield, Yorkshire	May 2, 1868
410	Newall, R. S., Ferndene, Gateshead ... *(Member of Council)*	May 2, 1863
411	Nicholson, E., jun., Beamish Colliery, Chester-le-Street	Aug. 7, 1869
412	Nicholson, J. W., 61, Grove St., Elswick Road, Newcastle-on-Tyne	Oct. 11, 1873
413	Nicholson, Marshall, Middleton Hall, Leeds	Nov. 7, 1863
414	Noble, Captain, Jesmond, Newcastle-upon-Tyne	Feb. 3, 1866
415	North, F. W., F.G.S., Rowley Hall Colliery, Dudley, Staffordshire	Oct. 6, 1864
416	Nuttall, Thomas, Broad Street, Bury, Lancashire	Sept. 11, 1875
417	Ogden, John M., Solicitor, Sunderland	Mar. 5, 1857
418	Ogilvie, A. Graeme, 4, Great George Street, Westminster, London	Mar. 3, 1877
419	Oliver, Robert, Charlaw Colliery, near Durham	Nov. 6, 1875
420	Pacey, T., Bishop Auckland	April 10, 1869
421	Palmer, A. S., Wardley Hall, near Newcastle-on-Tyne	July 2, 1872
422	Palmer, C. M., M.P., Quay, Newcastle-upon-Tyne	Nov. 5, 1852
423	Pamely, C., Radstock Coal Works, near Bath	Sept. 5, 1868
424	Panton, F. S., Silksworth Colliery, Sunderland	Oct. 5, 1867

		ELECTED.
425	PARKIN, C., West Rosedale Ironstone Co., Ld., Pickering, Yorkshire	June 5, 1875
426	PARKIN, JOHN, Rosedale Abbey, Yorkshire	April 11, 1874
427	PARRINGTON, M. W., Wearmouth Colliery, Sunderland	Dec. 1, 1864
428	PARTON, T., F.G.S., Ash Cottage, Birmingham Road, West Bromwich	Oct. 2, 1869
429	PATTISON, JOHN, Engineer, Naples	Nov. 7, 1874
430	PEACE, M. W., Wigan, Lancashire	July 2, 1872
431	PEACOCK, DAVID, West Bromwich	Aug. 7, 1869
432	PEARCE, F. H., Bowling Iron Works, Bradford	Oct. 1, 1857
433	PEASE, J. W., M.P., Hutton Hall, Guisbro', Yorkshire	Mar. 5, 1857
434	PEEL, JOHN, Wharncliffe and Silkstone Coll., Wortley, near Sheffield	Nov. 1, 1860
435	PEEL, JOHN, Horsley Colliery, Wylam-on-Tyne	Mar. 3, 1877
436	PEILE, WILLIAM, Rosemount, Roath, Cardiff	Oct. 1, 1863
437	PENMAN, J. H., 2, Clarence Buildings, Booth Street, Manchester	Mar. 7, 1874
438	PICKUP, P. W., Dunkenhalgh Collieries, Accrington, Lancashire	Feb. 6, 1875
439	PINCHING, ARCHD. E., The Terrace, Gravesend	May 5, 1877
440	POTTER, ADDISON, C.B., Heaton Hall, Newcastle-on-Tyne	Mar. 6, 1869
441	POTTER, A. M., Shiremoor Coll., Northumberland *(Member of Council)*	Feb. 3, 1872
442	POTTER, C. J., Heaton Hall, Newcastle-on-Tyne	Oct. 3, 1874
443*	POTTER, W. A., Cramlington House, Northumberland	1853
444	PRICE, JOHN, Messrs. Palmer Brothers & Co., Jarrow-on-Tyne	Mar. 3, 1877
445	PRICE, J. R., Standish, near Wigan	Aug. 7, 1869
446	PRIESTMAN, JON., Coal Owner, Newcastle-on-Tyne	Sept. 2, 1871
447	PRINGLE, EDWARD, Choppington Colliery, Northumberland	Aug. 4, 1877
448	RAMSAY, J. A., Westbrook, Darlington	Mar. 6, 1869
449	RAMSAY, J. T., Walbottle Hall, near Blaydon-on-Tyne	Aug. 3, 1853
450	RAMSAY, WM., Tursdale Colliery, County Durham	Sept. 11, 1875
451	REED, ROBERT, Felling Colliery, Gateshead	Dec. 3, 1863
452	REES, DANIEL, Glandare, Aberdare	1862
453	REFEEN, WM., Teplitz, Bohemia	Oct. 5, 1872
454	REID, ANDREW, Newcastle-on-Tyne	April 2, 1870
455	RICHARDS, E. W., Messrs. Bolckow, Vaughan, & Co., Middlesbro'	Aug 5, 1876
456	RICHARDS, G. C., M.E., Woodhouse, near Sheffield	June 5, 1875
457	RICHARDSON, H., Backworth Colliery, Newcastle-on-Tyne	Mar. 2, 1865
458	RICHARDSON, J. W., Iron Shipbuilder, Newcastle-on-Tyne	Sept. 3, 1870
459	RIDLEY, G., Trinity Chambers, Newcastle-on-Tyne	Feb. 4, 1865
460	RIDLEY, J. H., R. & W. Hawthorn's, Newcastle-on-Tyne	April 6, 1872
461	RIDYARD, J., Bridgewater Offices, Walkden, nr. Bolton-le-Moors, Lan.	Nov. 7, 1874
462	RIGBY, JOHN, Ash Villa, Alsager, Stoke-upon-Trent	Feb. 5, 1876
463	RITSON, U. A , 6, Queen Street, Newcastle-on-Tyne	Oct. 7, 1871
464	RITSON, W. A., Shilbottle Colliery, near Alnwick	April 2, 1870
465	ROBERTSON, W., M.E., 123, St. Vincent Street, Glasgow	Mar. 5, 1870
466	ROBINSON, G. C., Brereton and Hayes Colls., Rugeley, Staffordshire	Nov. 5, 1870
467	ROBINSON, H., C.E., 7, Westminster Chambers, London	Sept. 3, 1870
468	ROBINSON, JOHN, Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876
469	ROBINSON, R., Howlish Hall, near Bishop Auckland	Feb. 1, 1868
470	ROBSON, E., Middlesbro'-on-Tees	April 2, 1870

		ELECTED.
471	Robson, J. S., Butterknowle Colliery, *via* Darlington	1853
472	Robson, J. T., Cambuslang, Glasgow	Sept. 4, 1869
473	Robson, Thomas, Lumley Colliery, Fence Houses	Oct. 4, 1860
474	Rogerson, John, Croxdale Hall, Durham	Mar. 6, 1869
475	Roscamp, J., Rosedale Lodge, near Pickering, Yorkshire	Feb. 2, 1867
476	Roseby, John, Haverholme House, Brigg, Lincolnshire	Nov. 2, 1872
477	Ross, A.	Oct. 1, 1857
478	Ross, J. A. G., Consulting Engineer, 13, Belgrave Terrace, Newcastle	July 2, 1872
479	Rosser, W., Mineral Surveyor, Llanelly, Carmarthenshire	1856
480	Rothwell, R. P., 27, Park Place, New York, U.S.	Mar. 5, 1870
481	Routledge, Jos., Ryhope Colliery, Sunderland	Sept. 11, 1875
482	Routledge, J. L., Ryhope Colliery, Sunderland	Oct. 7, 1876
483	Routledge, Wm., Sydney, Cape Breton	Aug. 6, 1857
484	Rowley, J. C., Shagpoint Colliery, Otago, New Zealand	Dec. 4, 1875
485	Rutherford, J., Halifax, Nova Scotia	1866
486	Rutherford, W., West Shield Row Colliery, *via* Chester-le-Street	Oct. 3, 1874
487	Rutter, Thos., Blaydon Main Colliery, Blaydon-on-Tyne	May 1, 1875
488	Ryder, W. J. H., Forth Street Brass Works, Newcastle-on-Tyne	Nov. 4, 1876

489	Saint, George, Vauxhall Collieries, Ruabon, North Wales	April 11, 1874
490	Scarth, W. T., Raby Castle, Darlington	April 4, 1868
491	Scott, Andrew, Broomhill Colliery, Acklington	Dec. 7, 1867
492	Scott, C. F., Gateshead Fell Colliery, Gateshead-on-Tyne	April 11, 1874
493	Scoular, G., Parkside, Frizington, Cumberland	July 2, 1872
494	Seddon, J. F., Great Harwood Collieries, near Accrington	June 1, 1867
495	Shallis, F. W., M. and J. Pritchard, 9, Gracechurch Street, London	April 6, 1872
496	Shaw, W., Jun., Wolsingham, *via* Darlington	June 3, 1871
497	Shiel, John, Framwellgate Colliery, County Durham	May 6, 1871
498	Shone, Isaac, Pentrefelin House, Wrexham	1858
499	Shortrede, T., Park House, Winstanley, Wigan	April 3, 1856
500	Shute, C A., Westoe, South Shields	April 11, 1874
501	Simpson, J., Heworth Colliery, near Gateshead-on-Tyne	Dec. 6, 1866
502	Simpson, Jos., Springhill Mines, Cumberland Co., Nova Scotia	Mar. 3, 1873
503	Simpson, J. B., Hedgefield House, Blaydon-on-Tyne (Vice-President)	Oct. 4, 1860
504	Simpson, J. C.	April 7, 1877
505	Simpson, R., Moor House, Ryton-on-Tyne	Aug. 21, 1852
506	Simpson, Robt., Drummond Colliery, Westville, Picton, N.S.	Dec. 4, 1875
507	Slinn, T., 2, Choppington Street, Westmorland Road, Newcastle	July 2, 1872
508	Small, G., Duffield Road, Derby	June 4, 1870
509	Smith, G. F., Grovehurst, Tunbridge Wells	Aug. 5, 1853
510	Smith, J., Bickershaw Colliery, Leigh, near Manchester	Mar. 7, 1874
511*	Smith, R. Clifford, Parkfield, Swinton, Manchester	Dec. 5, 1874
512	Smith, T., Sen., M.E., Cinderford Villas, nr. Newnham, Gloucester	May, 5, 1877
513	Smith, T. E., Phœnix Foundry, Newgate Street, Newcastle-on-Tyne	Dec. 5, 1874
514	Snowdon, T., Jun., West Bitchburn Coll., nr. Towlaw, *via* Darlington	Sept. 4, 1869
515	Sopwith, A., Cannock Chase Collieries, near Walsall	Aug. 1, 1868
516	Sopwith, Thos., 6, Great George St., Westminster, London, S.W.	Mar. 3, 1877

		ELECTED.
517	SOUTHERN, R., Burleigh House, The Parade, Tredegarville, Cardiff ...	Aug. 3, 1865
518	SOUTHWORTH, THOS., Hindley Green Collieries, near Wigan	May 2, 1874
519	SPENCE, G.	June 7, 1873
520	SPENCE, JAMES, Clifton and Melgramfitz Collieries, Workington ...	Nov. 7, 1874
521	SPENCER, JOHN, Westgate Road, Newcastle-on-Tyne	Sept. 4, 1869
522	SPENCER, M., Newburn, near Newcastle-on-Tyne	Sept. 4, 1869
523	SPENCER, T., Ryton, Newcastle-on-Tyne	Dec. 6, 1866
524	SPENCER, W., 125, London Road, Leicester	Aug. 21, 1852
525	STEAVENSON, A. L., Durham ... ... *(Member of Council)*	Dec. 6, 1855
526	STEAVENSON, D. F., B.A., LL.B., Barrister-at-Law, Cross House, Westgate Road, Newcastle-on-Tyne	April 1, 1871
527	STEELE, CHARLES R., Almburgh House, near Maryport	Mar. 3, 1864
528	STEPHENSON, G. R., 9, Victoria Chambers, Westminster, London, S.W.	Oct. 4, 1860
529	STEPHENSON, W. H., Elswick House, Newcastle-on-Tyne	Mar. 7, 1867
530	STEVENSON, R.	Feb. 5, 1876
531	STOBART, W., Wearmouth Colliery, Sunderland	July 2, 1872
532	STOREY, THOS. E., Clough Hall Iron Works, Kidsgrove, Staffordshire	Feb. 5, 1876
533	STRAKER, JOHN, Stagshaw House, Corbridge-on-Tyne	May 2, 1867
534	STRAKER, J. H., Willington House, Co. Durham	Oct. 3, 1874
535	STRATTON, T. H. M., Tredegar, South Wales	Dec. 3, 1870
536	SWALLOW, J., Pontop Hall, Lintz Green	May 2, 1874
537	SWALLOW, R. T., Springwell, Gateshead	1862
538	SWAN, H. F., Shipbuilder, Newcastle-on-Tyne	Sept. 2, 1871
539	SWAN, J. G., Upsall Hall, near Middlesbro'	Sept. 2, 1871
540	SWANN, C. G., Sec., General Mining Asso. Ld., 6, New Broad St., London	Aug. 7, 1875
541	TATE, SIMON, Kimblesworth Colliery, Co. Durham	Sept. 11, 1875
542	TAYLOR, HUGH, King Street, Quay, Newcastle-on-Tyne	Sept. 5, 1856
543	TAYLOR, T., King Street, Quay, Newcastle-on-Tyne	July 2, 1872
544	TAYLOR-SMITH, THOMAS, Urpeth Hall, Chester-le-Street	Aug. 2, 1866
545	THOMAS, A., Bilson House, near Newnham, Gloucestershire	Mar. 2, 1872
546	THOMPSON, JAMES, Hurworth, Darlington	June 2, 1866
547	THOMPSON, JOHN, Boughton Hall, Chester	Sept. 2, 1865
548	THOMPSON, J., Hilton House, Blackrod, near Chorley...	April 6, 1867
549	THOMPSON, R., Jun., Rodridge House, Wingate, Co. Durham ...	Sept. 7, 1867
550	THOMPSON, T. C., Milton Hall, Carlisle	May 4, 1854
551	THOMSON, JOHN, Eston Mines, by Middlesbro'	April 7, 1877
552	THOMSON, JOS. F., Manvers Main Colliery, Rotherham	Feb. 6, 1875
553	TINN, J., C.E., Ashton Iron Rolling Mills, Bower Ashton, Bristol ...	Sept. 7, 1867
554	TYLDEN-WRIGHT, C., Shireoaks Colliery, Worksop, Notts	1862
555	TYLOR, ALFRED E., 123, Bute Street, Cardiff	April 1, 1876
556	TYSON, WM. JOHN, 1, Lowther Street, Whitehaven	Mar. 3, 1877
557	TYZACK, D., Kelung, Formosa Island, c/o Com. of Customs, Amoy, China	Feb. 14, 1874
558	TYZACK, WILFRED, Tanfield Lea Coll., Lintz Green Station, Newcastle	Oct. 7, 1876
559	VIVIAN, JOHN, Diamond Boring Company, Whitehaven	Mar. 3, 1877

		ELECTED.
560	Wadham, E., C. and M.E., Millwood, Dalton-in-Furness	Dec. 7, 1867
561	Wake, H. H., River Wear Commissioners, Sunderland	Feb. 3, 1872
562	Walker, G. B., Wharncliffe Silkstone Collieries, Wortley, nr. Sheffield	Dec. 2, 1871
563	Walker, J. S., 15, Wallgate, Wigan, Lancashire	Dec. 4, 1869
564	Walker, W., Saltburn-by-the-Sea	Mar. 5, 1870
565	Wallace, Henry, Trench Hall, Gateshead	Nov. 2, 1872
566	Ward, H., Rodbaston Hall, near Penkridge, Stafford...	Mar. 6, 1862
567	Wardale, John D., M.E., Redheugh Engine Works, Gateshead ...	May 1, 1875
568	Wardell, S. C., Doe Hill House, Alfreton	April 1, 1865
569	Warrington, J.	Oct. 6, 1859
570	Watson, H., High Bridge Works, Newcastle-on-Tyne	Mar. 7, 1868
571	Watson, H. B., High Bridge Works, Newcastle-on-Tyne	Mar. 3, 1877
572	Watson, M., Flimby and Broughton Moor Collieries, near Maryport..	Mar. 7, 1868
573	Weeks, J. G., Bedlington Colliery, Bedlington *(Member of Council)*	Feb. 4, 1865
574	Westmacott, P. G. B., Elswick Iron Works, Newcastle	June 2, 1866
575	Whately, W. L., Wearmouth Colliery, Sunderland	Dec. 4, 1875
576	White, H., Weardale Coal Company, Towlaw, near Darlington ...	1866
577	White, J. F., M.E., Wakefield	July 2, 1872
578	White, J. W. H., Woodlesford, near Leeds	Sept. 2, 1876
579	Whitehead, James, Brindle Lodge, near Preston, Lancashire ...	Dec. 4, 1875
580	Whitelaw, John, 118, George Street, Edinburgh	Feb. 5, 1870
581	Whitelaw, T., Shields and Dalzell Collieries, Motherwell	April 6, 1872
582	Whittem, Thos. S., Wyken Colliery, near Coventry	Dec. 5, 1874
583	Widdas, C., North Bitchburn Colliery, Howden, Darlington... ...	Dec. 5, 1868
584	Wight, W. H., Cowpen Colliery, Blyth...	Feb. 3, 1877
585	Wild, J. G., Ellistown Colliery, Ellistown, near Leicester	Oct. 5, 1867
586	Williams, E., Cleveland Lodge, Middlesbro'	Sept. 2, 1865
587	Williams, J. J., Pantgwyn House, Holywell, Flintshire	Nov. 2, 1872
588	Williamson, John, Chemical Manufacturer, South Shields... ...	Sept. 2, 1871
589	Williamson, John, Cannock, &c., Collieries, Hednesford	Nov. 2, 1872
590	Willis, J., 14, Portland Terrace, Newcastle *(Member of Council)*	Mar. 5, 1857
591	Wilson, J. B., Wingfield Iron Works and Colliery, Alfreton... ...	Nov. 5, 1852
592	Wilson, Robert, Flimby Colliery, Maryport	Aug. 1, 1874
593	Wilson, W. B., Kippax and Allerton Collieries, Leeds	Feb. 6, 1869
594	Winter, T. B., Grey Street, Newcastle-on-Tyne	Oct. 7, 1871
595	Wood, C. L., Freeland, Bridge of Earn, Perthshire	1853
596	Wood, Lindsay, Southill, Chester-le-Street (Past President, *Member of Council)*	Oct. 1, 1857
597	Wood, Thomas, Rainton House, Fence Houses	Sept. 3, 1870
598	Wood, W. H., West Hetton, Ferryhill	1856
599	Wood, W. O., Trimdon Grange Coll., Co. Durham *(Mem. of Council)*	Nov. 7, 1863
600	Woolcock, Henry, St. Bees, Cumberland	Mar. 3, 1873
601	Wright, G. H., 12, Trumpington Street, Cambridge	July 2, 1872
602	Wright, J. M., Barmoor, Ryton-on-Tyne	Aug. 5, 1876
603	Wrightson, T., Stockton-on-Tees	Sept. 13, 1873
604	Young, Philip	Oct. 11, 1873

Ordinary Members.

		ELECTED.
1	Ackroyd, Wm., Jun., M.E., Morley Main Collieries, Morley, nr. Leeds	Feb. 7, 1880
2	Bell, C. E., Park House, Durham	Dec. 3, 1870
3	Bramall, Henry, M.I.C.E., St. Helen's, Lancashire	Oct. 5, 1878
4	Broja, Richard, Mining Engineer, Ostwall, Dortmund	Nov. 6, 1880
5	Butler, W. F., C.E., 6, Queen Anne's Gate, Westminster, London, S.W.	Feb. 7, 1880
6	Dacres, Thomas, Dearham Colliery, Maryport	May 4, 1878
7*	Dixon, James S., 170, Hope Street, Glasgow	Aug. 3, 1878
8	Ellis, W. R., F.G.S., Wigan	June 1, 1878
9	Gilchrist, Thomas, Eltringham, Prudhoe-on-Tyne	May 4, 1878
10	Goudie, J. H., 13, Lowther Street, Whitehaven	Sept. 7, 1878
11	Kellett, William, Wigan	June 1, 1878
12	Lancaster, John, Auchinbeath, &c., Collieries, Lanarkshire	Sept. 7, 1878
13	Laws, W. G., Civil Engineer, Newcastle-on-Tyne	Oct. 2, 1880
14	Llewellin, David Morgan, F.G.S., Glanwern Offices, Pontypool	May 14, 1881
15	Martin, Tom Pattinson, Allhallows Colliery, Mealsgate, Carlisle	Feb. 15, 1879
16	Potts, Jos., Jun., Architect, &c., North Cliff, Roker, Sunderland	Dec. 6, 1879
17	Prior, Edward G., Inspector of Mines, Nanaims, British Columbia	Feb. 7, 1880
18	Rogers, William, M.E., 19, King Street, Wigan	Nov. 2, 1878
19	Russell, Robert, M.E., Coltness Iron Works, Newmains, N.B.	Aug. 3, 1878
20	Spencer, John W., Newburn, near Newcastle-on-Tyne	May 4, 1878
21	Topping, Walter, Messrs. Cross, Tetley, & Co., Platt Bridge, Wigan	Mar. 2, 1878
22	Winstanley, Robt., M.E., 32, St. Ann's Street, Manchester	Sept. 7, 1878

Associate Members.

1	Arnold, Thomas, Mineral Surveyor, Louchor, Glamorganshire	Oct. 2, 1880
2	Audus, T., Mineral Traffic Manager, N.E. Railway, Newcastle-on-Tyne	Aug. 7, 1880
3	Bacon, Arthur H., Murton Colliery, Sunderland	Nov. 3, 1877
4	Bailes, E. T., Wingate, Ferryhill	June 7, 1879
5	Barnes, A. W., Grassmore Colliery, near Chesterfield	Oct. 5, 1872
6	Barrett, Charles Rollo, New Seaham, Seaham Harbour	Nov. 7, 1874
7	Berkley, R. W., Marley Hill Colliery, Gateshead	Feb. 14, 1874
8	Bewick, T. B., Haydon Bridge, Northumberland	Mar. 7, 1874
9	Bird, W. J., Wingate Colliery, Durham	Nov. 6, 1875
10	Brough, Thomas, Seaham Colliery, Seaham Harbour	Feb. 1, 1873
11	Brown, M. W., 7, Elswick Park, Newcastle-on-Tyne	Oct. 7, 1871
12	Brown, W. B., Springfield, Wavertree, Liverpool	Mar. 2, 1878
13	Bruce, John, 2, Framlington Place, Newcastle-on-Tyne	Feb. 14, 1874
14	Bulman, H. F., West Rainton, Fence Houses	May 2, 1874
15	Burnley, E. F., Whitwood Collieries, Normanton	April 11, 1874
16	Cabrera, Fidel, c/o H. Kendall & Son, 12, Gt. Winchester St., London	Oct. 6, 1877

		ELECTED.
17	Chambers, W. Henry, 15, Victoria Road, Barnsley	Dec. 2, 1871
18	Charlton, W. A., Manager, Messrs. Tangye Bros., 25, Lincoln St., Gateshead-on-Tyne	Nov. 6, 1880
19	Clark, Robt., Garnant Collieries, Cwmaman, nr. Llanelly, So. Wales	Sept. 11, 1875
20	Clough, James, Bedlington Collieries, near Morpeth	April 5, 1873
21	Clovis, Louis, 1, Borough Houses, Gateshead-on-Tyne	Feb. 15, 1879
22	Cobbold, C. H., Ross, Herefordshire	May 3, 1873
23	Cochrane Ralph D., Hetton Colliery Offices, Fence Houses	June 1, 1878
24	Cooper, R. W., Solicitor, Newcastle-on-Tyne	Sept. 4, 1880
25	Dalziel, W. G., 2, Pembroke Terrace, Cardiff	Sept. 7, 1878
26	Dodd, M., Jun., Heddon Colliery, Wylam-on-Tyne	Dec. 4, 1875
27	Douglas, M. H., Marsden Colliery, South Shields	Aug. 2, 1879
28	Doyle, Patrick, C.E., F.M.S., F.L.S., M.R.A.S., Municipal Chambers, Charters Towers, *via* Townsville, Queensland, Australia	Mar. 1, 1879
29	Eden, C. H., Etherley House, Darlington	Sept. 13, 1873
30	Edge, J. C., Ince Hall Coal and Cannel Co., Limited, Wigan	Dec. 5, 1874
31	Edge, John H., Coalport Wire Rope and Chain Works, Shifnal, Salop	Sept. 7, 1878
32	Fairley, James, Craghead and Holmside Collieries, Chester-le-Street	Aug. 7, 1880
33	Fryar, Mark, Denby Colliery, Derby	Oct. 7, 1876
34	Gambier, G. G. C.	Aug. 3, 1878
35	Gerrard, James, Ince Hall Coal and Cannel Company, Wigan	Mar. 3. 1873
36	Greener, T. Y., Rainford Collieries, St. Helen's, Lancashire	July 2, 1872
37	Greener, W. J., Pemberton Colliery, Wigan	Mar. 2, 1878
38	Gresley, W. S., Overseale, Ashby-de-la-Zouch	Oct. 5, 1878
39	Hamilton, E., Rig Wood, Saltburn-by-the-Sea	Nov. 1, 1873
40	Harris, W. S., Andrews House, near Gateshead	Feb. 14, 1874
41	Harrison, J. W., M.E., Gildersome, near Leeds	Aug. 3, 1878
42	Hedley, E., Rainham Lodge, The Avenue, Beckenham, Kent	Dec. 2, 1871
43	Hughes, E. G., Solway View, Whitehaven	June 1, 1878
44	Humble, Stephen, Uttoxeter Road, Derby	Oct. 6, 1877
45	Jepson, H., Ebbw Vale Works, Ebbw Vale, Mon.	July 2, 1872
46	Johnson, W., Abram Colliery. Wigan	Feb. 14, 1874
47	Jordan, J. J., South Derwent Colliery, *via* Lintz Green	Mar. 3, 1873
48	Leach, C. C. Bedlington Collieries, Bedlington	Mar. 7, 1874
49	Liddell, J. M., Murton Colliery, near Sunderland	Mar. 6, 1875
50	Lisle, J., Washington Colliery, County Durham	July 2, 1872
51	Maccabe, H. O., Russell Vale, Wollongong, New South Wales	Sept. 7, 1878
52	Makepeace, H. R., Bog & Home Farm Colls., Larkhall, Hamilton, N.B.	Mar. 3, 1877
53	Markham, G. E., Howlish Offices, Bishop Auckland	Dec. 4, 1875
54	Melly, E. F., Nunnery Colliery Offices, Sheffield	Oct. 5, 1878
55	Merivale, W., C.E., Engineer's Office, Central Station. Newcastle	Mar. 5, 1881
56	Miller, D. S., Neston Collieries, Cheshire	Nov. 7, 1874
57*	Miller, N., Kurhurballee Coll.. East India Railway, Chord Line, Bengal	Oct. 5, 1878
58	Moreing, C. A., 37, Spring Gardens, London	Nov. 7, 1874
59	Morison, John, Newbattle Collieries, Dalkeith, N.B.	Dec. 4, 1880
60	Prichard, W., Nav. and Deep Duffryn Colls., Mountain Ash, So. Wales	Dec. 7, 1878
61	Pringle, Jos., Manager, Coxlodge Colliery, So. Gosforth, Newcastle	Mar. 5, 1881

		Elected.
62	Rathbone, Edgar P., 28, The Boltons, South Kensington, London	Mar. 7, 1874
63	Rylands, Richard A., Haford Las, Minera, Wrexham	June 1, 1878
64	Saise, W., D. Sc., Giridi, E.I.R., Chord Line, *via* Muddapore, Bengal	Nov. 3, 1877
65	Sawyer, A. R., Ass. R.S.M., Basford, Stoke-upon-Trent	Dec. 6, 1873
66	Seymour, T. M., Lambton Colls.,Waratah, nr. Newcastle, New S.Wales	Dec. 4, 1875
67	Smith, J. Bagnold, The Laurels, Chesterfield	Nov. 2, 1878
68	Smith, Thos. Reader, M.E., Rockingham Colliery, near Barnsley	Feb. 5, 1881
69	Stobart, F. Blue House, Washington, Co. Durham	Aug. 2. 1873
70	Stones, T. H.. Wigan Coal & Iron Co., Westleigh, nr. Leigh, Lancashire	Nov. 7, 1874
71	Tait, James, Estate Agent, Garmondsway Moor, Coxhoe	May 14, 1881
72	Telford, W. H., Cramlington Colliery, Northumberland	Oct. 3, 1874
73	Turnbull, George, Seaham Colliery, Seaham Harbour	Oct. 4, 1879
74	Walters, Hargrave, Coton Park and Linton Coll., Burton-on-Trent	June 4, 1881
75	Walton, J. Coulthard, South Benwell Colliery, Newcastle-on-Tyne	Nov. 7, 1874
76	Wardle, Edward, M.E., Craghead Colliery, Chester-le-Street	Feb. 5, 1881

Students.

1	Armitage, Matthew	Oct. 6, 1877
2	Atkinson, A. A., 4, Belle Vue Crescent, Sunderland	Aug. 3, 1878
3	Atkinson, E. E., Westbourne House, Long Benton	Nov. 4, 1876
4	Atkinson, Fred., Maryport	Feb. 14, 1874
5	Ayton, E. F., Lumley Colliery, Fence Houses	Feb. 5, 1876
6	Ayton, Henry, Seaton Delaval Colliery, Dudley, Northumberland	Mar. 6, 1875
7	Baumgartner, W. O., East Hetton Coll. Office, Coxhoe, Co. Durham	Sept. 6, 1879
8	Bell, Geo. Fred., 13, Old Elvet, Durham	Sept. 6, 1879
9	Bird, Harry, Mines de l'Argentiére, La Bersée sur Durance, Hautes Alpe, France	April 7, 1877
10	Blackett, W. C., Jun., 6, Old Elvet, Durham	Nov. 4, 1876
11	Blakeley, A. B., Hollyroyd, Dewsbury	Feb. 15, 1879
12	Bowlker, T. J., Heddon Vicarage, Wylam-on-Tyne	May 5, 1877
13	Bramwell, Hugh, Tynemouth	Oct. 4, 1879
14	Brown, C. Gilpin, Hetton Colliery, Fence Houses	Nov. 4, 1876
15	Buckham, Robert, Alderdean House, Lanchester, Durham	Oct. 5, 1878
16	Bunning, C. Z., Gaviller's Office, Coleford, Gloucester	Dec. 6, 1873
17	Candler, T. E., East Lodge, Crook, Darlington	May 1, 1875
18	Chandley, Charles, Atherton Collieries, near Manchester	Nov. 6, 1880
19	Chapman, Alf. C., Mining Offices, Marsden, South Shields	Oct. 4, 1879
20	Child, H., Whitkirk, Leeds	Feb. 15, 1879

		ELECTED.
21	Cockburn, W. C., 8, Summerhill Grove, Newcastle-on-Tyne	July 2, 1872
22	Cox, L. Clifford, Ravenstone, near Ashby-de-la-Zouch	April 1, 1876
23	Crawford, T. W., Peases' West Collieries, Crook, by Darlington	Dec. 4, 1875
24	Crone, F. E., Killingworth House, near Newcastle	Sept. 2, 1876
25	Curry, W. Thos., Wardley Colliery, Newcastle-on-Tyne	Sept. 4, 1880
26	Davidson, C. C., Ore Bank House, Bigrigg, *via* Carnforth, Cumberland	Nov. 4, 1876
27	Davis, Kenneth M., Towneley and Stella Collieries, Ryton-on-Tyne	April 5, 1879
28	Depledge, M. F., Satley Vicarage, Darlington	April 7, 1877
29	Donkin, Wm., Usworth Colliery, Washington Station, Co. Durham	Sept. 2, 1876
30	Dorman, Frank, The Palace, Maidstone, Kent	May 1, 1875
31	Douglas, Arthur Stanley, Harton Colliery, near South Shields	June 1, 1878
32	Dowson, W. C., Belle Vue House, Escomb, near Bishop Auckland	Mar. 2, 1878
33	Dunn, A. F., Poynton, Stockport, Cheshire	June 2, 1877
34	Durnford, H. St. John, Birdwell, near Barnsley	June 2, 1877
35	Evans, David L., Goldtops, Newport, Monmouthshire	May 4, 1878
36	Fenwick, J. W., 16, Percy Gardens, Tynemouth	Oct. 7, 1876
37	Ferens, Fredk. J., 220, Gilesgate, Durham	Dec. 4, 1880
38	Fletcher, John E., Ellesmere Park, Eccles, near Manchester	Dec. 1, 1877
39	Forster, Thomas E., Backworth, Newcastle-on-Tyne	Oct. 7, 1876
40	Forsyth, Frank W.	Dec. 2, 1876
41	Fowler, Robert, Wearmouth Colliery, Sunderland	Dec. 2, 1876
42	Gallwey, Arthur P., Towneley and Stella Collieries, Ryton-on-Tyne	Oct. 2, 1880
43	Gilchrist, J. R., Newbottle Colliery Offices, Fence Houses	Feb. 3, 1877
44	Gordon, Chas., St. Chads, Lichfield	May 5, 1877
45	Gould, Alex., Cowpen Colliery, Blyth	Dec. 1, 1877
46	Greig, J., Brancepeth, Durham	Feb. 5, 1881
47	Guthrie, James Kenneth, Ryton-on-Tyne	Mar. 1, 1879
48	Haddock, W. T., Jun., Ryhope Colliery, Sunderland	Oct. 7, 1876
49	Hallas, G. H., Hindley Green Colliery, near Wigan	Oct. 7, 1876
50	Hallimond, W. T., 55, Western Hill, Durham	May 2, 1874
51	Hare, Samuel, Gladstone Street, Crook	Aug. 2, 1879
52	Harrison, Robert J., Backworth Colliery, near Newcastle-on-Tyne	May 1, 1875
53	Harrison, R. W., Public Wharf, Leicester	Mar. 3, 1877
54	Hedley, Sept. H., Londonderry Offices, Seaham Harbour	Feb. 15, 1879
55	Hendy, J. C. B., Usworth Colliery, Washington Station, Co. Durham	Sept. 2, 1876
56	Heslop, Septimus, Urpeth, Chester-le-Street	Dec. 4, 1880
57	Heslop, Thomas, North Bitchburn Colliery, Darlington	Oct. 2, 1880
58	Hill, Leonard, No. 4, Brancepeth, Durham	Oct. 6, 1877
59	Hooper, Edward, Haydon Bridge, Northumberland	June 4, 1881
60	Howard, Walter, 13, Cavendish Street, Chesterfield	April 13, 1878
61	Hudson, Joseph G. S., Albion Mines, Pictou County, Nova Scotia	Mar. 2, 1878
62	Humble, Joicey, 17, Westmorland Terrace, Newcastle-on-Tyne	Mar. 3, 1877

		ELECTED
63.	Humble, Robert, 17, Westmorland Terrace, Newcastle-on-Tyne ...	Sept. 2, 1876
64	Hunter, John P., Backworth Colliery, near Newcastle-on-Tyne ...	Oct. 6, 1877
65	Jobling, Thos. E., Coxlodge Colliery, by Kenton, Newcastle-on-Tyne	Oct. 7, 1876
66	Kayll, A. C., Felling Colliery, Gateshead	Oct. 7, 1876
67	Kirkhouse, E. G., Medomsley, Lintz Green, Newcastle-on-Tyne ...	Aug. 3, 1878
68	Kirkup, Philip, Peases' West Collieries, by Darlington	Mar. 2, 1878
69	Kirton, Hugh, Browney Colliery, Durham	April 7, 1877
70	Lindsay, Clarence S., Marsden, South Shields	Mar. 4, 1876
71	Liveing, E. H., 52, Queen Anne Street, Cavendish Square, London	Sept. 1, 1877
72	Locke, Ernest G., Ellistown Colliery, Bagworth, near Leicester ...	Dec. 2, 1876
73	Longbotham, R. H., Ormskirk Road, Newton, Wigan	Sept. 2, 1876
74	Mackinlay, Thos. B., West Pelton Colliery, Chester-le-Street ...	Nov. 1, 1879
75	Maddison, Thos. R., Thornhill Collieries, near Dewsbury	Mar. 3, 1877
76	Mundle, Robert, Leam Cottage, Woodburn	Mar. 6, 1875
77	Murray, W. C., So. Derwent Coll., *via* Lintz Green, Annfield Plain	Oct. 4, 1879
78	Murton, Charles J., Jesmond Villas, Newcastle-on-Tyne	Mar. 6, 1880
79	Nicholson, Jos. C., Newbottle Colliery, Fence Houses	Feb. 3, 1877
80	Noble, J. C., Usworth Hall, near Washington Station, Co. Durham...	May 5, 1877
81	Ornsby, R. E., Seaton Delaval Colliery, Dudley, Northumberland ..	Mar. 6, 1875
82	Palmer, Henry, East Howle Colliery, near Ferryhill	Nov. 2, 1878
83	Pattison, Jos. W., Londonderry Offices, Seaham Harbour	Feb. 15, 1879
84	Peake, Charles Edwd., Cwmaman Colliery, Aberdare, South Wales	Nov. 3, 1877
85	Peake, R. C., Harton Colliery Offices, South Shields	Feb. 7, 1880
86	Peart, A. W., Cwmaman Colliery Offices, Aberdare	Nov. 4, 1876
87	Pickering, W. H., College of Physical Science, Newcastle	Mar. 2, 1878
88	Pickstone, Wm., Oak Bank, Black Lane, near Manchester	Sept. 11, 1875
89	Pike, Arnold, Silksworth Colliery, Sunderland	Feb. 5, 1881
90	Pocock, Francis A.	Mar. 6, 1875
91	Potter, E. A., Cramlington House, Northumberland	Feb. 6, 1875
92	Prest, J. J., St. Helen's Colliery, Bishop Auckland	May 1, 1875
93	Price, S. R., Houghton Main Colliery, near Barnsley, Yorkshire ...	Nov. 3, 1877
94	Pringle, H. A., Lofthouse Mines, Saltburn-by-the-Sea	Oct. 2, 1880
95	Pringle, Hy. Geo., Tanfield Lea Coll., Lintz Green Station, Newcastle	Dec. 4, 1880
96	Proctor, C. P., Killingworth Colliery, Newcastle	Oct. 7, 1876
97	Reed, R., Fountain Head, Seaton Sluice, *via* Whitley, Northumberland	Feb. 3, 1877
98	Rees, Ernest P., Langley Park Colliery, Durham	Mar. 4, 1876
99	Richardson, R. W. P., 8, Mount Pleasant, Consett, Co. Durham ...	Mar. 4, 1876
100	Robinson, Frank, Ackhurst Hall, Wigan	Sept. 2, 1876
101	Robinson, Geo., Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876

		ELECTED.
102	Robson, Harry N., 3, North Bailey, Durham	Dec. 4, 1875
103	Robson, Thos. O., Medomsley, Newcastle-on-Tyne	Sept. 11, 1875
104	Routledge, W. H., Staveley Coal and Iron Co. Limited, Chesterfield	Oct. 7, 1876
105	Scarth, R. W., Stanghow House, Stanghow, near Guisbro'	Dec. 4, 1875
106	Schier, H. C., East Hetton Colliery Offices, Coxhoe, Co. Durham	Dec. 4, 1875
107	Scott, Alex., Lofthouse Colliery, Limited, Wakefield	Mar. 2, 1878
108	Scott, Walter, Cornsay Colliery, Lanchester	Sept. 6, 1879
109	Scott, Wm., Brancepeth Colliery Offices, Willington, Co. Durham	Mar. 4, 1876
110	Smith, Thos., 17, Woodbine Terrace, Bensham Road, Gateshead	Feb. 15, 1879
111	Smith, T. F., Jun., Cinderford Villas, near Newnham, Gloucestershire	May 5, 1877
112	Southern, E. O., 5, Fenwick Terrace, Jesmond, Newcastle	Dec. 5, 1874
113	Southern, W. J., Redheugh Colliery, Gateshead	Aug. 1, 1874
114	Spence, R. F., Cramlington	Nov. 2, 1878
115	Stobart, Henry Temple, Eton Villa, Saltburn-by-the-Sea	Oct. 2, 1880
116	Stoker, Arthur P., Birtley, near Chester-le-Street	Oct. 6, 1877
117	Todd, John T., Hetton-le-Hole, Fence Houses	Nov. 4, 1876
118	Todner, W. J. S., 22, Alexander Street, Elswick, Newcastle-on-Tyne	Sept. 6, 1879
119	Topham, Edward C.	Nov. 3, 1877
120	Vernes, Amidee, 8, Claremont Place, Gateshead	May 4, 1878
121	Walker, F. W., Aldbro', Darlington	Sept. 2, 1876
122	White, C. E., Hebburn Colliery, near Newcastle-on-Tyne	Nov. 4, 1876
123	Wilson, J. D., 8, Walker Terrace, Gateshead-on-Tyne	Sept. 11, 1875

Subscribing Collieries.

1 Ashington Colliery, Newcastle-on-Tyne.
2 Haswell Colliery, Fence Houses.
3 Hetton Collieries, Fence Houses.
4 Lambton Collieries, Fence Houses.
5 Londonderry Collieries.
6 North Hetton Colliery, Fence Houses.
7 Ryhope Colliery, near Sunderland.
8 Seghill Colliery, Northumberland.
9 South Hetton and Murton Collieries.
10 Stella Colliery, Hedgefield, Blaydon-on-Tyne.
11 Throckley Colliery, Newcastle-on-Tyne.
12 Wearmouth Colliery, Sunderland.
13 Whitworth Colliery, Ferryhill.

CHARTER

OF

THE NORTH OF ENGLAND

Institute of Mining and Mechanical Engineers.

FOUNDED 1852.

INCORPORATED NOVEMBER 28TH, 1876.

Victoria, by the Grace of God, of the United Kingdom of Great Britain and Ireland, Queen, Defender of the Faith, TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING:

WHEREAS it has been represented to us that NICHOLAS WOOD, of Hetton, in the County of Durham, Esquire (since deceased); THOMAS EMERSON FORSTER, of Newcastle-upon-Tyne, Esquire (since deceased); SIR GEORGE ELLIOT, Baronet (then George Elliot, Esquire), of Houghton Hall, in the said County of Durham, and EDWARD FENWICK BOYD, of Moor House, in the said County of Durham, Esquire, and others of our loving subjects, did, in the year one thousand eight hundred and fifty-two, form themselves into a Society, which is known by the name of THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS, having for its objects the Prevention of Accidents in Mines and the Advancement of the Sciences of Mining and Engineering generally, of which Society LINDSAY WOOD, of Southill, Chester-le-Street, in the County of Durham, Esquire, is the present President. AND WHEREAS it has been further represented to us that the Society was not constituted for gain, and that neither its projectors nor Members derive nor have derived pecuniary profit from its prosperity; that it has during its existence of a period of nearly a quarter of a century steadily devoted itself to the preservation of human life and the safer development of mineral property; that it has contributed substantially and beneficially to the prosperity of the country and the welfare and happiness of the working members of the community; that the Society has since its establishment diligently pursued its aforesaid objects, and in so doing has made costly experiments

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and researches with a view to the saving of life by improvements in the ventilation of mines, by ascertaining the conditions under which the safety lamp may be relied on for security; that the experiments conducted by the Society have related to accidents in mines of every description, and have not been limited to those proceeding from explosions; that the various modes of getting coal, whether by mechanical appliances or otherwise, have received careful and continuous attention, while the improvements in the mode of working and hauling belowground, the machinery employed for preventing the disastrous falls of roof underground, and the prevention of spontaneous combustion in seams of coal as well as in cargoes, and the providing additional security for the miners in ascending and descending the pits, the improvements in the cages used for this purpose, and in the safeguards against what is technically known as "overwinding," have been most successful in lessening the dangers of mining, and in preserving human life; that the Society has held meetings at stated periods, at which the results of the said experiments and researches have been considered and discussed, and has published a series of Transactions filling many volumes, and forming in itself a highly valuable Library of scientific reference, by which the same have been made known to the public, and has formed a Library of Scientific Works and Collections of Models and Apparatus, and that distinguished persons in foreign countries have availed themselves of the facilities afforded by the Society for communicating important scientific and practical discoveries, and thus a useful interchange of valuable information has been effected; that in particular, with regard to ventilation, the experiments and researches of the Society, which have involved much pecuniary outlay and personal labour, and the details of which are recorded in the successive volumes of the Society's Transactions, have led to large and important advances in the practical knowledge of that subject, and that the Society's researches have tended largely to increase the security of life; that the Members of the Society exceed 800 in number, and include a large proportion of the leading Mining Engineers in the United Kingdom. AND WHEREAS in order to secure the property of the Society, and to extend its useful operations, and to give it a more permanent establishment among the Scientific Institutions of our Kingdom, we have been besought to grant to the said LINDSAY WOOD, and other the present Members of the Society, and to those who shall hereafter become Members thereof, our Royal Charter of Incorporation. NOW KNOW YE that we, being desirous of encouraging a design so laudable and salutary of our special grace, certain knowledge, and mere motion, have willed granted, and declared, and do, by these presents, for us, our heirs, and successors, will, grant, and declare, that the said LINDSAY WOOD, and such others of our loving subjects as are now Members of the said Society, and such others as shall from time to time hereafter become Members thereof, according to such Bye-laws as shall be made as hereinafter mentioned, and their successors, shall for ever hereafter be, by virtue of these presents, one body, politic and corporate, by the name of "THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS," and by the name aforesaid shall have perpetual succession and a Common Seal, with full power and authority to alter, vary, break, and renew the same at their discretion, and by the same name to sue and be sued, implead and be impleaded, answer and be answered unto, in every Court of us, our heirs and successors, and be for ever able and capable in the law to purchase, acquire, receive, possess, hold, and enjoy to them and their successors any goods and chattels whatsoever, and also be able and capable in the law (notwithstanding the statutes and mortmain) to purchase, acquire, possess, hold and enjoy to them and their successors a hall or house, and any such other lands, tenements, or hereditaments whatsoever, as they may deem requisite for the purposes of the Society, the yearly value of which, including the site of the said hall or house, shall not exceed in the whole the sum of three thousand pounds, computing the same respectfully at the rack rent which might have been had or gotten for the same respectfully at the time of the purchase or acquisition thereof. AND WE DO HEREBY GRANT our especial licence and authority unto all and every person and persons and bodies politic and corporate, otherwise competent, to grant, sell, alien, convey or devise in mortmain unto and to the use of the said Society and their successors, any lands, tenements, or hereditaments not exceeding with the lands, tenements or hereditaments so purchased or previously acquired such annual value as aforesaid, and also any moneys, stocks, securities, and other personal estate to be laid out and disposed of in the purchase of any lands, tenements, or hereditaments not exceeding the like annual value. AND WE FURTHER will, grant, and declare, that the said Society shall have full power and authority, from time to time, to sell, grant, demise, exchange and dispose of absolutely, or by way of mortgage, or otherwise, any of the lands, tenements, hereditaments and possessions, wherein they have any estate or interest, or which they shall acquire as aforesaid, but that no sale, mortgage, or other disposition of any lands, tenements, or hereditaments of the Society shall be made, except with the approbation and concurrence of a General Meeting. And our will and pleasure is, and we further grant and declare that for the better rule and government of the Society, and the direction and management of the concerns thereof, there shall be a Council of the Society, to be appointed from among the Members thereof, and to include the President and the Vice-Presidents, and such other office-bearers or past office-bearers as may be directed by such Bye-laws as hereinafter mentioned, but so that the Council, including all *ex-officio* Members thereof, shall consist of not more than forty or less than twelve Members, and that the Vice-Presidents shall be not more than six or less than two in number. AND WE DO HEREBY FURTHER will and declare that the said LINDSAY WOOD shall be the first President of the Society, and the persons now being the Vice-Presidents, and the Treasurer and Secretary, shall be the first Vice-Presidents, and the first Treasurer and Secretary, and the persons now being the Members of the Council shall be the first Members of the Council of the Society, and that they respectfully shall continue such until the first election shall be made at a General Meeting in pursuance of these presents. AND WE DO HEREBY FURTHER will and declare that, subject to the powers by these presents vested in the General Meetings of the Society, the Council shall have the management of the Society, and of the income and property thereof, including the appointment of officers and servants, the definition of their duties, and the removal of any of such officers and servants, and generally may do all such acts and deeds as they shall deem necessary or fitting to be done, in order to carry into full operation and effect the objects and purposes of the Society, but so always that the same be not inconsistent with, or repugnant to, any of the provisions of this our Charter, or the Laws of our Realm, or any Bye-law of the Society in force for the time being. AND WE DO FURTHER will and declare that at any General Meeting of the Society, it shall be lawful for the Society, subject as hereinafter mentioned, to make such Bye-laws as to them shall seem necessary or proper for the regulation and good government of the Society, and of the Members and affairs thereof, and generally for carrying the objects of the Society into full and complete effect, and particularly (and without its being intended hereby to prejudice the foregoing generality), to make Bye-laws for all or any of the purposes hereinafter mentioned, that is to say: for fixing the number of Vice-Presidents, and the number of Members of which the Council shall consist, and the manner of electing the President and Vice-Presidents, and other Members of the Council, and the period of their continuance in office, and the manner and time of supplying any vacancy therein; and for regulating the times at which General Meetings of the Society and Meetings of the Council shall be held, and for convening the same and regulating the proceedings thereat, and for regulating the manner of admitting persons to be Members of the Society, and of removing or expelling Members from the Society, and for imposing reasonable fines or penalties for non-performance of any such Bye-laws, or for disobedience thereto, and from time to time to annul, alter, or change any such Bye-laws so always that all Bye-laws to be made as aforesaid be not repugnant to these presents, or to any of the laws of our Realm. AND WE DO FURTHER will and declare that the present Rules and Regulations of the Society, so far as they are not inconsistent with these presents, shall continue in force, and be deemed the Bye-laws of the Society until the same shall be altered by a General Meeting, provided always that the present Rules and Regulations of the Society and any future Bye-laws of the Society so to be made as aforesaid shall have no force or effect whatsoever until the same shall have been approved in writing by our Secretary of State for the Home Department. IN WITNESS WHEREOF WE HAVE CAUSED THESE OUR LETTERS TO BE MADE PATENT.

Witness Ourself at our Palace, at Westminster, this 28th day of November, in the fortieth year of our reign.

By Her Majesty's Command.
CARDEW.

THE NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

BYE-LAWS

PASSED AT A GENERAL MEETING ON THE 16TH JUNE, 1877.

1.—The members of the North of England Institute of Mining and Mechanical Engineers shall consist of four classes, viz.:—Original Members, Ordinary Members, Associate Members, and Honorary Members, with a class of Students attached.

2.—ORIGINAL MEMBERS shall be those who were Ordinary Members on the 1st of August, 1877.

3.—ORDINARY MEMBERS.—Every candidate for admission into the class of Ordinary Members, or for transfer into that class, shall come within the following conditions :—He shall be more than twenty-eight years of age, have been regularly educated as a Mining or Mechanical Engineer, or in some other recognised branch of Engineering, according to the usual routine of pupilage, and have had subsequent employment for at least five years in some responsible situation as an Engineer, or if he has not undergone the usual routine of pupilage, he must have practised on his own account in the profession of an Engineer for at least five years, and have acquired a considerable degree of eminence in the same.

4.—ASSOCIATE MEMBERS shall be persons practising as Mining or Mechanical Engineers, or in some other recognised branch of Engineering, and other persons connected with or interested in Mining or Engineering.

5.—HONORARY MEMBERS shall be persons who have distinguished themselves by their literary or scientific attainments, or who have made important communications to the Society.

6.—Students shall be persons who are qualifying themselves for the profession of Mining or Mechanical Engineering, or some other of the recognised branches of Engineering, and such persons may continue Students until they attain the age of twenty-three years.

7.—The annual subscription of each Original Member, and of each Ordinary Member who was a Student on the 1st of August, 1877, shall be £2 2s., of each Ordinary Member (except as last mentioned) £3 3s., of each Associate Member £2 2s., and of each Student £1 1s., payable in advance, and shall be considered due on election, and afterwards on the first Saturday in August of each year.

8.—Any Member may, at any time, compound for all future subscriptions by a payment of £25, where the annual subscription is £3 3s., and by a payment of £20 where the annual subscription is £2 2s. All persons so compounding shall be Original, Ordinary, or Associate Members for life, as the case may be ; but any Associate Member for life who may afterwards desire to become an Ordinary Member for life, may do so, after being elected in the manner described in Bye-law 13, and on payment of the further sum of £5.

9.—Owners of Collieries, Engineers, Manufacturers, and Employers of labour generally, may subscribe annually to the funds of the Institute, and each such subscriber of £2 2s. annually shall be entitled to a ticket to admit two persons to the rooms, library, meetings, lectures, and public proceedings of the Society; and for every additional £2 2s., subscribed annually, two other persons shall be admissible up to the number of ten persons ; and each such Subscriber shall also be entitled for each £2 2s. subscription to have a copy of the Proceedings of the Institute sent to him.

10.—In case any Member, who has been long distinguished in his professional career, becomes unable, from ill-health, advanced age, or other sufficient cause, to carry on a lucrative practice, the Council may, on the report of a Sub-Committee appointed for that purpose, if they find good reason for the remission of the annual subscription, so remit it. They may also remit any arrears which are due from a member, or they may accept from him a collection of books, or drawings, or models, or other contributions, in lieu of the composition mentioned in Bye-law 8, and may thereupon constitute him a Life Member, or permit him to resume his former rank in the Institute.

11.—Persons desirous of becoming Ordinary Members shall be proposed and recommended, according to the Form A in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must be signed by the proposer and at least five other Members certifying a personal knowledge of the candidate. The proposal so made being delivered to the Secretary, shall be submitted to the Council, who on approving the qualifications shall determine if the candidate is to be presented for ballot, and if it is so determined, the Chairman of the Council shall sign such approbation. The same shall be read at the next Ordinary General Meeting, and afterwards be placed in some conspicuous situation until the following Ordinary General Meeting, when the candidate shall be balloted for.

12.—Persons desirous of being admitted into the Institute as Associate Members, or Students, shall be proposed by three Members; Honorary Members shall be proposed by at least five Members, and shall in addition be recommended by the Council, who shall also have the power of defining the time during which, and the circumstances under which, they shall be Honorary Members. The nomination shall be in writing, and signed by the proposers (according to the Form B in the Appendix), and shall be submitted to the first Ordinary General Meeting after the date thereof. The name of the person proposed shall be exhibited in the Society's room until the next Ordinary General Meeting, when the candidate shall be balloted for.

13.—Associate Members or Students, desirous of becoming Ordinary Members, shall be proposed and recommended according to the Form C in the Appendix, in which form the name, usual residence, and qualifications of the candidate shall be distinctly specified. This form must certify a personal knowledge of the candidate, and be signed by the proposer and at least two other Members, and the proposal shall then be treated in the manner described in Bye-law 11. Students may become Associate Members at any time after attaining the age of twenty-three on payment of an Associate Member's subscription.

14.—The balloting shall be conducted in the following manner:—Each Member attending the Meeting at which a ballot is to take place shall be supplied (on demand) with a list of the names of the persons to be balloted for, according to the Form D in the Appendix, and shall strike out the names of such candidates as he desires shall not be elected, and return the list to the scrutineers appointed by the presiding Chairman for the purpose, and such scrutineers shall examine the lists so returned, and inform the meeting what elections have been made. No candidate shall be elected unless he secures the votes of two-thirds of the Members voting.

15.—Notice of election shall be sent to every person within one week after his election, according to the Form E in the Appendix, enclosing at the same time a copy of Form F, which shall be returned by the person elected, signed, and accompanied with the amount of his annual subscription, or life composition, within two months from the date of such election, which otherwise should become void.

16.—Every Ordinary Member elected having signed a declaration in the Form F, and having likewise made the proper payment, shall receive certificate of his election.

17.—Any person whose subscription is two years in arrear shall be reported to the Council, who shall direct application to be made for it, according to the Form G in the Appendix, and in the event of its continuing one month in arrear after such application, the Council shall have the power, after remonstrance by letter, according to the Form H in the Appendix, of declaring that the defaulter has ceased to be a member.

18.—In case the expulsion of any person shall be judged expedient by ten or more Members, and they think fit to draw up and sign a proposal requiring such expulsion, the same being delivered to the Secretary, shall be by him laid before the Council for consideration. If the Council, after due inquiry, do not find reason to concur in the proposal, no entry thereof shall be made in any minutes, nor shall any public discussion thereon be permitted, unless by requisition signed by one-half the Members of the Institute ; but if the Council do find good reason for the proposed expulsion, they shall direct the Secretary to address a letter, according to the Form I in the Appendix, to the person proposed to be expelled, advising him to withdraw from the Institute. If that advice be followed, no entry on the minutes nor any public discussion on the subject shall be permitted ; but if that advice be not followed, nor an explanation given which is satisfactory to the Council, they shall call a General Meeting for the purpose of deciding on the question of expulsion ; and if a majority of the persons present at such Meeting (provided the number so present be not less than forty) vote that such person be expelled, the Chairman of that Meeting shall declare the same accordingly, and the Secretary shall communicate the same to the person, according to the Form J in the Appendix.

19.—The Officers of the Institute, other than the Treasurer and the Secretary, shall be elected from the Original, Ordinary and Associate Members, and shall consist of a President, six Vice-Presidents, and eighteen Councillors, who, with the Treasurer and the Secretary (if Members of the Institute) shall constitute the Council. The President, Vice-Presidents, and Councillors shall be elected at the Annual Meeting in August (except in cases of vacancies) and shall be eligible for re-election, with the exception of any President or Vice-President who may have held office for the three immediately preceding years, and such six Councillors as may have attended the fewest Council Meetings during the past year; but such Members shall be eligible for re-election after being one year out of office.

20.—The Treasurer and the Secretary shall be appointed by the Council, and shall be removable by the Council, subject to appeal to a General Meeting. One and the same person may hold both these offices.

21.—Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the scrutineers. The Votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four scrutineers, who shall receive the balloting papers, and, after making the necessary scrutiny, destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the scrutineers for the election of Officers.

22.—In case of the decease or resignation of any Officer or Officers, the Council, if they deem it requisite that the vacancy shall be filled up, shall present to the next Ordinary General Meeting a list of persons whom they nominate as suitable for the vacant offices, and a new Officer or Officers shall be elected at the succeeding Ordinary General Meeting.

23.—The President shall take the chair at all meetings of the Institute, the Council, and Committees, at which he is present (he being *ex-officio* a member of all), and shall regulate and keep order in the proceedings.

24.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institute, to keep order, and to regulate the proceedings. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any Member of Council, or in case of their absence, any Member present, to take the chair at the meeting.

25.—The Council may appoint Committees for the purpose of transacting any particular business, or of investigating specific subjects connected with the objects of the Institute. Such Committees shall report to the Council, who shall act thereon as they see occasion.

26.—The Treasurer and the Secretary shall act under the direction and control of the Council, by which body their duties shall from time to time be defined.

27.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed or invested by him according to the direction of the Council.

28.—The Copyright of all papers communicated to, and accepted for printing by the Council, and printed within twelve months, shall become vested in the Institute, and such communications shall not be published for sale or otherwise, without the written permission of the Council.

29.—An Ordinary General Meeting shall be held on the first Saturday of every month (except January and July) at two o'clock, unless otherwise determined by the Council; and the Ordinary General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year, shall be presented by the Council. A Special General Meeting shall be called whenever the Council may think fit, and also on a requisition to the Council, signed by ten or more Members. The business of a Special Meeting shall be confined to that specified in the notice convening it.

30.—At meetings of the Council, five shall be a quorum. The minutes of the Council's proceedings shall be at all times open to the inspection of the Members.

31.—All Past-Presidents shall be *ex-officio* Members of the Council so long as they continue Members of the Institute, and Vice-Presidents who have not been re-elected or have become ineligible from having held office for three consecutive years, shall be *ex-officio* Members of the Council for the following year.

32.—Every question, not otherwise provided for, which shall come before any Meeting, shall be decided by the votes of the majority of the Original, Ordinary, and Associate Members then present.

33.—All papers shall be sent for the approval of the Council at least twelve days before a General Meeting, and after approval, shall be read before the Institute. The Council shall also direct whether any paper read before the Institute shall be printed in the Transactions, and notice shall be given to the writer within one month after it has been read, whether it is to be printed or not.

34.—All proofs of reports of discussions, forwarded to Members for correction, must be returned to the Secretary within seven days from the date of their receipt, otherwise they will be considered correct and be printed off.

35.—The Institute is not, as a body, responsible for the statements and opinions advanced in the papers which may be read, nor in the discussions which may take place at the meetings of the Institute.

36.—Twelve copies of each paper printed by the Institute shall be presented to the author for private use.

37.—Members elected at any meeting between the Annual Meetings shall be entitled to all papers issued in that year, so soon as they have signed and returned Form F, and paid their subscriptions.

38.—The Transactions of the Institute shall not be forwarded to Members whose subscriptions are more than one year in arrear.

39.—No duplicate copies of any portion of the Transactions shall be issued to any of the Members unless by written order from the Council.

40.—Invitations shall be forwarded to any person whose presence at the discussions the Council may think advisable, and strangers so invited shall be permitted to take part in the proceedings but not to vote. Any Member of the Institute shall also have power to introduce two strangers (see Form L) to any General Meeting, but they shall not take part in the proceedings except by permission of the Meeting.

41.—No alteration shall be made in the Bye-laws of the Institute, except at the Annual Meeting, or at a Special Meeting for that purpose, and the particulars of every such alteration shall be announced at a previous Ordinary Meeting, and inserted in its minutes, and shall be exhibited in the room of the Institute fourteen days previous to such Annual or Special Meeting, and such Meeting shall have power to adopt any modification of such proposed alteration of the Bye-laws.

Approved,
R. ASSHETON CROSS.

Whitehall,
2nd July, 1877.

APPENDIX TO THE BYE-LAWS.

[FORM A.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being upwards of twenty-eight years of age, and desirous of being elected an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers, I recommend him from *personal knowledge* as a person in every respect worthy of that distinction, because—

[Here specify distinctly the qualifications of the Candidate, according to the spirit of Bye-law 3.]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed____________________________Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an ordinary Member.

FROM PERSONAL KNOWLEDGE.

____
____
________________________ Five Members.
____
____

[To be filled up by the Council.]

The Council, having considered the above recommendation, present A. B. to be balloted for as a of the North of England Institute of Mining and Mechanical Engineers.

Signed________________________Chairman.

Dated this day of 18

[FORM B.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being desirous of admission into the North of England Institute of Mining and Mechanical Engineers, we, the undersigned, propose and recommend that he shall become [an Honorary Member, or an Associate Member, or a Student] thereof.

____
____
______________________________ Three* Members.
____
____

* If an Honorary Member, five signatures are necessary, and the following Form must be filled in by the Council.

Dated this day of 18

[To be filled up by the Council.]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Honorary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed ______________________________ Chairman.

Dated day of 18

[FORM C.]

A. B. [Christian Name, Surname, Occupation, and Address in full], being at present a of the North of England Institute of Mining and Mechanical Engineers, and upwards of twenty-eight years of age, and being desirous of becoming an Ordinary Member of the said Institute, I recommend him, from *personal knowledge*, as a person in every respect worthy of that distinction, because—

[Here specify distinctly the Qualifications of the Candidate according to the spirit of Bye-law 3.]

On the above grounds, I beg leave to propose him to the Council as a proper person to be admitted an Ordinary Member.

Signed ______________________________ Member.

Dated this day of 18

We, the undersigned, concur in the above recommendation, being convinced that A. B. is in every respect a proper person to be admitted an Ordinary Member.

FROM PERSONAL KNOWLEDGE.

____________________ } Two
____________________ } Members.

[*To be filled up by the Council.*]

The Council, having considered the above recommendation, present A. B. to be balloted for as an Ordinary Member of the North of England Institute of Mining and Mechanical Engineers.

Signed ____________________ Chairman.

Dated day of 18

[FORM D.]

List of the names of persons to be balloted for at the Meeting on , the day of 18

ORDINARY MEMBERS :—

____

____

____

ASSOCIATE MEMBERS :—

____

____

HONORARY MEMBERS :—

____

____

STUDENTS :—

____

____

Strike out the names of such persons as you desire should *not* be elected, and hand the list to the Chairman.

[FORM E.]

SIR,—I beg leave to inform you that on the day of you were elected a of the North of England Institute of Mining and Mechanical Engineers, but in conformity with its Rules your election cannot be confirmed until the enclosed form be returned to me with your signature, and until your first annual subscription be paid, the amount of which is £ , or, at your option, the life-composition of £

If the subscription is not received within two months from the present date, the election will become void under Bye-law 15.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM F.]

I, the undersigned, being elected a of the North of England Institute of Mining and Mechanical Engineers, do hereby agree that I will be governed by the Charter and Bye-laws of the said Institute for the time being; and that I will advance the objects of the Institute as far as shall be in my power, and will not aid in any unauthorised publication of the proceedings, and will attend the meetings thereof as often as I conveniently can; provided that whenever I shall signify in writing to the Secretary that I am desirous of withdrawing my name therefrom, I shall (after the payment of any arrears which may be due by me at that period) cease to be a Member.

Witness my hand this day of 18

[FORM G.]

Sir,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to draw your attention to Bye-law 17, and to remind you that the sum of £ of your annual subscriptions to the funds of the Institute remains unpaid, and that you are in consequence in arrear of subscription. I am also directed to request that you will cause the same to be paid without further delay, otherwise the Council will be under the necessity of exercising their discretion as to using the power vested in them by the Article above referred to.

I am, Sir,

Yours faithfully,

Secretary.

Dated 18

[FORM H.]

Sir,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you, that in consequence of non-payment of your arrears of subscription, and in pursuance of Bye-law 17, the Council have determined that unless payment of the amount £ is made previous to the day of next, they will proceed to declare that you have ceased to be a Member of the Institute.

But, notwithstanding this declaration, you will remain liable for payment of the arrears due from you.

I am, Sir,
Yours faithfully,
Secretary.

Dated 18

[FORM I.]

Sir,—I am directed by the Council of the North of England Institute of Mining and Mechanical Engineers to inform you that, upon mature consideration of a proposal which has been laid before them relative to you, they feel it their duty to advise you to withdraw from the Institute, or otherwise they will be obliged to act in accordance with Bye-law 18.

I am, Sir,
Yours faithfully,
Secretary.

Dated 18

[FORM J.]

Sir,—It is my duty to inform you that, under a resolution passed at a Special General Meeting of the North of England Institute of Mining and Mechanical Engineers, held on the day of 18 , according to the provisions of Bye-law 18 you have ceased to be a Member of the Institute.

I am, Sir,
Yours faithfully,
Secretary.

Dated 18

[FORM K.]

BALLOTING LIST.

Ballot to take place at the Meeting of ______ 18 ______ at Two o'Clock.

President—One Name only to be returned, or the vote will be lost.

______ President for the current year eligible for re-election.

______
______ } New Nominations.

Vice-Presidents—Six Names only to be returned, or the vote will be lost.

The Votes for any Members who may not be elected as President or Vice-Presidents will count for them as other Members of the Council.

______
______
______ } Vice-Presidents for the current year eligible for re-election.
______

______
______
______ } New Nominations.
______

Council—Eighteen Names only to be returned, or the vote will be lost.

______
______
______
______
______
______ } Members of the Council for the current year eligible for re-election.
______
______
______
______
______
______

______
______
______
______
______ } New Nominations.
______
______
______
______
______

Any list returned with a greater number of Names than
One President,
Six Vice-Presidents,
Eighteen Councillors,
Will be rejected by the Scrutineers as informal, and the Votes will consequently be lost.

Extract from Bye-law 21.

Each Original, Ordinary, and Associate Member shall be at liberty to nominate in writing, and send to the Secretary not less than eight days prior to the Ordinary General Meeting in June, a list, duly signed, of Members suitable to fill the Offices of President, Vice-Presidents, and Members of Council, for the ensuing year. The Council shall prepare a list of the persons so nominated, together with the names of the Officers for the current year eligible for re-election, and of such other Members as they deem suitable for the various offices. Such list shall comprise the names of not less than thirty. The list so prepared by the Council shall be submitted to the General Meeting in June, and shall be the balloting list for the annual election in August. (See Form K in the Appendix.) A copy of this list shall be posted at least seven days previous to the Annual Meeting, to every Original, Ordinary, and Associate Member; who may erase any name or names from the list, and substitute the name or names of any other person or persons eligible for each respective office; but the number of persons on the list, after such erasure or substitution, must not exceed the number to be elected to the respective offices. Papers which do not accord with these directions shall be rejected by the Scrutineers. The votes for any Members who may not be elected President or Vice-Presidents shall count for them as Members of the Council. The Chairman shall appoint four Scrutineers, who shall receive the balloting papers, and after making the necessary scrutiny destroy the same, and sign and hand to the Chairman a list of the elected Officers. The balloting papers may be returned through the post, addressed to the Secretary, or be handed to him, or to the Chairman of the Meeting, so as to be received before the appointment of the Scrutineers for the election of Officers.

Names substituted for any of the above are to be written in the blank spaces opposite those they are intended to supersede.

The following Members are ineligible from causes specified in Bye-law 19:—

As President ____________________

As Vice-President ____________________

As Councillors ____________________

[FORM L.]

Admit
of
to the Meeting on Saturday, the
(Signature of Member or Student)
The Chair to be taken at Two o'Clock.

I undertake to abide by the Regulations of the North of England Institute of Mining and Mechanical Engineers, and not to aid in any unauthorised publication of the Proceedings.

(Signature of Visitor)

Not transferable.

NORTH OF ENGLAND INSTITUTE

OF

MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING, SATURDAY, SEPTEMBER 4TH, 1880, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

T. J. BEWICK, Esq., in the Chair.

The Secretary read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were elected, having been previously nominated :—

Associate Member—

Mr. R. W. Cooper, Solicitor, Newcastle-on-Tyne.

Student—

Mr. Wm. Thomas Curry, Wardley Colliery, Newcastle-on-Tyne.

The following were nominated for election at the next meeting :—

Ordinary Member—

Mr. Wm. George Laws, Civil Engineer, Newcastle.

Associate Member—

Mr. Thomas Arnold, Mineral Surveyor, Louchor, Glamorganshire.

Students—

Mr. Arthur P. Galwey, Towneley and Stella Collieries, Ryton-on-Tyne.
Mr. Henry A. Pringle, Lofthouse Mines, Saltburn-by-the-Sea.
Mr. Henry Temple Stobart, North Bitchburn Colliery, Darlington.
Mr. Thomas Heslop, North Bitchburn Colliery, Darlington.

A paper "On the Kurhurballee Coal-field, with some Remarks on Indian Coals," was then read by Mr. Walter Saise, D.Sc. (Lond.), F.G.S., F.C.S.

THE KURHURBALLEE COAL-FIELD, WITH SOME REMARKS ON INDIAN COALS.

By WALTER SAISE, D.Sc. (Lond.), F.G.S., F.C.S.,
Associate of the Royal School of Mines, London, Assistant Manager of East Indian Railway Collieries.

(Read by permission of the Directors of the East Indian Railway Company.)

The East Indian Railway Company owns the greater part of this coal-field, and the writer being in their service, and having collected the most of the information contained in the following paper, in his official capacity as their servant, he thought it necessary to obtain their consent to the publication of matter which affects them more than anyone else; their sanction was not only cheerfully given, but every assistance was rendered to the writer to make the paper as full and complete as possible.

The only literature on this subject with which the writer is acquainted is:—1st. An excellent memoir by Mr. Theodore Hughes, Associate of the Royal School of Mines, published in Vol. VII. of the Geological Survey of India. It gives all particulars obtainable up to the date of publication, *i.e.*, 1871. 2nd. A very elaborate and complete monograph, by Dr. Otto Feistmantel, "On the Flora of the Karbarbári Beds."

The writer intends in this paper to make the diagrams tell their own tale and to say little more than is absolutely necessary. The diagrams have been prepared with great care, and will give a comprehensive sketch of what is at present known of the field.

The coal-field is situated in the district of Hazaribagh, between the parallels of 86° 10′ and 86° 23′ east longitude, and of 24° 10′ and 24° 14′ north latitude. (See Plate I.)

It is within 24 miles of one of the main lines of the East Indian Railway which runs from Calcutta to Delhi, and which, by means of a connection with the Great Indian Peninsular Railway, is the highway to Bombay, as will be seen by reference to the map of India.

The East Indian Railway runs through and taps the Great Ránigani, or Raneegunge, coal-field, which it is stated has an area of 500 square miles. Fifty miles beyond the Raneegunge coal-field there is a branch line to the Kurhurballee coal-field; the station at which the branch leaves the main line is called Muddapore. This branch line is 23 miles long, and consists of a single road with pass-bye lines at the two stations, Jagadispur and Mohesmunda. The terminal station is called Giridi.

At Giridi two branches run to the collieries, one branch going to the Serampore (properly Srirámpur) Colliery estate, and the other to the Kurhurballee Colliery. These branches are shown on the sketch surface map, Plate I.

The coal is loaded by hand into the coal trucks, which are usually covered and closed. These trucks are used for bringing rice and other merchandize one way and taking coal the other. The gauge of the railway is six feet.

The coal-field, which has an area of about 11 square miles, all of which, however, is not productive, with a greatest length of six miles and a breadth of 2¾, is held by four Companies, three of which are actively engaged in working coal; these latter are the East Indian Railway Company, Bengal Coal Company, and Raneegunge Coal Association.

The East Indian Railway possesses several wharves on the two branches for loading their coal. The Bengal Coal Company and the Raneegunge Coal Association have each one siding and wharf. The East Indian Railway coal is led to the main wharves by tip waggons running on a metre gauge railway. The metre gauge railway at Kurhurballee is about one-and-a-half miles long, and the same at Serampore; these are marked on the surface map. Where the mines are near the wharves the coal is led in the ordinary coal tubs (which hold from five to seven cwts.) by hand on a 1 foot 9 inch gauge railway, or by bullock carts. The East Indian Railway Company have led the way in the matter of leading coal on the surface, but the other Companies are following closely.

The Raneegunge Coal Association convey their coal over a 1 foot 9 inch gauge railway by a small locomotive, and by ponies, and the Bengal Coal Company are connecting their distant mines to the railway by a tramway, which is in course of construction.

The Kurhurballee coal-field is one of the coal-fields that lie in the metamorphic higher ground which rises out of the alluvial flats of Lower Bengal. The mean height above the sea is 950 feet, some of the hills of hard sandstone rising to a height of 1,100 feet. Around the coal-field the hills of metamorphic rock rise in isolated peaks as high as 1,600 feet; while the Parasnáth, the sacred hill of the Jains, as well as the sanatorium of colliery officials, towers to a height of 4,479 feet above the sea.

The coal-field lies between the Osri and the Barákar, of which the former is a tributary. Although the Osri passes within a mile of the northern boundary of the field, the direction of drainage is towards the Barákar, which lies several miles further from the coal-field. The force which determined the initial direction of drainage had probably some connection with the faulted and disturbed boundary on the north of the field.

The coal-field is drained by several important streams or "nalas" (pron. Nullah) which are named in the map. The west of the field is drained by the Sooknid and Khakho, which are supplied by smaller ones called the Dhurdhurwa, Muckpitto, and Komersote.

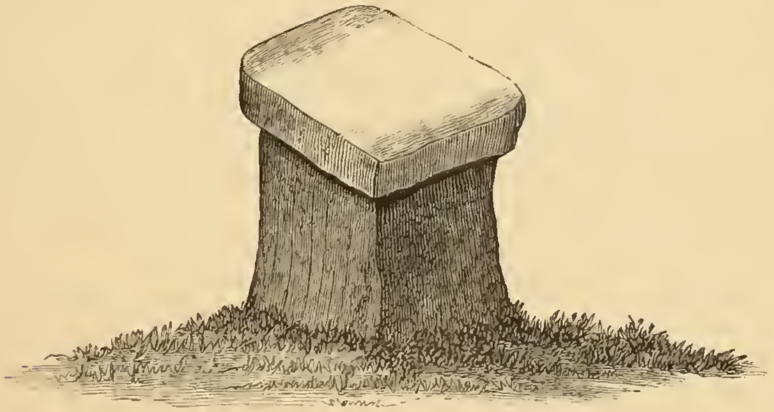
The centre and west of the field are drained by the Komaljore, Puthrodiha, Purtdiha, and Suni Nalas, which unite with those from the west of the field, and flow into the Barákar.

During the rainy season these "nalas" are goodly streams; during the rest of the year they are but beds of sand in which water may be found by digging small wells.

The yearly rainfall is about 50 inches, the greater portion of which falls during the months of July, August, and September.

Nowhere has the writer seen the degrading action of rain so well marked as in India. After the baking, parching heat of the hot season has destroyed all vegetation, and the ground is cracked and bare, down pours the rain, and muddy rivulets collect and pour into a crack in the ground, which rapidly becomes a small cañon, as it may be called, the depth depending on the thickness of the soil. These rivulets, or small waterfalls, collect together, and become at last a roaring "nala," full of the mud that it has collected in its course. The ground is very much cut up by these ravines or cañons in the soil.

The loss of soil in this way in uncultivated parts must be very great. Large stones protect the soil immediately beneath them from the carving power of the rain, and it is not uncommon to see stones a foot or so in diameter standing on these earth pillars.



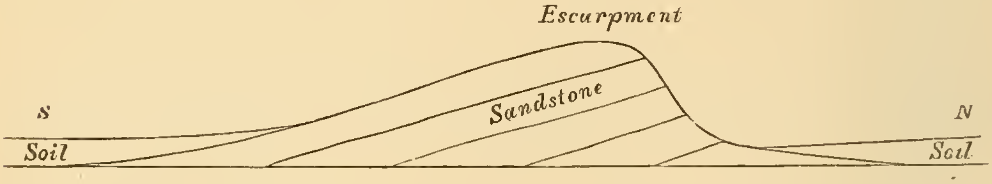
The height of these pillars is a measurement of the amount of denudation due to rain in that part.

The work of disintegration goes on apace even on the bare rocks; scales become detached and splintered off during the scorching heat of the summer, and the rains carry these away, leaving the heavier portions *in sitû.*

The writer has seen large collections of waterworn pebbles lying on the bare rock. The rock is a conglomerate, and the inference is, that the enclosing matter has been carried away, leaving the pebbles exposed.

Another feature very noticeable in the coal-field is the large number of potholes to be observed in the tracks of the hill-torrents, or at any point where a stream passes rapidly over a rocky bed. These potholes vary from a few inches to a foot in diameter, and usually contain the pebble which, under the twirling action of the waters, has drilled the holes.

The hills in the coal-field are formed by the escarpment of hard beds of sandstone. The steep precipitous sides are those at right angles to the dip, as shown in the woodcut. These hills are covered with sparse vegetation, the bare rocks projecting through at every turn. They are covered by a slight growth of scrub jungle, the chief tree being a stunted sál.



The streams have cut this escarpment into several isolated hills, but the general feature is very marked, the steep side facing the north. The hard sandstone hills dip ultimately under the richer soil of the plains. In the lower parts of the field the Mango, Tamarind, the Jack tree, the Peepul, the Bir or Banyan grow, here and there surrounded by plots of Indian corn (maize) and the picturesque villages of the natives. Whenever the water can be caught and spread over a small area of ground the frugal native cultivates his rice. These little patches of ground are plentiful near the nalas, or in the course of any flow of water which is so necessary in rice cultivation.

The coal-field lies in a basin of metamorphic rocks which form an easily recognizable boundary when exposed. The metamorphic rocks are granites, gneiss, micaceous and chloritic schists, and hornblende rock. The granites vary from pegmatite, or fine grained, to coarsely porphyritic, in which the crystals of felspar are of very large size.

Large dykes of trap and quartz reefs intersect these rocks. The trap dykes are micaceous and felspathic, and extend into the coal-field damaging the seams and interfering with mining progress, as the writer will hereafter have to mention.

The decomposition of the metamorphic rocks goes on to a great depth. The writer sank a well in this compound 40 feet in depth, the whole requiring nothing but the pick and shovel, or at least the natives' substitute for a shovel, viz., the "khodári" or "hoe." The section was that of a solid schist, and yet the fragments could be squeezed to pieces by the hand, the grains falling into coarse sand of mica, quartz, etc.

From the metamorphic rocks surrounding the field, or from some similar source, the materials which went to form the sandstones, conglomerates and shales were derived. The sandstones are peculiarly felspathic, the crystals of felspar being very large and nearly perfect at times. Mica occurs in the laminæ of the shales to a large extent.

At Kurhurballee and Jogitand, and on the south of Serampore, in some places, the conglomeratic sandstone contains broken pieces of garnets showing their derived nature from pre-existing metamorphic rocks.

The loose pebbles found in the present streams of the coal-field, of granite, gneiss, hornblende rock, quartz, etc., are similar to those found in the conglomerates of the coal-measures.

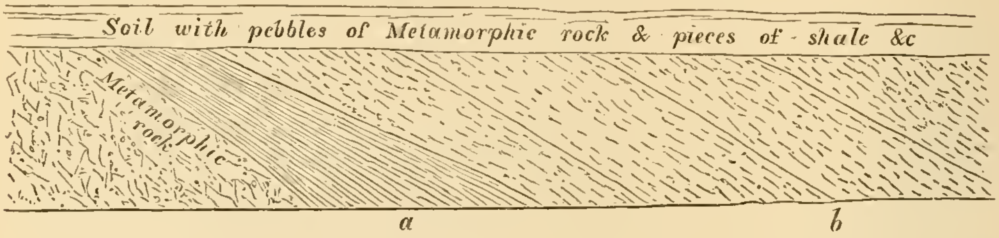
The base of the coal-measures consists of a series of strata of marked character and unproductive of coal. They are called the Talchir series, the productive measures lying on them being called the Karharbári beds. These Talchir beds form the Farewell Rock of this coal-field, and wherever exposed they occupy the lowest part of the measures.

They are exposed very unequally over the coal-field, partly owing to, first, the Karharbári beds overlapping them; second, to the Karharbári beds being faulted against the metamorphic rocks; or, third, to the thinning out of the Talchirs.

This feature of the thickenning and thinning out of the coal-measures is very noticeable, and points to a limited area of deposition.

The unproductive measures consist, where exposed, of a base of boulder conglomerate, containing very large and rounded boulders of metamorphic rock, as well as smaller pebbles. They are contained in a fine silt like base. Above these come bluish white, bluish green, or brownish coloured shales, which break up into needles, and are hence called needle shales.

In lithological characters they reminded the writer very much of the lias shales. They overlap the boulder conglomerate in places as is shown by the section on the next page; this section was obtained from a cutting made for the purpose of diverting the course of a stream which flooded a mine. The Talchirs are shown on the surface map, Plate I., which is adapted from the map issued by the Geological Survey of India.



a.—Grey Shales. *b.*—Sandstone.

Above the measures referred to come the productive coal-measures, with which this paper has more particularly and exhaustively to deal.

The measures consist chiefly of sandstone of varying texture and structure, with conglomerates, shales, duns, and coal seams, but with no fire-clay proper. The floor is either sandstone or hard shale in every case. The sandstones easily weather and are therefore not much used. Coping stones for the platforms of stations have been made of them, but they are not of good quality.

Near the base of the productive coal-measures or Karharbári beds comes the lower seam (or seams Nos. 1 and 2 of the Geological Survey). This seam or group of seams presents very different sections in different parts of the coal-field, as may be seen by reference to Plate III.

At Kurhurballee alone is the upper as well as the lower division worked, and there only on the east of the district.

As the upper division recedes from the lower it diminishes in thickness, and becomes unworkable; the lower bed, however, becomes much thicker, and less stoney. The name "lower seam" is used to comprehend the whole of these two main divisions. If every division were created into a separate seam, it would cause some trouble.

This seam has a thickness of 21 feet from roof to floor at Kurhurballee, but this includes a great deal of stone and shale parting.

At Serampore the lower band, which alone is worked, varies from 11 feet to 15 feet, and there are indications of its becoming much thicker towards the south-east.

The inconstant character of this seam, as regards thickness, is well illustrated by Plate IV. (section of the lower seam).

The quality of the coal, as far as its chemical composition is concerned, does not vary much, though in physical structure it alters, in some places being very hard and rubbly, and in others soft. The seam extends over about eight square miles of country, five of which belong to the East Indian Railway Company.

The diagrammatic sections (Plate II.) will show the geological conditions under which the seams exist, and the surface map (Plate I.) shows the area over which the seams extend.

The coal-field is divided into two unequal divisions by an anticlinal, the northern portion being a semi-basin of small size, the southern portion forming the largest portion of the field.

The upper section (section on A B, Plate II.) shows the ground as proved by the shafts thereon named and figured.

South of No. 41 shaft is found same faulty ground, which the shaft No. 25 proves to be a downthrow south. This shaft is 200 feet deep. Passing south, the same seam is now worked by No. 22 shaft, at a depth of 242 feet. Farther south, at No. 16B shaft, the seams were worked at a moderate depth of 100 feet or thereabouts, dipping to the north, the workings ending against a fault. No. 16A shaft has been sunk 245 feet, and has met with a thin seam 70 feet above the main seam. The axis of the synclinal would therefore be in the line of this fault.

North and south of this section are the metamorphic rocks.

The evidence from the section on A B has been used to explain the observed facts collected from boring, trial shafts, etc., in other parts of the coal-field, and sections on C D and E F are the results.

Taking a line of section (C D) across the centre of the coal-field, it will be noticed that there is a greater extent of coal-measures.

The higher and more hilly ground that this section passes through, the greater thickness of measures, on account of its being the centre of the field, allow some higher seams to come in, cropping on Bhaddoah Hill, as will be seen on the section.

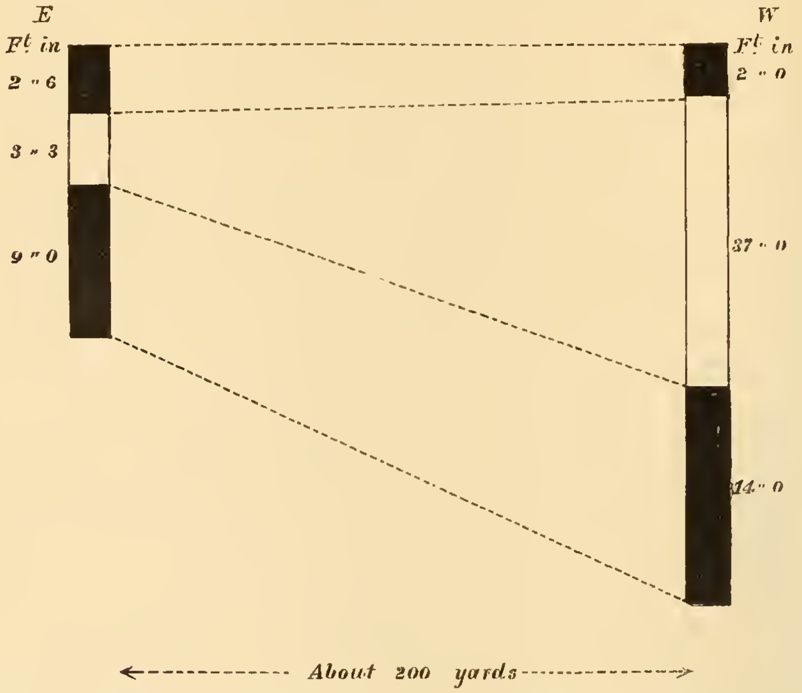
The force of upheaval which brought up the metamorphic rock on the north of section A B has, in this part of the field, only produced an anticlinal, with the result of giving a larger extent of coal for enterprise and energy.

The section on E F shows a somewhat similar state of things. The anticlinal axis, prolonged into the metamorphic rocks, and a small basin of unproductive coal-measures, lie to the north of the productive coal-field.

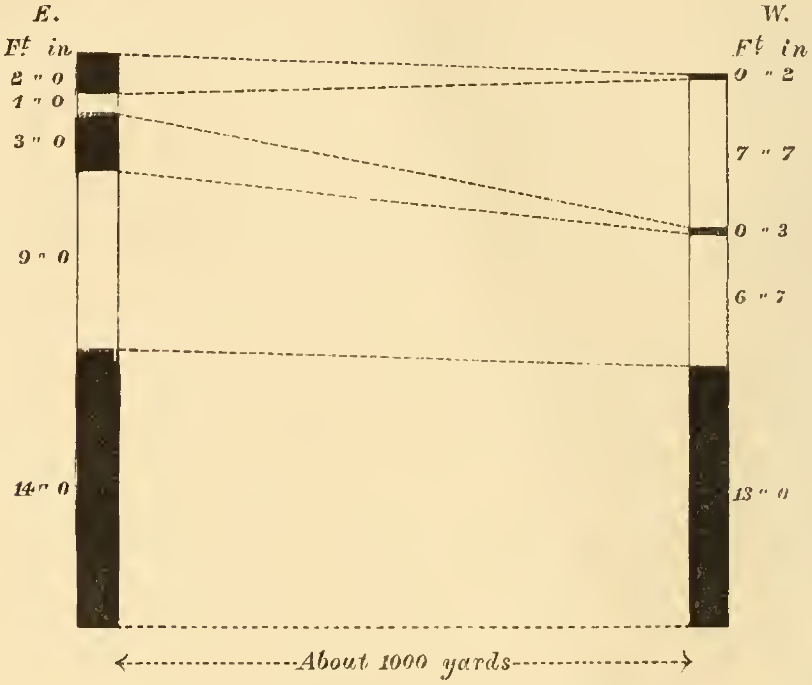
The following facts, selected from a multitude of examples, will show the difficulty in giving one general section of the coal-field.

Had the writer attempted one general section only, the most important feature of the field would have been overlooked, viz., the alteration of thickness of seams and enclosing strata.

At Serampore, within a distance of 200 yards, the parting between the two beds of coal thickens in the manner shown in the sketch.



At Kurhurballee, in the part of the coal-field on the north dip, the following may be noticed. It will be seen that 2 feet of coal has dwindled down to 2 inches, and 3 feet to 3 inches, the parting stone increasing from 1 foot to 7 feet 7 inches.



The writer has therefore adopted the plan of giving four general sections of the field in four places shown on the surface map. The evidence, from which these general sections are obtained, is also shown in the shape of pit sections or sections of borings.

The first part of the field that will be noticed is that lying north of the anticlinal. The seams are here faulted and disturbed, the dip varying from a few degrees to 30 or 35 degrees.

The section on C D gives the general conditions under which the coal seams occur. They abut, after dipping towards the north, against the metamorphic rocks, which form the boundary in other parts of the field. The strike of the seams forms a semi-basin, as will be seen by the surface map. The fault which brings up the metamorphic rocks, forms the northern boundary.

On the eastern side of the field there is a much larger development of stone and shale in the seams than occurs on the west of the field. This may be seen from an examination of sections of 5 G and 40 and 17 B and 23 B (Plates IV. and V.)

The lower seam exists over the greater portion of the area. The upper seam, which is 160 feet above the lower one, exists over a large portion of this part of the field. The general section A, Plate III., gives the probable section of No. 23 D, now sinking, of the East Indian Railway collieries, which is to win and work the whole of the coal in the two seams mentioned. The total thickness of measures close to the fault must be about 400 feet, and this includes the large amount of 36 feet of coal, 21 feet of which is included in the two seams at present worked. The remaining 15 feet is spread over seams considered too thin to be workable, or at all events too thin to attract attention while so much thick coal is available.

There are two well-marked seams each containing more than four feet of coal, one lying above the lower seam and the other above the upper seam. They are landmarks in the field, and as it is essential that they should have some designation in literature on the coal-field, the writer proposes the names given in the general section A, one from the chairman, the other from the agent in India. This is preferable to numbering the seams, which must cause confusion when a seam that has been overlooked is found to exist between two already numbered seams.

On the south of the anticlinal the lower seam dips regularly to the south, as shown in sections on A B, C D, and E F, Plate II., until within a short distance of the southern boundary, where there is a synclinal axis coincident over a great portion of it, with a fault which brings up the lower seam.

The upper seam appears to be about 3 or 4 feet thick on the south of the anticlinal until it reaches Serampore, where it gives from 3 feet 6 inches to 5 feet of coal, in a total thickness of seam of 8 feet 6 inches.

Above this upper seam the ground in the south of the anticlinal does not resemble that on the north of the anticlinal.

There are two seams cropping on Bhaddoah Hill, the upper and lower one named the Bhaddoah seam. On the side of the hill they are about 30 feet apart, but as they dip to the south the thickness of intervening strata becomes much less, and the upper seam increases in thickness. On the south of Bhaddoah Hill the upper seam is represented by 8 feet of shale. The writer is inclined to believe that the thick seams of Khundiha represent the Bhaddoah seams.

On the west of Bhaddoah, towards the villages of Maheslundi and Karharbári, the Karharbári beds abut against the metamorphic rocks, and the outcrop of the lower seam is not exposed. It probably lies at no very great depth however.

Still farther west the seam crops, and has been worked in years past to some extent, and proved of excellent quality.

Eastward of Jogitand the seam passes through Kuldiha to Buriadih, into the Serampore estates of the East Indian Railway and Raneegunge Coal Association. The sections on A B, to which the writer has already called attention, showed the position and depth of the coal in this part of the field, and the general section on the right (Plate III.) gives a generalized section at the point marked D on the surface map (Plate I).

The great thickening of the strata will be the most noticeable feature, and corresponding with the increase of thickness of rock strata there appears to be an increase in the thickness of the coal on the lower seam. The increase in the thickness of strata cannot be better shown than by comparing some shafts at Serampore with those at Kurhurballee.

On referring to the section of No. 22 shaft or No. 21 shaft, it will be found that 250 feet of strata enclose 16 or 17 feet of coal.

The ground included in shafts No. 23B and 24 (Plate I), at Kurhurballee, on the north pitch, amounts to 280 feet or thereabouts, and this includes 29 feet of coal.

Farther south than No. 22 the strata still increases in thickness; and No. 16A shaft, close to the fault, has been sunk 250 feet, and has only met with the small seam which lies about 70 or 80 feet above the lower seam. When completed, this shaft will be 360 deep—about the same as No. 23 D. This latter will cut 36 feet of coal, including the upper and lower seams; whereas 16A will only cut the lower seam, the upper seam cropping some hundred of feet on the deep side of the shaft.

At 23D the upper seam will lie about 160 feet above the lower seam. At No. 16A, or near the southern boundary, the distance between the seams is from 450 to 500 feet. This is a great increase on 160 feet. Above this seam crop the Khundiha seams, which are but little explored or known, but which the writer has connected by boreholes with the Bhaddoah seams. These will lie at the point marked D, quite 200 to 300 feet higher than the upper seam.

The total thickness of productive measures in this part of the field, *i.e.*, at D, Plate I., therefore, is probably not less than 1,000 feet.

The greatest thickness of strata is thus seen to be near the southern boundary. The structure of the field with the faulted boundaries is most interesting.

It will be observed that the faults, as regards actual throw or heave, are not very great. That on the north may be about 600 feet, that running along the south of the field is probably from 200 to 400 feet in vertical throw.

Trap dykes intersect the field as shown in the surface map. Where they come in contact with the coal the latter becomes coked and useless for some distance. Plate VII. gives a few interesting examples which the writer met with during his inspection of sinkings or of the workings.

The lower seam is often divided by a band of trap which, with the stone and shale partings, divides the seam into four or five beds of coal.

Specimens of the trap were carefully examined microscopically by Mr. Rutley, of the Museum, Jermyn Street, and he reports on them all as being micaceous traps very decomposed indeed, the felspar being replaced by carbonate of calcium. In one specimen he thought he discerned olivine, but he is not quite sure of this.

The sections (Plate VII.) represent a band of trap passing across the coal and coking it for some distance. This is the upper seam. The trap is brownish white and very decomposed, and when first cut it yielded a great quantity of water.

In the lower seam, No. 6B mine, the trap is parallel to the bedding, and is very decomposed.

In No. 40 shaft the working was delayed by the presence of the trap which, though decomposed (as was shown by microscopic examination), was very hard to cut through. The coal was coked and hardened to the extent shown. A great deal of pyrites was found in the coal. The shale was hardened and laminated, and contained flakes of white calcspar that gave it a very pretty appearance.

In No. 24 shaft the trap was very thick and massive, but was of the same variety as at No. 40 shaft. There were 8 feet of coal above the trap at the pit bottom, but as the gallery or headway was driven, the thickness of good coal decreased to three feet, and then the trap broke through the seam into the roof. The coal was burnt, the shale being hardened and split into polygonal columns, and pieces of coal (or rather coke) and burnt shale were included in the igneous matter. Below the trap the coal was found burnt as at the top.

Having considered the geological structure of the field, the writer will now attempt to show the amount of coal in the field.

The coal-field is small in area, as has already been stated, but it is great as regards thickness of coal. The area of the lower seam may be taken at eight square miles. This is the seam with the greatest extent, as well as the greatest thickness, and really contains the greatest portion of the mineral wealth of the coal-field, It is the best seam too as regards structure and chemical composition, as hereafter will be seen, and has a mean specific gravity of 1·35. The thickness of the seam, the writer can safely say, is, on an average, not less than 14 feet of coal, but may be safely taken as 12 feet 6 inches. In one shaft there were 15 feet of coal with more beneath. Eight square miles of a seam 12 feet 6 inches in thickness and of a specific gravity of 1·35 means 105,008,040 tons.

The upper seam is only worked at Kurhurballee, and, in the absence of workings on it elsewhere, the writer will only calculate the quantity in this part of the field. At a specific gravity of 1·33, and assuming an average of 72 inches, there are about 1,578,990 tons of this coal.

The Bhaddoah seam, which is the most easily and cheaply worked at present as it lies in the hill, is a useful seam (see Plate VI.), and a tolerably good one, as shown in the table of analyses.

The Khundiha seam (the analyses gives the composition of the top band of the three seams shown in general sections) is probably the upper Bhaddoah seam, and underneath it the writer expects to find good coal.

The specific gravity is 1·40, the average thickness is taken at 86 inches. This means an amount of 11,793,420 tons. It may be summed up as follows :—

	Tons.
Lower seam	105,008,040
Upper seam	1,578,990
Bhaddoah seam	11,793,420
	118,380,450
Allowing 30 per cent. for waste, etc., etc. ...	35,514,135
There remains	82,866,315
Allow for what is worked	1,500,000
	81,366,315

The output of the coal-field is from 400,000 to 450,000 tons per annum, of which the East Indian Railway raises 250,000 to 300,000 tons. Assuming an output of 500,000 tons, the coal-field will have a life of 162 years.

This coal-field yields nearly half the output of India.

Many seams of what in England, with approved methods and intelligent workmen, would be considered good workable seams, are left unnoticed. As it is probable that these thinner seams will in the future attract attention, the writer thinks they should be allowed for. In the Kurhurballee (general section A., Plate I.) 21 feet only out of 36 feet of coal was worked. Allowing that 4 feet of coal more may be won over the whole coal-field, 14,000,000 tons must be added to the above estimate, after allowing for waste in working, etc., etc. This would prolong the life of the field another quarter of a century.

QUALITY AND COMPOSITION OF THE COAL.

The physical structure of the coal may be thus described.

It is very laminated, in the better specimens the laminæ being inconspicuous, but in that from "Khundiha," the laminated character is very exaggerated. It shows on examination thick laminæ of bright bituminous matter alternating with laminæ of mineral charcoal and shale. The mineral charcoal can be seen in all the coals when broken parallel to the planes of bedding. Microscopically it appears very like wood charcoal, which in fact it is. The writer exposed some of this mineral charcoal to heat with the following result. It gave off a large amount of volatile matter without caking, and burnt slowly to a flocculent yellowish ash, like wood ashes in appearance :—

	Per Cent.
Ash	2·22
Carbon, fixed	70·58
Volatile matter and water	27·20

The bituminous layers bubbled up on heating, and burnt with a reddish ash. The analysis gave the following :—

	Per Cent.
Ash	0·94
Fixed carbon	73·59
Volatile matter	25·47

Under the microscope the writer recognized a long flattened spore case in the bituminous matter.

A reference to the tables of analyses which follow will show that the layers of shale or carbonaceous shale must be present in a large degree in the Khundiha seam; in a less degree in the other seams, as the amount of ash in the seams is greater than that shown by the above analyses to be contained in the mineral charcoal and the bituminous matter.

The first table gives the commercial analyses of the different seams, *i.e.*, the fixed carbon, the volatile matter, ash, sulphur, and heating power of the coals.

TABLE I.

	Specific Gravity.	Ash.	Fixed Carbon.	Volatile Matter.	Sulphur.	Calorific Power.	Remarks.
Lower Seam	1·37	11·67	67·51	20·82	0·72	12·93	Ash white.
	1·34	9·53	64·67	25·80	0·84	13·20	Caking coal; ash fawn-coloured.
	1·35	9·15	66·84	24·00	0·42	13·20	
Upper Seam ...	1·33	11·96	60·46	27·59	0·52	12·50	Caking coal; ash white.
Bhaddoah Seam	1·40	13·60	61·03	25·37	0·80	12·40	Caking coal; ash grey.
	1·40	18·08	61·45	20·46	—	12·26	Ash grey.
Average ...	1·38	12·33	63·66	24·01	0·66	12·75	
Khundiha ...	—	22·32	59·10	18·58	—	11·00	Ash earthy.

The following table gives the ultimate composition of the seams:—

TABLE II.

	Carbon.	Hydrogen	Nitrogen and Oxygen.	Sulphur.	Ash.	Remarks
Lower Seam ...	74·41	4·28	8·92	0·72	11·67	Upper portion of seam.
	78·00	4·72	6·91	0·84	9·53	Serampore, Lower part of seam.
	78·20	4·34	7·89	0·42	9·15	Jogitand.
Upper Seam ...	70·93	4·10	12·49	0·52	11·96	Kurhurballee.
Bhaddoah Seam	71·46	4·31	9·83	0·80	13·60	Bhaddoah (Kurhurballee.)
	68·94	3·26	9·72	—	18·08	Serampore.
Khundiha ...	64·38	3·71	9·59	—	22·32	Serampore.

The most noticeable feature is the high specific gravity of the coal. The next point is the rather large amount of ash—large, the writer means, in comparison with English standard coals. In running down the list of analyses it must be recollected that the lower seam forms the largest proportion of the coal in the field, and the largest proportion of the output, and this seam has only 9 per cent. of ash, which is not very great.

The next point is the large amount of carbon and hydrogen, and the proportion of fixed carbon, which is coke with the ash abstracted. The calorific power, or the pounds of water that can be converted from 212 degrees into steam by one pound of coal, is also good. They were ascertained by Thomson's calorimeter.

In order to arrive at a correct idea of the quality of these coals, the writer has in the following table put the lower seam, as well as the average of the Kurhurballee seams, in comparison with Welsh and Bristol coals, and also with the coals from the Ràniganj coal-field. The Ràniganj analyses are the average of two good specimens, and the general average of sixteen samples from different portions of the seams. The sulphur is not given, but it is stated to be high :—

TABLE III.

		Specific Gravity.	Ash.	Fixed Carbon.	Sulphur.	Volatile Matter.	Authority.
INDIAN— Kurhurballee	Lower Seam	1·35	9·15	66·84	0·42	24·00	Author.
	Average	1·38	12·33	63·66	0·66	24 01	
Ràniganj	Good specimen ...	—	10·70	51·80	—	37·50	Mem. Geo. Survey of India, Vol. III.
	Average of 16 do.	—	16·27	51·08	—	32·65	
ENGLISH—							
Welsh coals		1·312	3·68	82·66	1·59	13·66	Official Report on Coal for Navy.
Bristol Lower Series (Steam)		1 312	6·16	69 35	1·56	24·48	Author.
Bristol Upper Series (Gas) ...		1·26	5·60	60·67	1 36	33·73	Author.

The above table will show the difference in character between the Kurhurballee coals and the Ràniganj. The Kurhurballee coal is slightly smaller in amount of ash, but the most noticeable difference is this—the Kurhurballee coal contains a large amount of *fixed carbon*, and the Ràniganj coal a large percentage of *volatile matter*. This is the difference between a gas coal and a steam coal. For house purposes coal is not so largely needed in India as in England. The chief value of coal is for steam purposes, and in this respect the Kurhurballee coals are decidedly superior. Some years ago experiments were made on the East Indian Railway to determine the relative values of the Kurhurballee and Ránigánj coals for locomotive purposes, and the results were largely in favour of the former.

When a comparison with English coals is made, the results, with the exception of the amount of sulphur, are not so favourable. The nearest approach to the Indian coal is in the Bristol coals of the lower series, which are largely used for house and steam purposes. There is one seam in the Bristol coal-field about 2 feet or 2 feet 6 inches in thickness (called the "two feet seam"), which so much resembles the Indian coal in composition and structure that the writer is constrained to compare them :—

	Kurhurballee.		Bristol. Two Feet Seam.
Ash	9·15	...	9·59
Fixed carbon	66·84	...	69·89
Volatile matter	24·01	...	20·52

The analyses of the seams at Jogitand and Serampore, places widely separated, show great similarity in structure and the colour of the ash, as shown in Tables I. and II. At Ramnuddi, on the extreme west of the field, the lower seam was worked some years ago, and an analysis yielded the following results :—

*	Ash	8·80
	Fixed carbon	67·80
	Volatile matter	23·40

the ash is described as being fawn-coloured. This is very similar to results in Table I. of the lower seam.

The writer believes that picked specimens would show a smaller percentage of ash, but the percentage of ash within reasonable limits is less a test of the value of coal than the amount of fixed carbon. The analyses given definitely show this fact, that the coals are good useful coals for steam purposes in consequence of containing so much fixed carbon.

The Khundiha seam is not used, in fact it was only recently cut in sinking for the better coal that will be met with below. Although it contains so much ash, and would be a dull burning coal, it contains a fair amount of carbon, and may probably be useful. It represents what in other parts of the field is a seam of worthless shale.

The coal raised by the East Indian Railway Company is used on the locomotives, and on the line generally, either in the form of coke or of large steam coal. The rubble and smithy (cobbles and nuts) are sold to other railways and the general public.

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* Memoirs Geological Survey of India, Vol. VII.

The coal raised by the other companies is sold to railways and the public generally.

The large quantity of small made in the extraction of the coal makes the production of coke a most important question. The small coal, incompletely coked in large German ovens, makes an excellent fuel for locomotive purposes. When burnt thoroughly there is so much ash, and the coke is so hard, as to be almost incombustible. Coking in this way, *i.e.*, leaving six inches or a foot of unburnt coal on the top of the coke means waste, but much less waste than when the small coal accumulates in heaps, and becomes positively useless under the effect of rain and heat.

AGE OF THE COAL-MEASURES.

The writer was much struck on his arrival in India by the absence of the form of fossil life he had been accustomed to see in the shales and sandstones of the English coal-measures. The fluted sigillaria, the scarred stigmaria, and the sculptured lepidodendron, are conspicuous by their absence. The most familiar was a neuropteris-like fern, which is called neuropteridium.

The writer regrets that his rapid retreat before the climate of India compelled him to leave specimens of fossils behind, but that loss is fully made up by the memoir of Dr. Feistmantel, which is invaluable to all interested in the flora of the coal-field.

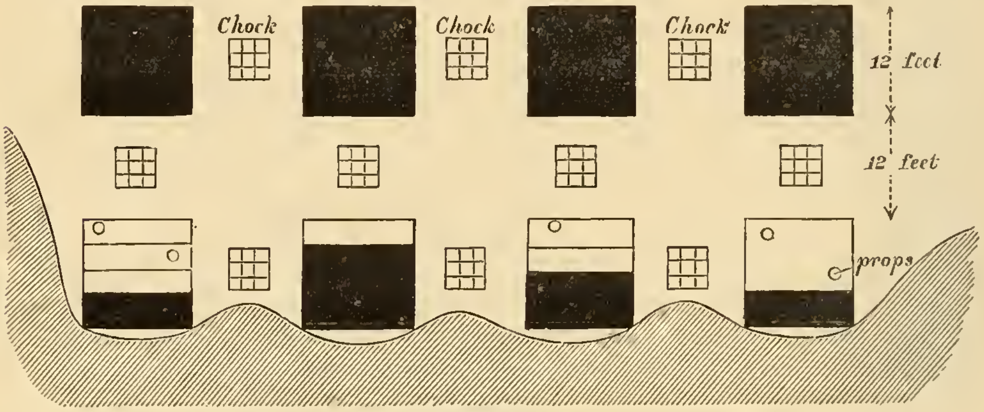
After an examination of the flora, Dr. Feistmantel writes—"I thought that on the whole I could not be wrong in considering these beds of the lowest triassic age." From his memoir the writer quotes the following species :—

EQUISETACEA ...	Schizoneura Gondwanensis.
	Sch. Meriani.
	Vertebraria Indica.
FILICES	Sphenopteris polymorpha.
	Neuropteridium valida.
	Gangamopteris cyclopteroides.
	G. Buiradica.
	G. major.
	G. angustifolia.
	Glossopteris communis.
	G. Damudica.
	G. decipiens.
CYCADACEA ...	Glossozamites Stoliczkanus.
	Nœgerrathiopsis Hislopi.
CONIFERÆ	Europhyllum Whittianum (?)
	Voltzia heterophylla.
	Albertia, etc.

With a few remarks on the method of working, and on the labour obtainable in the coal-field, the writer will close the paper.

The system adopted is a kind of board and pillar, such a system as probably obtained in England in the infancy of mining engineering. The pillars vary from 10 feet to 40 feet square, galleries being usually 12 feet wide. This system has one advantage, that of giving a large output in a short time ; but there are so many and obvious disadvantages (the greatest being the waste of coal) that nothing can be said in favour of the system. The workings formerly passed from the crop towards the dip, a shaft being sunk just in time to witness the exhaustion of the rise coal, and to see the difficulties of dip drainage from every face or gallery below the level of the pump. A great improvement has taken place of late, thanks to machinery and management, and the result is highly satisfactory.

The small pillars have been successfully extracted in the hill workings. The chocks used are old railway sleepers, as wood is extremely scarce and dear. Much of the timber is lost, and occasionally some coal ; but accidents to the men are rare. A face of four or five pillars is taken out at a time, chocks being put between those pillars that have to come out, and a row of chocks between those pillars and the next row of pillars.



GOAF.

The sketch above represents the method. The chocks are 4 feet square. The pillars are worked off from the galleries towards the goaf, props being put up under bad stones. A special set of men, called propping coolies, with a sirdar, or foreman, examine the roof, and look after the men. The chocks are taken out, and the roof allowed to fall. If the roof hangs after several rows of pillars are gone, the work is suspended, and the place vigilantly watched, no man being allowed to approach the open. The cracking of the roof is the sign for cessation of work; and the men withdraw until it is safely down. The men, who at first were difficult to get into pillar workings, take to it kindly, as they can cut much more coal than in the solid, and get the same hewing prices. This pillar working is in a seam from 6 to 8 feet thick; and it is this thickness that makes it possible. The covering is from 20 to 50 feet of rock.

The tools used by the men who work in pairs are long crowbars, or "sábels," and picks. The men that use sábels strike alternately. The coal is hand-picked into the baskets, and carried to the surface, or to the coal tubs, which are on the English pattern, and in the better arranged mines run on 1 foot 9 inch gauge tramways. The mines are in nearly all cases connected with the surface by inclines, as the men prefer walking down to their work.

The native labour, which is controlled and directed by European officers, comprises Hindoos, Mussulmans, and quasi-aboriginal tribes.

The higher caste Hindoos (Brahmins, Rajpoots, Kyásths) take responsible positions as clerks, accountants, native overmen, store-keepers, surveyors, and draughtsmen, or any position that will not degrade them or their caste. The better class of Mussulmans fill the same positions. They speak English fluently, if not correctly, and are a thoroughly useful class of men.

The miners are recruited from Hindoos and Mussulmans of the lower type. The Hindoos comprise the Gopas, or cow-herds; Sunris, or distillers; Beldárs, or labourers; Kahárs, bearers, or domestic servants. The Lohárs—blacksmiths, and Barhi—carpenters, find work in their respective trades.

The bulk of the miners consist of aborigines that have adopted a bastard kind of Hindooism. The *Bauris*—labourers, from lower Bengal, who have been attracted by high wages into the district, make some of the best of miners, but are at the same time the most difficult to manage.

The Doms—basket-makers, and general scavengers, form a large proportion of the labour. The Bhuiyas—labourers, also form a portion of the miners.

The Kols and Santháls are aboriginal tribes, with a different language and different religion to the rest of the miners. They make excellent miners, and are tractable men.

The lower orders of the Mussulmans, as the Meahs, make a large proportion of the miners.

The men live in ranges of brick huts built by the companies, or in mud huts made and thatched by themselves. The miners that visit the collieries in the hot season make huts of poles, the walls being the leaves and leafy branches of trees interlaced.

Men, women, and children work in the mines in India. The strong and sturdy men hew the coal, the women, the decrepit, and children carry it away in baskets on the head either to the surface or to the tubs or trams which are "putted" away by dusky putter lads or women. The payment for hewing, which includes a certain amount of carrying, is made per basket or "bálti," four of which go to the ton.

The price varies from eight pice or two annas to twelve pice or three annas per bucket. This means eight annas (1s.) to twelve annas (1s. 6d.) per ton for large coal. A uniform price of three pice per bucket or three annas per ton is made for small coal, which is afterwards hand-sorted into steam rubble, rubble, and smithy. All that goes through a one-inch mesh is called smithy. This is paid for at a uniform rate of one pice per maund (82 lbs.) This means about 6·8 annas (10·2d.) per ton.

When the coal is teamed from the pit trams it is loaded at one anna per ton into the coal trucks. This is done by men, women, and children too.

It will be seen that the miners wages are high, higher than ordinary labour, which may be put at two annas, or threepence a day.

Men paid by the day receive from two to four annas (3d. to 6d.), women get a half-anna per day less for the same work, and so do children.

In shallow pits the coal is raised in iron buckets by a "gin" worked by women. In a pit 100 feet deep about twenty women are required, five at each arm. They receive one-and-a-half annas daily. The "Sirdar" or foreman gets three annas.

The miners are paid weekly on Sunday mornings, and go away to the Bazaar which has been established in the coal-field by the East Indian Railway Company for the benefit of the miners, to lay in their stocks of rice, curry powders, etc., for the ensuing week. Monday sees but few of them at work, and Tuesday not many more; but Wednesday, Thursday, and Friday as well as Saturday are good working days. The miners are then in full swing anticipating the next pay. Some idea may be formed of the size and use of the Bazaar, to which merchants and hucksters (as we may term the men with their handful of merchandise) flock from miles around with articles of food, dress and jewelry (of brass and lead) when it is stated that from £500 to £1,000 pass hands in a single day.

The holidays are numerous and religiously respected, a day of laziness being followed by a night of carousing and noise. The tom-toms and their chants make night truly hideous.

The men are not perfectly weaned from their ordinary caste pursuits. The hold on them is not great, and any discontent is followed by migration. They pick up their beds, or rather the wives do, collect the cooking utensils, gird up their loins, and depart.

Labour has been attracted to settle in the immediate vicinity by allotment of land at nominal rents on the understanding that when cultivation is over, they shall work in the mines.

Some men, as the Sunris, or Soories, come from a distance, say 40 or 50 miles, stay during the hot season, and return, when they can follow their own avocations, to their own homes.

The rainy season no sooner commences than the labour decreases. Men, women, and children, go away to cultivate their own plots, or the plots of those to whom they are indebted, and the output drops. From the beginning of July until November the cultivation, and then the religious festivals, keep the output low. From November till June following the most of the coal is raised. Cheap rice makes labour scarce, as a native will not work if he has enough to eat without it. Scarcity fills the mines to overflowing. Still the general state is "want of labour." It will probably take many years to train up a set of miners, who will follow nothing else but mining as a profession.

The lamps used by the natives are bits of earthenware, on which a little oil is poured and a wick laid, the end of which is lighted. There is no fire-damp. Ventilation is natural and easy from the number of shafts. It is only in the deeper ones that arrangements are made for producing and directing the air currents.

Machinery is being largely introduced. The engines are of second motion type, either fixed or semi-portable. The largest pair is a pair of 18-inch cylinders, by Fowler. This firm has supplied iron pit-head frames, and these with wire-rope guides, signals, etc., have begun to give the coal-field quite an English appearance.

The writer trusts that the paper will have been interesting and brief, at both of which he has aimed. The amount of material at hand was very great—the difficulty was to condense it. The condition of Indian miners, their customs, religions, and character, would fill a large book of itself, and be thoroughly interesting. He trusts that the members of the Institute, who now occupy positions in the Indian coal-fields of Rániganj and Nerbuddha, coal-fields much larger and earlier developed than the one described, may be prevailed on to give an account of the districts in which they have laboured with success.

The writer has to express his obligations to Mr. Ernest Cook, B.Sc., of the Bristol Mining School, for his assistance in the analyses of these coals, and to Mr. Albert Henshaw for his assistance in getting the plans ready.

Mr. JOHN COOKE asked Dr. Saise whether the rice was not discoloured when it came in the return coal waggons ?

Dr. SAISE, in reply, said the waggons were swept out before the rice and other material were put into them.

Mr. T. W. BENSON said, he had great pleasure in proposing a vote of thanks to Dr. Saise for his very interesting paper. It appeared that even in the remote district treated of, the working of collieries was not altogether free from the difficulties complained of in this neighbourhood. He had listened to the paper with much interest, and regretted that the attendance of members was not larger. No doubt that was owing to a very great number of the members being away from home at this period, and also to the fact that one or two other gatherings of a similar nature were being held simultaneously in the district.

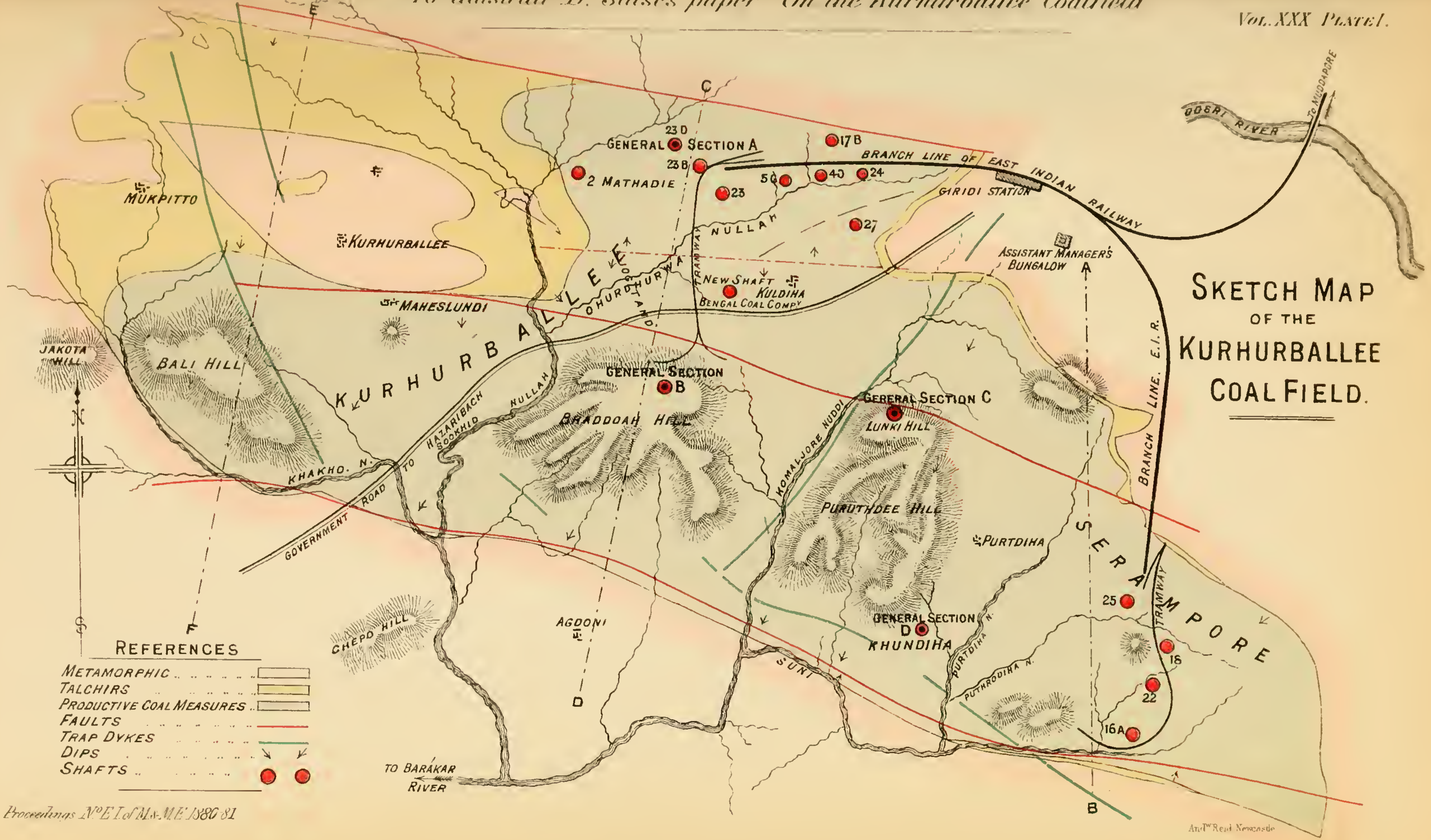
Mr. JOHN COOKE seconded the vote of thanks, which was carried unanimously.

LUMINOUS PAINT.

At the invitation of Professor Freire-Marreco, the members proceeded to the Laboratory of the College of Physical Science and were there shown a specimen of the new Luminous Paint, the Professor explaining the same and the various uses to which it could be applied.

The meeting then terminated.

To illustrate Dr Saise's paper "On the Kurhurballee Coalfield"



SKETCH MAP OF THE KURHURBALLEE COAL FIELD.

Proceedings Nº E I of M & M E 1880-81

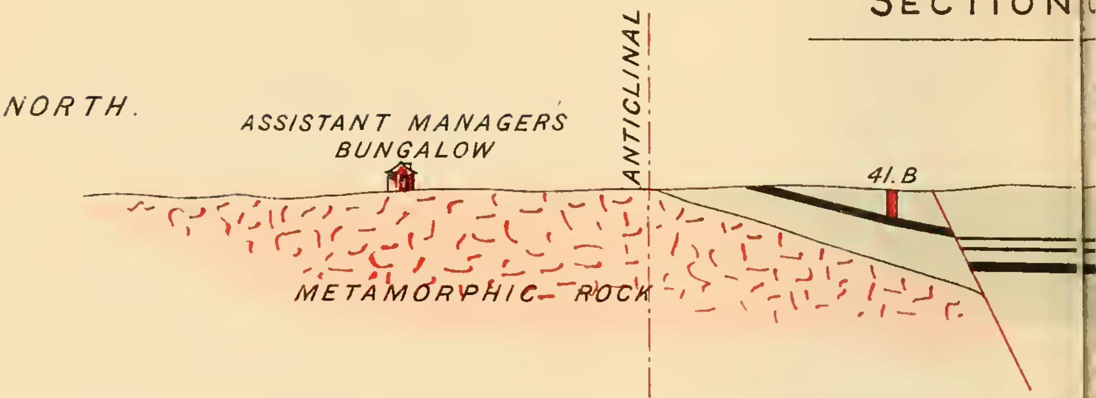
Andw Reid Newcastle

To illustrate Dr Saise's paper

DIAGRAMMATIC SECT

ILLUSTRATING

SECTION



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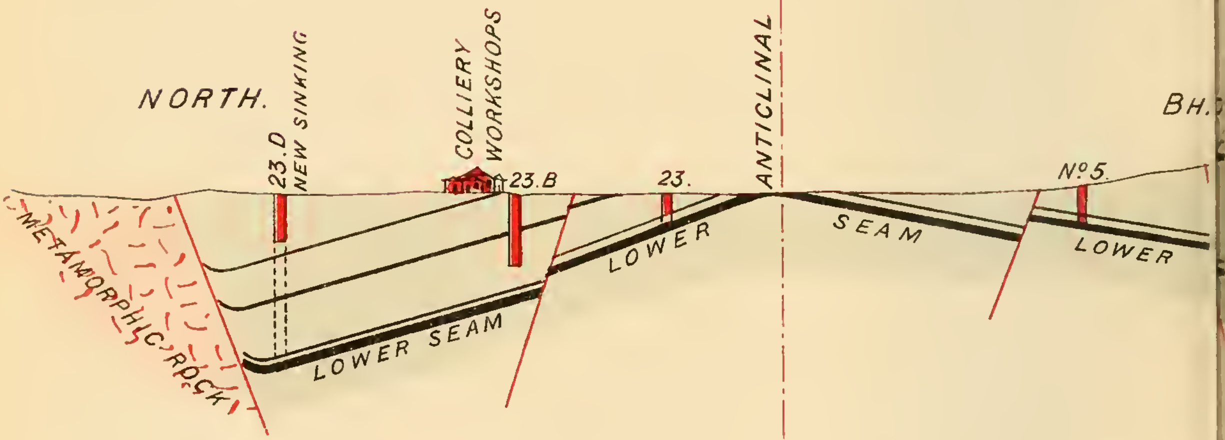

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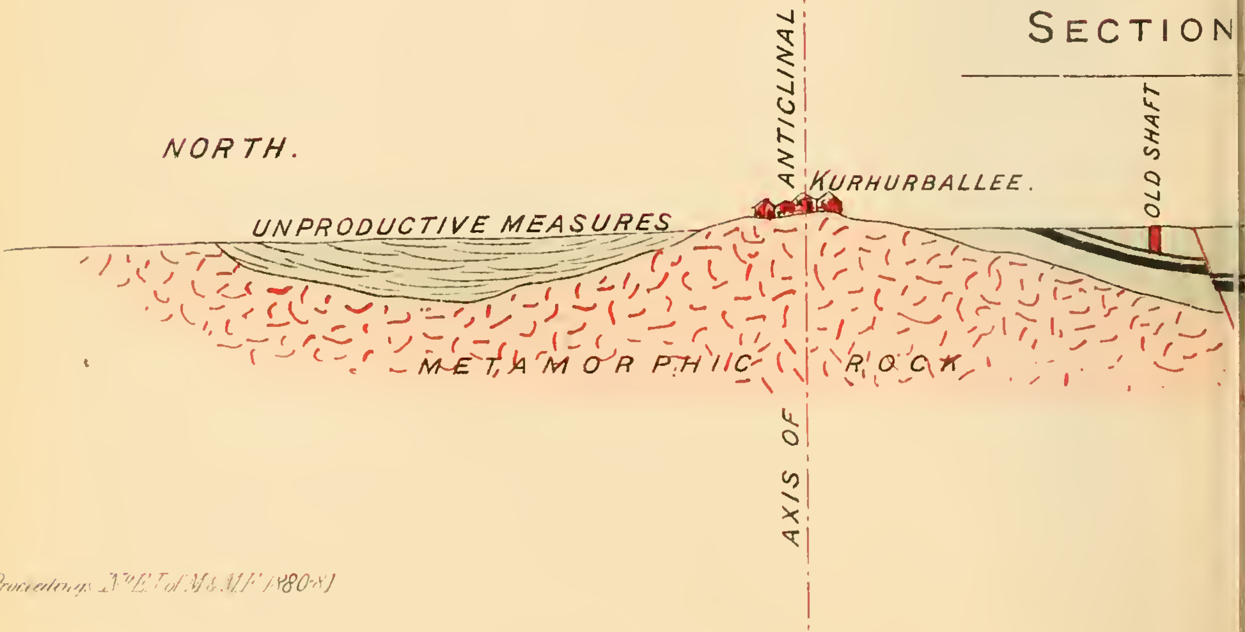
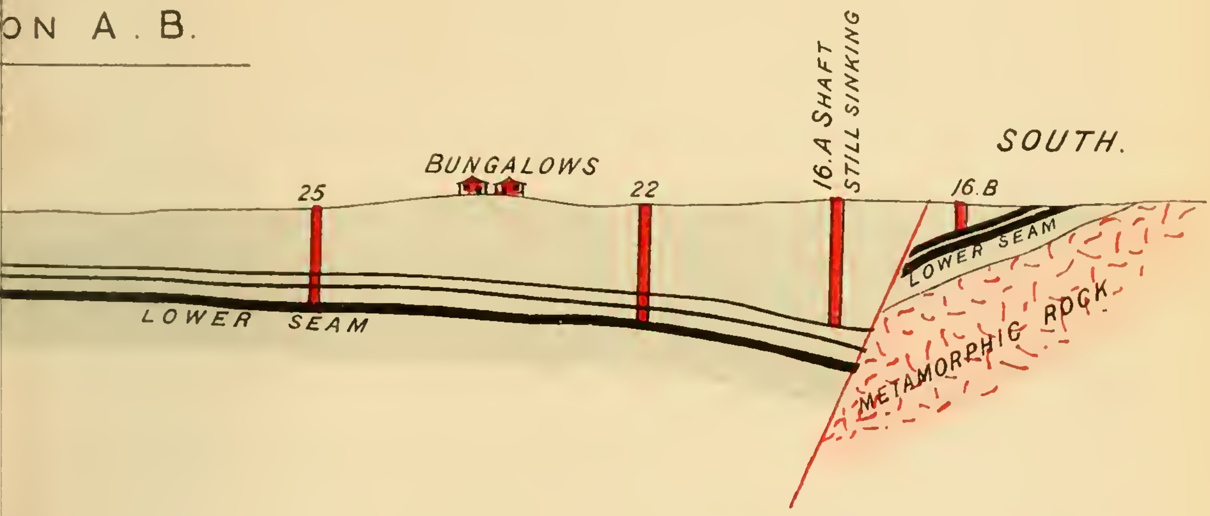


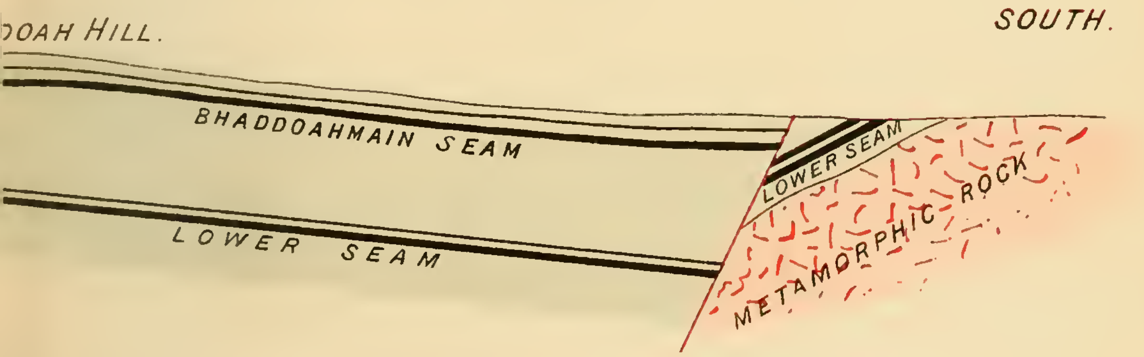
NS ACROSS COALFIELD.

S STRUCTURE.

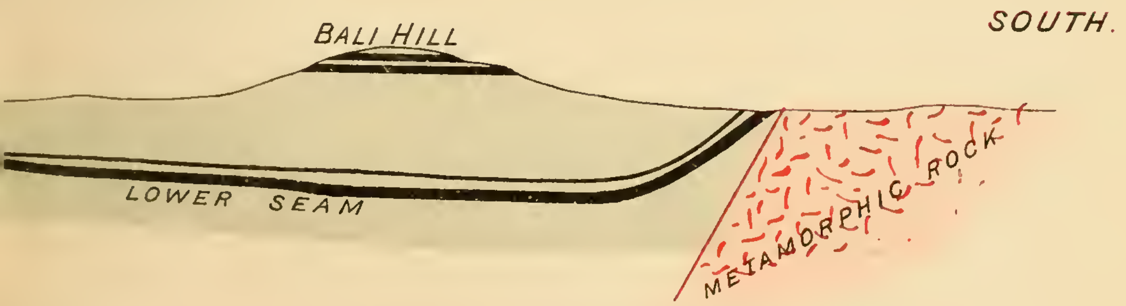
ON A. B.



ON C. D.



ON E. F.



Andrew Reid Newcastle

To illustrate Dr. Saise's paper "On the Kurhurballee Coalfield."

SECTIONS OF SHAFTS AND BORINGS

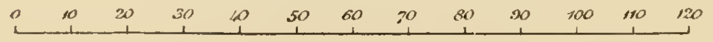
to illustrate the number of Seams in the

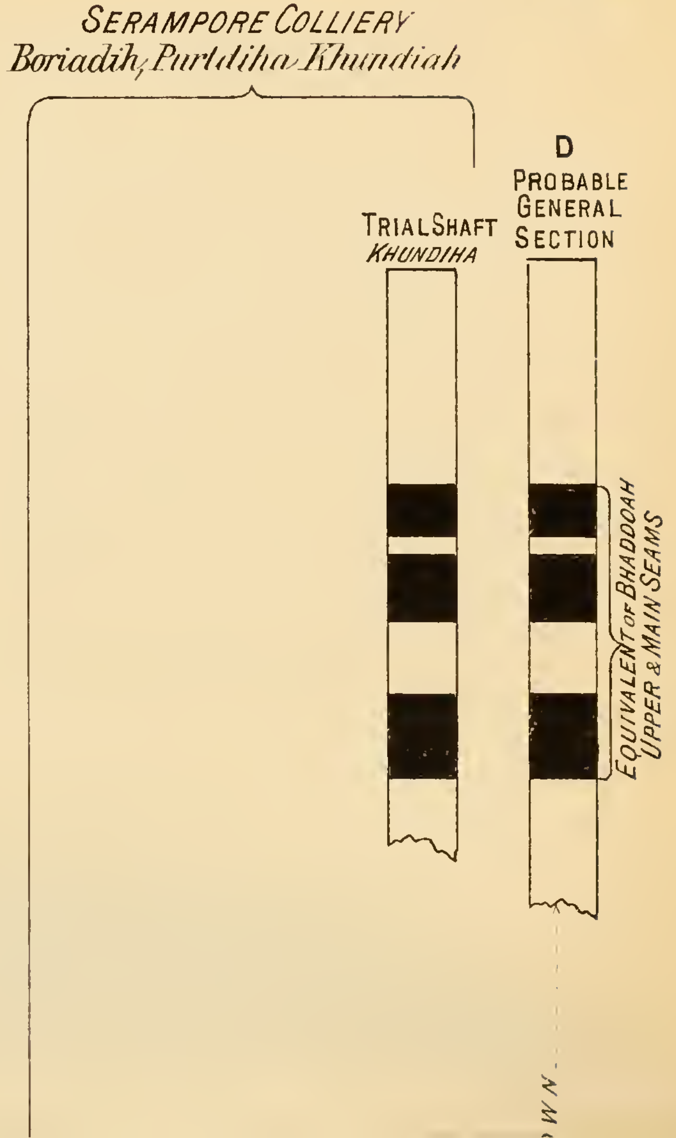
KURHURBALLEE COAL FIELD,

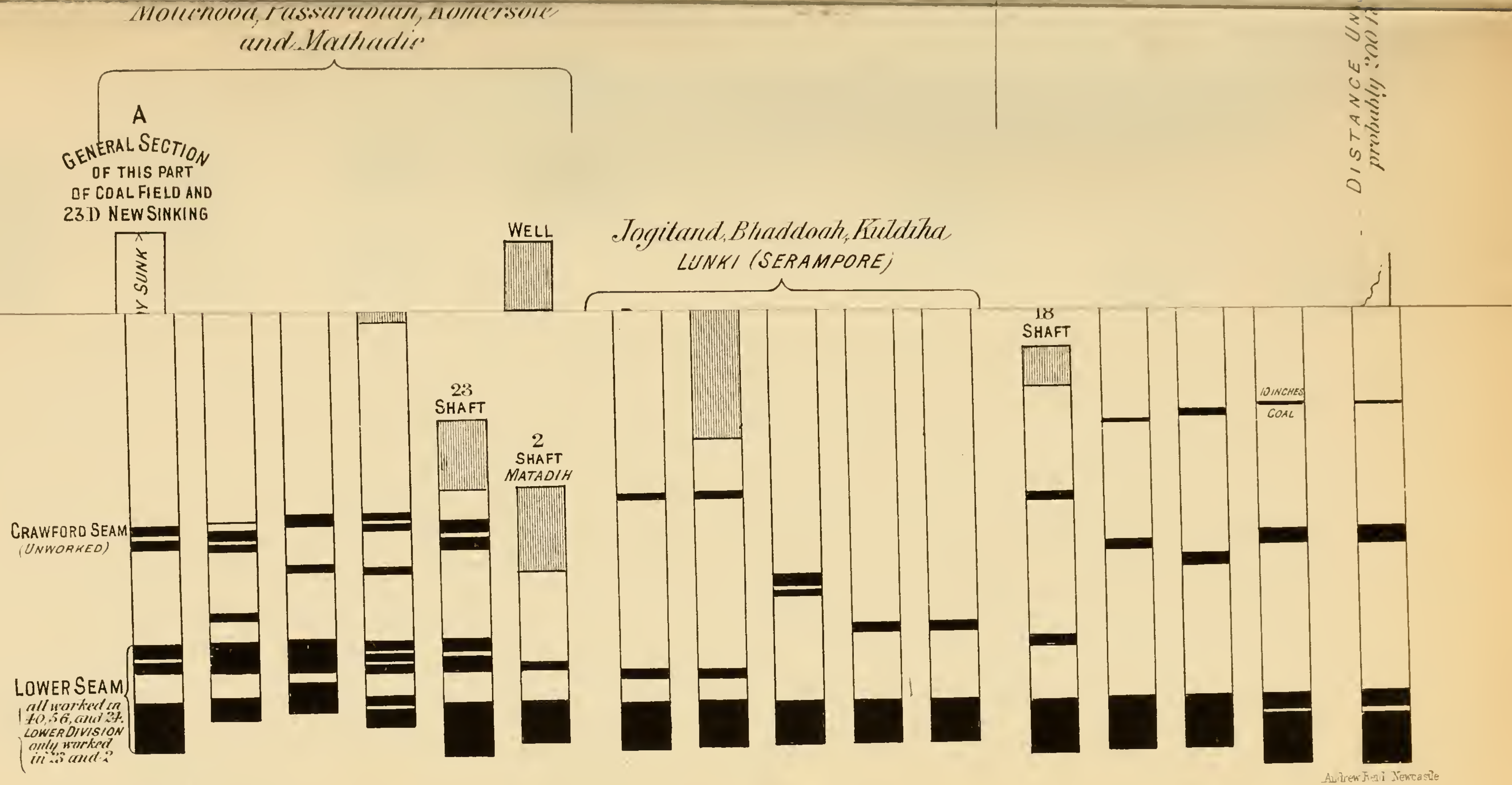
WITH GENERAL SECTIONS TYPICAL OF DIFFERENT

PARTS OF THE COAL FIELD.

Vertical Scale of Feet







Proceedings Nº E.I. of M.&M.E. 1880-81

Andrew Reid Newcastle

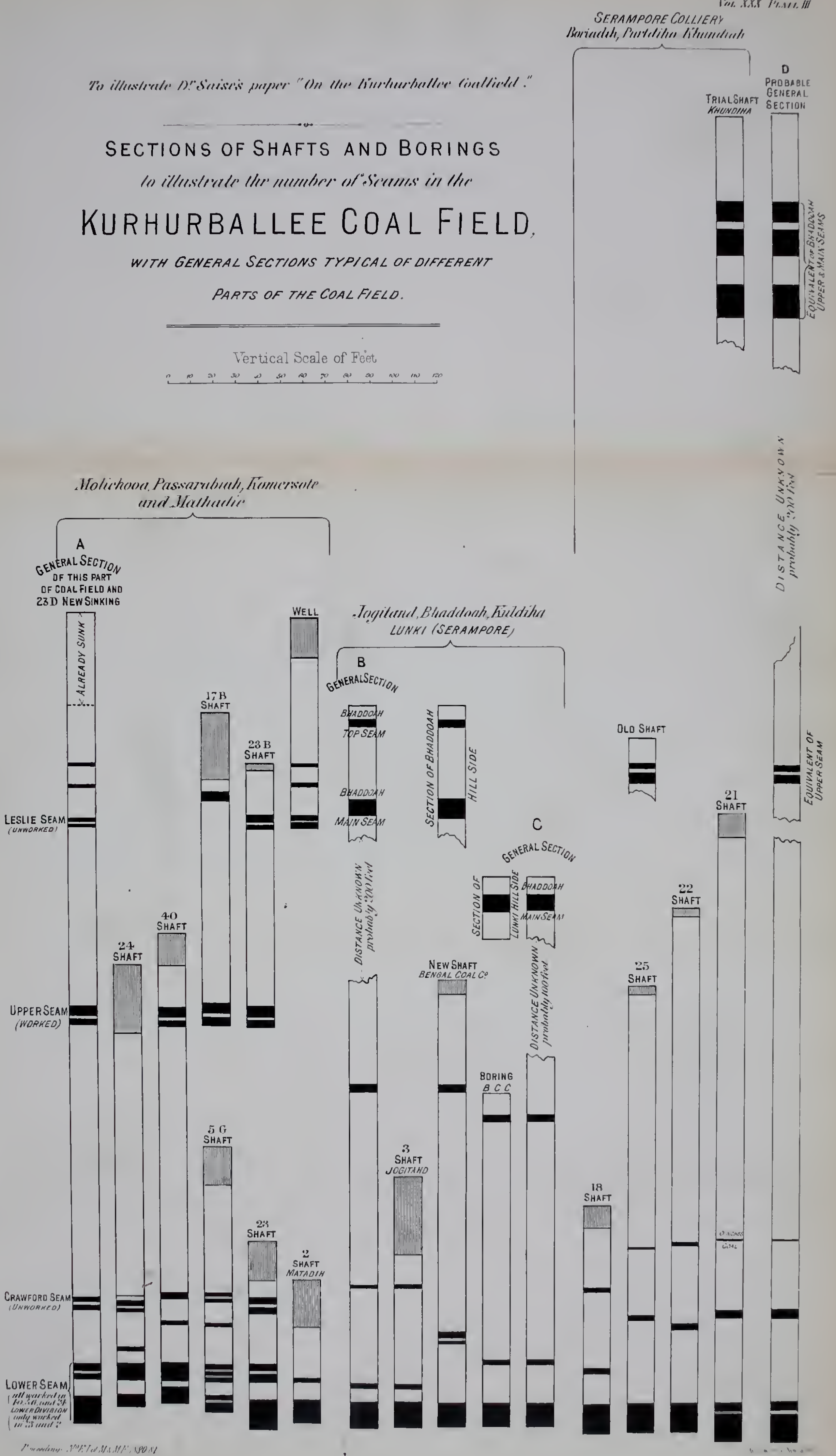
To illustrate Dr. Saise's paper "On the Kurhurballee Coalfield."

SECTIONS OF SHAFTS AND BORINGS

to illustrate the number of Seams in the

KURHURBALLEE COAL FIELD,

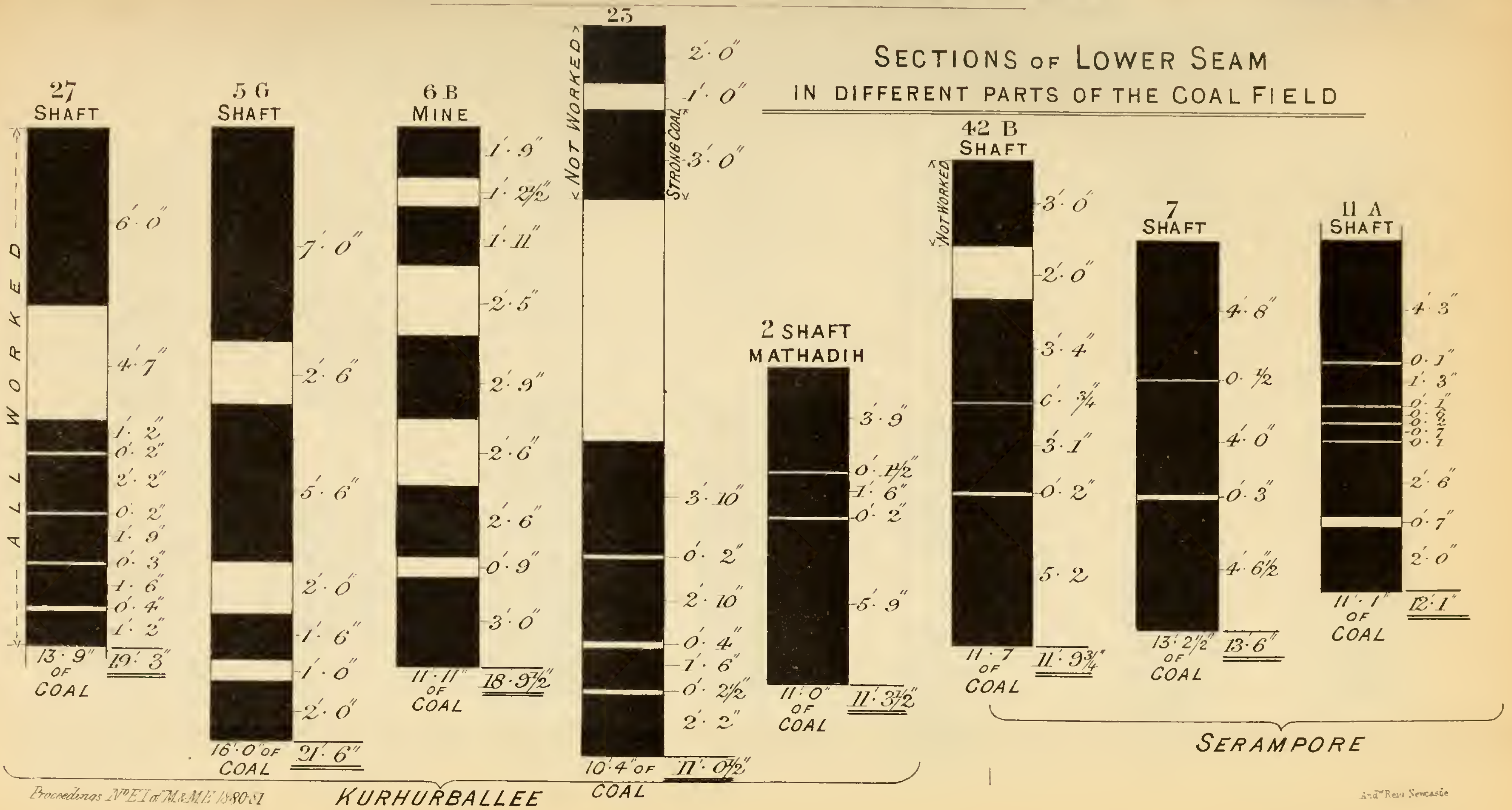
WITH GENERAL SECTIONS TYPICAL OF DIFFERENT PARTS OF THE COAL FIELD.



Proceedings. N° E I of M & M E, 80-81

To illustrate Dr. Saise's paper "On the Kurhurballee Coalfield."

SECTIONS OF LOWER SEAM
IN DIFFERENT PARTS OF THE COAL FIELD



Proceedings No. E I of M.&M.E. 1880-81

Andw Reid Newcastle

To illustrate Dr. Saise's paper "On the Kurhurballee Coalfield."

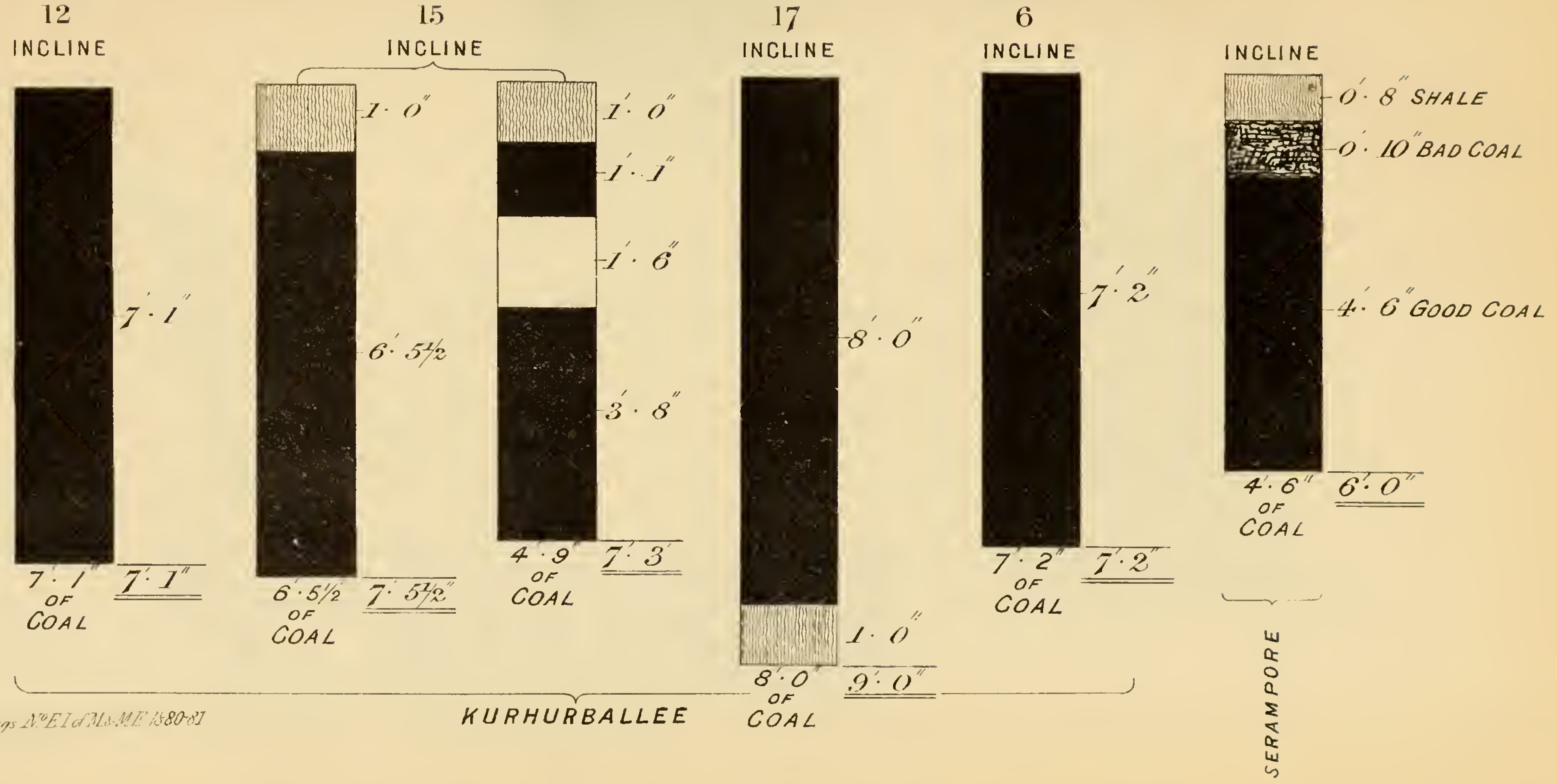
SECTIONS OF UPPER SEAM IN DIFFERENT PARTS OF THE COAL FIELD

Proceedings No. E.I. of M.&M.E. 1880-81

And.w Reid Newcastle

To illustrate Dr. Saise's paper "On the Kurhurballee Coalfield"

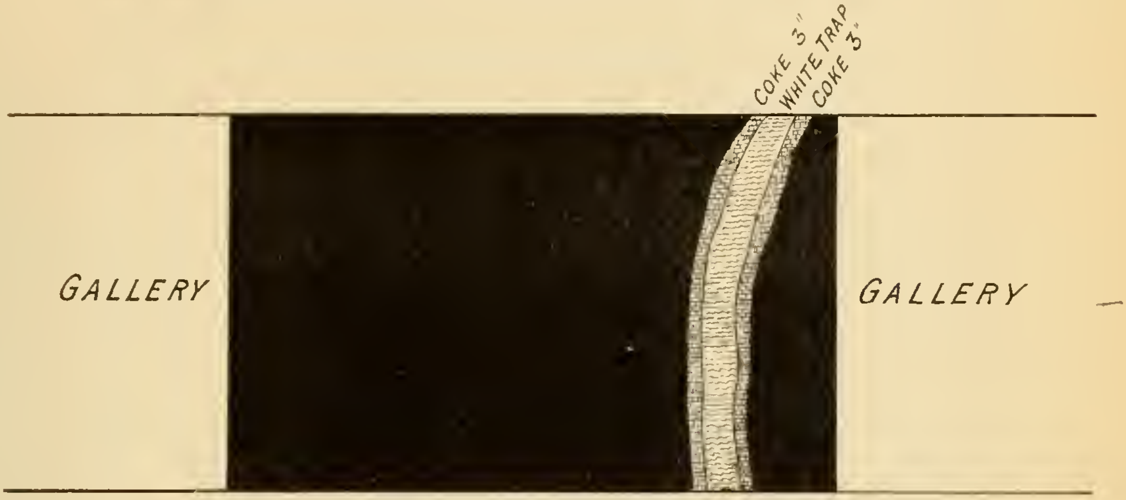
SECTIONS OF BHADDOAH MAIN SEAM.



Proceedings No. E I of M & M E 1880-81

To illustrate Dr Saise's paper "On the Kurhurballee Coalfield."

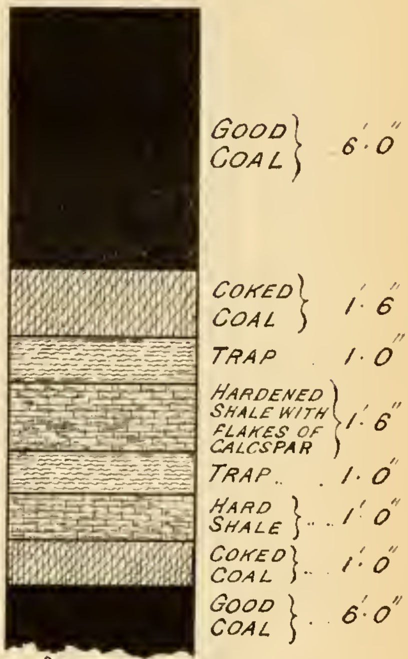
SECTIONS ILLUSTRATING THE OCCURRENCE OF TRAP
IN CONNECTION WITH
COAL SEAMS AT KURHURBALLEE.

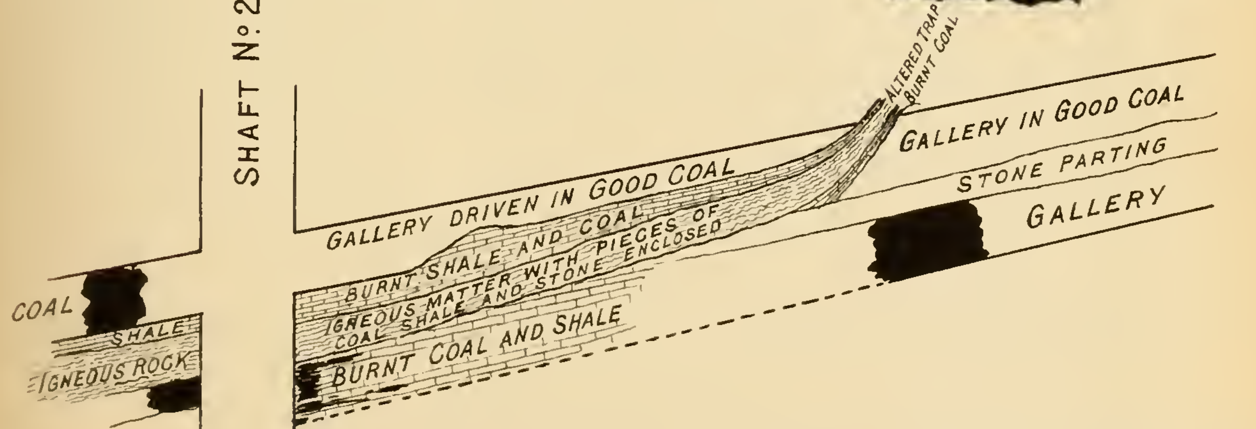


No. 23 B _ MINE ON UPPER SEAM

LOWER SEAM _ No. 6 B MINE

No. 40 _ SHAFT





APPEARANCE PRESENTED IN GALLERY BETWEEN No. 24 & 5 H SHAFT
SHEWING INTRUSION OF IGNEOUS MATTER WITH SEAM OF COAL.

Proceedings No. E I of M & M E 1880-81

Andw Reid Newcastle

PROCEEDINGS.

GENERAL MEETING, SATURDAY, OCTOBER 2ND, 1880, IN THE WOOD MEMORIAL HALL.

G. C. GREENWELL, Esq., President, in the Chair.

The Secretary read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were elected members, having been previously nominated :—

Ordinary Member—

Mr. W. George Laws, Civil Engineer, Newcastle-on-Tyne.

Associate Member—

Mr. Thomas Arnold, Mineral Surveyor, Louchor, Glamorganshire.

Students—

Mr. Arthur P. Galwey, Towneley and Stella Collieries, Ryton-on-Tyne.
Mr. Henry A. Pringle, Lofthouse Mines, Saltburn-by-the-Sea.
Mr. Henry Temple Stobart, North Bitchburn Colliery, Darlington.
Mr. Thomas Heslop, North Bitchburn Colliery, Darlington.

The following were nominated for election at the next meeting :—

Ordinary Member—

Mr. Richard Broja, Mining Engineer, Dortmund.

Associate Member—

Mr. W. A. Charlton, Manager, Tangye Bros., 25, Lincoln Street, Gateshead-on-Tyne.

Student—

Mr. Charles Chandley, Atherton Collieries, near Manchester.

The Secretary read the following paper on "The Hematite Deposits of West Cumberland," by Mr. J. D. Kendall.

HEMATITE DEPOSITS OF WEST CUMBERLAND.
(SUPPLEMENTARY PAPER.)

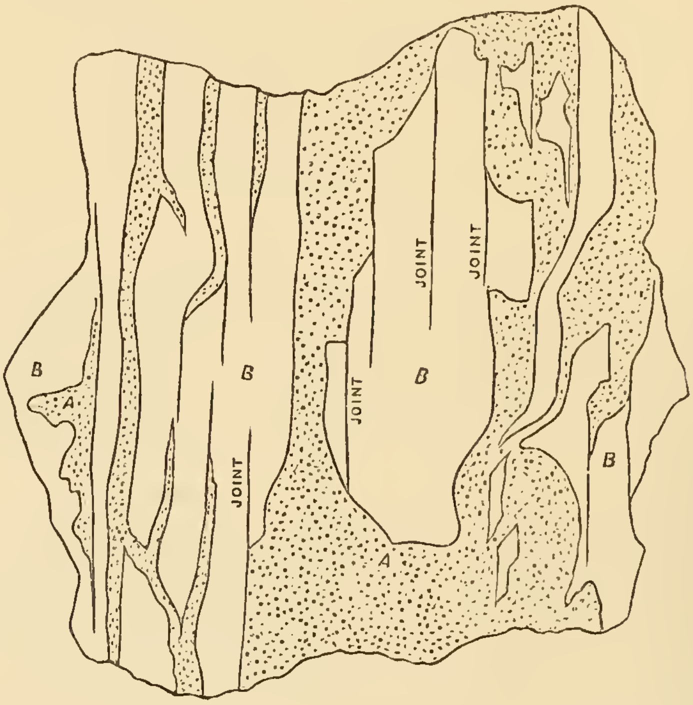
By J. D. KENDALL.

In the writer's paper on this subject, published in Vol. XXVIII., page 109, of the Institute Transactions, a number of reasons were given for considering the deposits in the Eskdale granite, the Skiddaw slates, and the volcanic lavas and ashes of Borrowdale, as having been formed by a process of replacement.

In the discussion which took place afterwards, and which was recorded in the same volume of the Transactions, page 219, a doubt was entertained by some of the speakers as to the possibility of such a replacement as was suggested, and an attempt was consequently made by the writer in replying to show the *modus operandi* of the process he suggested. At that time no evidence was adduced in support of the indirect or double replacement process which it was contended had produced the deposits of hematite in the siliceous and aluminous rocks before mentioned, for the simple reason that none had been observed. Since then, however, the writer has met with evidence which he considers to be of great interest, and which at the same time he believes is wholly in favour of his explanation.

The evidence spoken of is to be met with in Eskdale, on the south side of the valley opposite Boot. The granite and volcanic lavas and ashes are there in horizontal contact, and they are both traversed by several veins of hematite, bearing nearly north and south. These veins are similar to those previously described, and have, like them, the same direction and "hade" as the principal joints of the rocks in which they occur. Parallel to these hematite veins there are several veins of a mineral that was shown to the writer as spathic iron, but which he soon discovered to be nothing more than a carbonate of lime and magnesia. The form and inner nature of these veins are exactly similar to those of the hematite veins previously described. Near the centre of them the limey matter is comparatively free from mechanical admixture, but, like the hematite, it becomes mixed with country rock as the "cheeks" are approached, no matter whether those cheeks be granite, or lavas and ashes.

Below is a section of part of one of these veins in the latter rocks, taken near the cheek to show how the limey matter there becomes mixed with the country rock. This, it will be remembered, is also a feature of hematite veins.



The writer would also call attention to the parallelism of the joints and the different parts of the limey deposit as shown in this section. The same thing holds good when the vein is taken as a whole, a fact which it will be remembered was pointed out by the writer as being presented by all hematite veins. Indeed, were hematite substituted for the carbonate of lime and magnesia, these veins would be indistinguishable from the veins of hematite that are to be seen now in their immediate neighbourhood. The writer would submit, therefore, that the same salt of iron which, he contends, acted on the carboniferous limestone to produce the hematite deposits in that formation, has only to be brought into contact with the limey veins in the granite and the volcanic lavas and ashes of Eskdale, to form, in those rocks, veins of hematite similar to those now found therein. That such was the way in which hematite veins were formed in siliceous and aluminous rocks generally, is rendered highly probable by the fact, that in these limey veins, enclosed veins of hematite are sometimes found holding such relation to the limey matter as to leave no doubt whatever that the latter preceded the former.

Below is an analysis of some ore taken from the Nabgill vein. The large percentage of lime in it is very curious, but it strongly supports the statements made by the writer in replying to the criticisms on his paper :—

	Per cent.
Ferric oxide	27·43
Manganous oxide	·03
Alumina	6·10
Lime	23·18
Magnesia	9·04
Phosphoric acid	·04
Sulphur	·02
*Insoluble siliceous matter	2·15
Carbonic acid and water	32·00
	99·99
Metallic iron	19·20

* Consisting of		
	Silica	1·84
	Alumina	·31
		2·15

Professor Lebour said, he wished to take that opportunity of making a few remarks upon Mr. Kendall's paper as to the origin of Hematite, because on the occasion of Mr. Kendall's reading the original paper, he (Professor L.) happened to come in after the paper was read and at the end of the discussion. Now that he had read the paper carefully, he found Mr. Kendall's theory consisted in this—that he supposes that a solution of perchloride of iron, coming in contact either with limestone, granite, slate, or lava, instantly alters the rock into a precipitate of red peroxide of iron. How this singular proceeding takes place in exactly the same way, whatever be the composition of the rock acted on by the solution, was so incomprehensible that one could scarcely credit that this was really Mr. Kendall's theory. But an hour before the meeting he looked up Mr. Kendall's paper, and that gentleman himself said so in so many words. He said that if a piece of chalk be put in a solution of perchloride of iron, the chalk is instantly attacked, and a red precipitate of peroxide of iron was obtained; and he said that that is exactly what happens when the same salt of iron is placed in contact with slate or with granite; and when it came in connexion with the lavas of the lake district. He admired Mr. Kendall's paper extremely; so far as the description of the deposits is concerned, it was one of the best papers they had ever had; and the descriptions and careful drawings of the veins and the pockets, and of the odd-shaped repositories in which the hematite is found were beyond all praise; but the theory which Mr. Kendall bases upon them was opposed, he thought, to every geological experience at any rate, and he would like some chemist to give his opinion on it from a chemical point of view. But from the geological point of view, he thought that every geologist would agree with him in saying that how the hematite, which is found in the North of England filling up vacancies in the rocks of a certain age, was deposited, was, at present, unknown, but that probably it was not according to Mr. Kendall's theory. Old caverns were found in the limestone filled up with hematite. Faults and fissures in rocks which were not of limestone, such as slate and lavas and granite, and so on, were also filled up with hematite; and these he thought could not possibly have been so filled up according to Mr. Kendall's theory. In the very drawing which Mr. Kendall gave as supporting his theory, there were a number of facts which militated against it. In the woodcut, page 28, there was delineated a vein of calcite and carbonate of magnesia, which he looked upon as representing what a hematite vein was before the introduction of the hematite; there was a simple representation of a typical vein of any sort of ore, and those lumps of country rock in the middle of the vein were simply the horses of the country rock, such as were found in almost every vein; and when these horses were found they did not always occur, as Mr. Kendall seemed to assume, as boulders tumbled at hazard in the vein, but often as portions of country rock *in sitû.* There was a great deal of mischief sometimes done by a single transverse section; in that illustrating Mr. Kendall's present remarks it is not known that the apparent boulders are really detached boulders; it is not known whether they may not diverge in a plane at right angles to the diagram; it is not known whether if they were followed in that direction they would not be found joining the country rock and forming part of it. He hoped that on the whole they would reject Mr. Kendall's conclusions, and accept, with very many thanks, his facts, which he believed were all perfectly correct and of the greatest possible value.

The PRESIDENT said, it seemed to him that in trying to account for a thing, people sometimes put themselves in greater difficulties than before. If they accounted for the deposition of hematite from a perchloride of iron, they must ask in the first instance where the perchloride of iron came from, and in fact, where were the perchlorides, or muriates, or whatever they might happen to be, which would be formed during the time of the deposit of the hematite from perchloride of iron. He fancied that these were much more difficult questions to answer than the simple question as to where the hematite came from. Did that not occur to Professor Lebour?

Professor LEBOUR said he quite agreed with the remarks of the President.

The SECRETARY then read the following paper :—

LIGHTNING IN THE PIT AT TANFIELD MOOR COLLIERY.

It having come to the notice of several members of the Institute that lightning had been stated to have entered Tanfield Moor Colliery on Monday, July 12th, 1880, and traversed the workings in several directions, Mr. William Joicey kindly gave them permission to examine the witnesses of the occurrence and the workings of the colliery so that a complete and accurate report could be drawn up of the circumstance; and, on the 30th July, 1880, Mr. C. Berkley, Mr. J. B. Simpson, Mr. W. H. Hedley, and the Secretary went out to the colliery and were met by Mr. W. Joicey, one of the owners, Mr. Pringle the viewer, and Mr. Arkless the resident viewer; and the following statement is a record of the information then obtained:—

The top of the working shaft at this Colliery is 36 fathoms from the Shield Row Seam, and Plate VIII. shows the arrangements at the bottom of the shaft; Fig. 1, Plate IX., shows the plan of the workings; and Fig. 2 shows a section through the north incline way and the south engine way; both plates show the position of the different witnesses at the time of the appearance of the lightning; and Plate X. shows the position of the pipes, ropes, and signal wires in the shaft. It will be seen by these plans that the Incline Bank leads northwards from the working shaft and ultimately reaches the day by a drift at X, and a little to the south of this is an upcast shaft. The Engine way leads south from the working shaft, and goes in-bye to the goaf at Y. It will be remarked that between this goaf and the working shaft there are two down-cast shafts, one of which is to the south of the furthest witness at this part of the pit. From what can be gathered, the lightning passed down the working shaft and struck the flat-sheets and then divided itself into two parts, one of which went north up the Incline way and probably passed out to the day at X, where it is supposed to have left traces of its exit in marks upon a bank of rubbish near by. The other part went south, along the Engine way, but after passing the point B, where it was noticed, its further course is not known; the thill of the seam is composed of soft sagger and the roof of strong post, both of which would offer great obstruction to the absorption of the electric fluid, and the probability is, that this portion of the fluid had been dissipated in the goaf, or had forced an exit by way of the down-cast shaft, No. 2.

The following evidence was taken :—

JOSEPH KIRTLEY, back overman, said, that on Monday, the 12th July, about 3 o'clock P.M., he was on the north side of the shaft, about six yards from it. A light, distinct but not very bright, fell and struck the flat-sheets, and split up into several lights like a lot of lighted matches. He could only see the light for a moment among the tub wheels. It struck the puller-out William Watson, who said, "Man, something struck me on the arm;" he complained that his arm was numb. The onsetter, James Offord; H. McGie and Wilfred Reay, drivers; and John Burdis, who minds the drags, also saw it. Watson told Kirtley afterwards that when he got home his left arm from the wrist to the elbow was quite yellow. Kirtley said, "That's lightning;" and the onsetter said the same. A heavy peal of thunder was heard very distinctly almost at the same moment. No injury was done either in the shaft or on the road where the lightning was said to have passed. He could liken it to nothing better than a box of matches all struck at once.

JAMES OFFORD, onsetter, said that on Monday, the 12th of July, about a quarter or half-past three, he was at the shaft bottom on the north side. He had just sent the west cage away and had his back to the pit, perhaps two or three yards from it, taking hold of a tub to be ready to set it on in the next cage, when he heard a crack like the report of a small pistol, and saw a light close to his feet. He was on the north side of the pit. William Watson was standing on the opposite side of the pit, and saw the fire strike the flat-sheets and make its way towards the North Incline. He also felt another part go past him to the south. He heard a heavy peal of thunder almost immediately on the light being seen: did not recollect ever hearing such a heavy peal; he never noticed lightning come down the pit before. The slides in the pit are all of wood. There are two sets of steam pipes; they come from bank under the heap-stead and down the pit, and go into the south side just over the head of the puller-out.

WILLIAM WATSON, 24 years of age, puller-out at bottom of pit, said that on Monday, a fortnight past, he was standing with his left hand on the empty tub that he had pulled out. He saw a flash of light come down and heard a noise like a gun; he would be two and a half yards from the pit. It struck on the plate, or flat-sheet, to the north of the side he was standing on. He felt something strike him on the arm, and saw the light divide when it struck. His arm was numbed for a time after, which made him think that part went past him. He had the numbness all the afternoon; he felt something go all over him. When he went home and got washed, his arm was yellow from the wrist to the elbow. His sister, Ann Watson, who is about 21 years of age, saw the arm was yellow, but no one else. He had no pain in it afterwards. He heard a heavy peal of thunder immediately after the light fell. The light, when it struck, seemed very bright, but he did not notice it brighten up the place to any distance.

The evidence of the five following witnesses relates to the portion of electric fluid which was observed to go up the North Incline:—

THOMAS CRISP said, he was a deputy, and on the afternoon of July 12th, the Monday previous to the Risca explosion (which occurred on Thursday, July 15th), he was on the north side of the pit, about 20 or 30 yards from the top of the Incline bank, in company with John Greener. (C, Plate IX.) They were bringing down a tram used for carrying timber when the electric fluid passed. Greener had his hand on the tram but he had not. He (Crisp) saw something like a lot of fire flying, and he thought the tram had cut the joint. It was like as though a person had trodden upon matches and they had gone off. Greener saw it as well as he. They then thought there had been a fall upon the rails, but as they proceeded down the bank no fall was to be seen. The fire came right up to the inclined plane; it seemed a little larger than the light of a candle, and came close by the tram where he was standing. To the best of his judgment it came along the metals.

JOHN GREENER said, that when going down the Incline with Crisp, and having hold of the tram, he saw a light on the rail about twenty yards off, about the size of a candle, flickering, not steady. It appeared to travel along the rail, and as it passed the tram it made a noise like the crack of a pistol, which he thought proceeded from matches or something on the way that was cracking. He saw it first fifty or sixty yards before it came to where he was standing. They were not far from a guiding-wheel which changed the direction of the rope, and there were men working at the wheel both east and west in a new place recently commenced. He had no idea that it was lightning as it flashed past; they had never seen such an appearance before.

In answer to some remarks from the visitors it was elicited that the rails were fished; that it was not noticed if the lightning came down the rails or the rope; that it was a self-acting incline; it was a flickering unsteady light that Greener saw which was past in a second; there was a noise as it came to the tram as of a pistol or gun shot; it was not very loud, and a similar noise was heard as it left the tram; the metallic contact might have been broken by a fish plate being off. Crisp said that he did not think of its being lightning, but supposed that matches had been dropped which crackled as they went off.

Nicholson Watson said, he was going up the Incline bank and met Crisp and Greener, his feet were on the rail, and he saw a light go close past them, which seemed to numb them for a short time; as it passed it was like the spark and noise from the cap of a pistol when exploded. There was a wheel near and two men hewing close to it; he went to the men, who said they had heard a great noise, which they thought had been caused by the electric light being tried at bank. Two hewers at the bank-head, William Athey and John Brown, told him they had heard a report going off like a gun, and he remarked to them, "They are trying the electric lights from bank," but he did not think of its being lightning till he got to the shaft.

John Hagan, a putter, said, he saw lightning come along the plates. (D, Plate IX.) It caught him as it passed, giving him a sort of queer feeling in the legs; it made a sharp cracking noise in the plates, like a gun; it passed him as he was going down with his pony. He had seen matches put on the rails to be exploded by the trams passing over them—and the appearance was like that caused by the trams going over the matches. He thought it was lightning at first, before any one had time to tell him, because of the feeling about his legs. Where he was standing the rails were about 4 feet long, not fished, and with a good space between them.

Thomas Spring said, he was a hewer on the north side, and was working about fifty yards from the bank-head. (D, Plate IX.) He heard the noise and went a few steps back from where he was working. He asked the lad, John Hagan, what it was, and he replied it was lightning. He thought it was a fall of stone at the bank-head, and to be sure that there was no one hurt he went out to see.

The statements of the four following witnesses relate to the portion on the south side of the shaft.

George Crisp said, he was a siding minder, and was about fifty yards from the shaft. (A, Plate IX.) He heard a cracking noise, and saw a bright light and flash of fire against the big binding sheave (two feet diameter) like five or six matches going off at once. All the tubs near at hand were at rest at the time. He had seen matches placed on the rail and exploded by the trams passing over them, but the light and noise could not be explained in this way now, because there were no tubs running by at the time.

MATTHEW HARDY, said, he was an engine flatter, and worked close to the shaft; was about 100 yards along the shaft siding when he saw a light like a spark from a lamp, and there was a noise like a match being struck by a tub passing over it. It was a custom in the pit to place matches on the rails at intervals of a yard or two apart, like fog signals on a way. The light appeared to be close to him on the rope, which was running, but he did not notice the direction in which the light passed.

GEORGE NICHOLSON, rolleywayman, said, he was at the outbye side of the junction, 700 yards south of the shaft. (B, Plate IX.) He saw no light, but heard a report as if a man had struck a plate a sharp blow with a hammer, although it could not have been that, as there was nobody about but himself and Miller.

JOHN PYLE said, he was the set-rider on the south side. (B, Plate IX.) He was about 700 yards from the shaft, near the junction, changing the ropes, and was just going to the siding when he heard a noise like somebody striking a match, or louder than that, but he saw nothing.

The gentlemen who have conducted this inquiry do not deem it necessary to make any comment upon the evidence, but simply to remark that they have every reason to believe that the facts recorded by the several witnesses are in every way to be relied upon, and that the information thus obtained forms a valuable record of the occurrence, and places beyond doubt the possibility of lightning penetrating into the workings of collieries. All further observations, which can only be based on conjecture, it is considered had better be made during the discussion after the communication has been read, which it is hoped will be taken up by some of the members of the Institute who have made electricity their special study.

The PRESIDENT said, this was an inquiry of very great interest. It was not entirely a new one, because suggestions had been made long since as to the possibility of lightning producing explosions. The question came before a Select Committee of the House of Commons on

Accidents in Mines, on the 26th of June, 1835, when evidence was taken upon the point. Mr. George Stephenson, in answers 1705 to 1733, gave his views at great length, and doubted the possibility of gas exploding underground by lightning. Mr. J. Buddle was then examined in answers 2191 to 2211, and said, amongst other evidence; that "the Lawson Main Pit was exploded by the lightning. The pit was upwards of 70 fathoms deep, and was not particularly fiery. The explosion took place at or above the surface. I happened to be near the pit during the thunderstorm. A flash of lightning exploded the gas, and a very heavy explosion immediately ensued. I cannot state the interval between the flash and the gas being perceived to be ignited, but I understood it to be instantaneous. I know a fact, recorded by my father, of the engine pump having acted as a conductor and carried the electric fluid to the bottom of the pit; but I do not know it of my own knowledge. My father saw it." The meeting would be exceedingly glad if any gentleman would be kind enough to favour them with any opinion on the matter, or with any facts which had come before them.

Mr. A. L. STEAVENSON said, he remembered hearing about ten years ago of a circumstance of a similar kind. It was told to him that the boys at the siding about a mile in-bye at the Page Bank Pit had seen lightning running along the rails at the time a heavy thunderstorm raged on the surface; but it seemed so entirely unlikely that he took very little notice of it at the time and made no inquiry. When he saw the notice of the Committee's report upon the agenda paper, however, the circumstance immediately recurred to him, and he would take the opportunity of trying to get some evidence on the subject. The difficulty which occurred to his mind at the time was, that the lightning should run along the rails and do no harm.

Mr. MAY said, he had had a little experience connected with the action of the electric fluid underground, which might be interesting to the members. In this particular case, at Tanfield, it was stated that the lightning went down the pit and went along the rails or along the rope; but the difficulty was to know what became of it. At Boldon Colliery they fitted up some electric bells about a mile from the shaft, and the electricity could not be got rid of after it had been used for the working of the bells, the bells themselves ceasing to work in consequence. Ultimately they tried to get rid of it by fastening one of the wires to the rails and thus endeavour to take the electricity out-bye again, but to no purpose, until it was discovered that about 200 yards of the way was not fished; and it was this break in the rails which prevented the bells working. As soon as a small piece of wire was attached on the 200 yards to couple up the lengths that were not fished, the bells went to work at once. Seeing the difficulty of getting rid of the small quantity of electricity required for the bells, he was led to ask how the much larger quantity that went down the Tanfield pit was got rid of. At Harton Colliery, during the late severe storms, the lightning struck some wires which were used for connecting the electric bells at the bottom of the pit with the engine house at the surface, and it passed along into the engine house and fused all the small wires upon a telephone, and so passed to the earth. The lightning did not go down the pit at all, as the resistance through the telephone on the surface in the engine house was very much lighter than that which it would have encountered in having to go down the pit.

Professor Herschel said, the question which seemed to be a very important one was, what became of the lightning when it entered a pit? And it was in a great measure answered by the very excellent paper which they had heard read, and which he thought contained more abundant information on a particular point of a very interesting character than he had met with for some time, or had ever been able to fall in with. The paper showed quite clearly what was the nature of the occurrence which took place in the passage of the fluid and certainly described a clear case of lightning stroke. It had been a matter of deliberation with him for a long time whether accidents of this kind, where injuries were done to instruments, might be produced without the actual stroke of the lightning, by what was called the return stroke. A flash of lightning which took place in the clouds never reached the earth at all. There was a great relief, not only of the strain on the clouds themselves, but of that on the earth which had sympathised with it; and the rush of the fluid which streamed through the earth might be of such magnitude as to do these injuries. If the water pipes and gas pipes of a town were connected together, by telegraph wire for example, the largeness of the area covered by the water pipes, and that covered by the gas pipes, might be very different; and under the attractions of electricity in the clouds, there might be an electricity of one kind accumulated in the large area of the water pipes, and of the other kind accumulated by influence, or induction, on the area of the gas pipes. When the relief takes place in the clouds these two electricities unite themselves on the earth, and the passage through the telegraph circuits which used these earths might be severe and injurious. He had often questioned whether there might be sufficient strength in these return strokes, as they are called, to do these injuries. He doubted it now; and this history which they had heard especially convinced him that the accidents which occur are really strokes of lightning—of electricities coming from the clouds to the earth. Then the question arose, where does the electricity go to ? And the fact just described by Mr. May that the bells would not work at the bottom of a pit because no good earth could be found there, was a fact which he could confirm by experience. He had had to put up bells in this house, and had taken the earth wire to almost every accessible piece of metal-work in the building, and finally even to the lead and gutters of the roof, without being able to find earth sufficient to work the bells, until he tried the water pipes, and in joining the wire up to the water pipes it found good earth. Laboratory electricity, however, differs altogether from lightning electricity; not, as was supposed by Mr. May, in the quantity of the fluid which had to be got rid of, for the difference was just the opposite. In the laboratory there was a great quantity of electricity to be got rid of, but it was of very low tension, and it would not overcome resistance. A passage to the earth that was unsuitable for a bell was quite suitable for a lightning stroke ; and the lightning would spring from wires to the earth, and make its escape where laboratory electricity could not follow. The quantity of lightning electricity was very small; but coupled with its high tension where it passes, it does a work far exceeding what a current of less stress would do, and it would melt the wires which it was able to traverse on account of its intensity or strength; it melted thin wires of great resistance, like those of telephone coils.

In a case like this, where a real stroke of lightning had, he believed, come down the steam pipe, and thus descended the shaft to a certain depth, it found there rails spread over a large surface of earth. This probably was a very dry pit, and it might very reasonably be asked how the electricity found its way from these rails ? It would not do any harm in passing along the rail, but in jumping across from one to the other, the flash and the heat produced there would be dangerous to a colliery by the risk of firing explosive gases. If a safe earth for the lightning at the bottom of the pit could be insured, there would be no injury from it underground. The facts which were learnt in the present case were, that the lightning on reaching the bottom of the steam pipe, not having any chance of escaping into a sump full of water as might have been the case had the pipe gone to the bottom of the shaft, sprang down to the plates, and from the plates to the rails, and found its way along the tram roads. The pit must have been very dry, for the lightning did not escape to the earth as readily as lightning from a lightning conductor is supposed to do; but having entered the rails, spread along them, seeking the earth at every foot or yard it ran in that way; and the fact, for instance, that at 700 yards from the shaft the sound was heard and no light seen, showed that the lightning had diminished in power by the time it arrived there; it had partly escaped into the earth. 400 and 500 yards from the shaft there was still much left; but he thought it would be found from the workmen's accounts, who were in the inclined way, that they spoke of considerably less light and less noise appearing between the breaks of the rails than the setter-on and the pusher-out at the bottom of the shaft mentioned, where the character of the flash as it fell upon the plates was like that of a gun, and the lightning struck with a light upon the plates which alarmed them all. There could be no doubt that the lightning did make a great flash just there, and passed on into the rails, and there it diminished its strength as it reached to greater distances. All that was perfectly in harmony with what would be understood from lightning leaking out of the rails as fast as it could all along the earth-way. The rails afforded a tolerable earth for the lightning. He thought it was of importance, however, to learn in such cases what took place above ground. There was a thunderstorm, and a thunderclap was heard at the same time. It would be well to know whether on every such occurrence as this it could be ascertained that a lightning flash was seen at the top of the pit. If this proved to have been the case, pits were in need of lightning conductors as much and more than ordinary buildings; just as a powder magazine should be protected by a good lightning conductor, so also should be a pit; and the nature of that lightning conductor should, he thought, occupy the attention of mining engineers and students, and of those who are acquainted with electrical science, and particularly of electrical engineers, of whom he hoped there might be some present who would give some information on the subject. The narrative which they had just heard, showed that rails, extensive as they were, and far as they might lead away lightning, are yet scarcely a better earth than short steam pipes, and that although the rails laid down in a pit do conduce to carrying away electricity, they yet retain the flash for long distances. On the other hand, this flash might probably be avoided by pointed conductors on the surface, which was the only way in which a lightning flash would ever be effectually prevented.

He had thought it might interest the members of the Institute to show them an instrument which he brought from Paris the other day; it was intended to serve as an electric light for the dark places in the pit. It was a gas-vacuum tube, through which a discharge of electricity passing produces a useful light. He would not wish to work by it, and as the sellers of the instrument said to him, he thought it was an instrument for amateurs, and not for practical use ; because there was danger of the electrical spark passing between unprotected portions of the wires connected with the instrument. The instrument, therefore, was one of a dangerous nature ; and he thought it should be borne in mind in reference to the use of electricity underground, and especially in very fiery pits, that there was always risk of a spark becoming sufficiently strong in the case of breakages of the circuit to have dangerous effects. The experience of George Stephenson on the subject, viz., that electricity seldom fires gas, and is probably not dangerous on that account, had no doubt a great deal of weight, and he (the Professor) thought it might be true that, as ordinary electric sparks have not nearly the body which a candle flame has, such small electrical sparks as are likely to occur in the bell circuits which are now frequently being put up would not be of any serious risk. But should it come to a question of using electricity for mechanical working underground, he thought the risk of inflammation occurring from the use of the electrical current might be a very serious one. In the examples which the members had had brought before them to-day, the discharges had been of a very much more violent character, and he would like to know how far the experience of telegraph engineers, on their lines where the instruments are sometimes destroyed even where lightning guards are used, led them to think that the destruction was likewise produced by the lightning stroke itself, and whether pointed conductors would avoid the occurrence of this damage ?

The PRESIDENT asked, how the steam pipes going down this shaft were supported ?

Mr. PRINGLE—They were supported by wood. (See Plate X.)

Professor HERSCHEL said, he had not before thought of the circumstance, but the lightning in this case made its way along C and D, Plate IX., to the open mouth of a drift, and from what had been described it may have passed out of the drift. On that the suggestion was made by Mr. Bunning that the lightning tried to make its way out to the air again. It would, of course, naturally have been expected that it would try to make its way to the earth. But he thought it quite possible that the explanation suggested was true, and that in this case the lightning tried to make its way through the earth by another flash having taken place—one down the pit and one down the drift—the two flashes seeking to join each other through the best conductor they could find, which was along the waggonway.

Not enough is known as to where lightning goes after it has struck a conductor, and as to what earths are needed to get rid of it; that was a point upon which the experience of telegraph engineers was wanted. It might be that rails were very poor means for the discharge of the electricity, and that the thill or floor of the seam was often so dry as to be a retentive material, or very bad conductor, as seems in this instance to have been the case. It might, therefore, be a question for the miner to inquire what sort of earth he ought to provide for his lightning conductor, which should be adopted at every pit.

Mr. D. P. Morison said, a very curious case occurred near Acomb, Hexham, about six or seven years ago, in an old pit which had been totally disused for two years. It had been sunk, he believed, originally for a lead mine. but they found a small seam of coal; and they had worked a little coal out of that pit and then tried for lead afterwards. When the pit was closed, the wire-rope guides and the ropes were left in the shaft, and two years after the pit had been closed up, in a thunderstorm on a Sunday afternoon, the pit blew up. The cages were sent out of the shaft along with the ropes and other *debris.* Now, there was no chance whatever of there being any naked light down below, or near the top, which was railed off. The pit was altogether in private grounds; and, according to the account of a man who was walking in a field near the pit, the flash of lightning and the blowing up of the cage were simultaneous.

Professor Herschel said, he had not heard of the case, but should think there would be many such, and that the ironwork which was laid and left down a pit might afford an excellent earth for the lightning and prove a great attraction for it; and he should think that rails carefully fished over a large area might be the best earth which could possibly be used for providing lightning conductors with.

Mr. A. L. Steavenson thought it natural to suppose that the lightning would strike the pulleys, which are the most prominent object at the pit head, and then run down the rope into the pit, much more likely than to follow the steam pipes.

The President said, there was only this objection to that supposition, and that was, if the lightning did strike the pulleys, instead of going down the shaft it would go down to the engine house and get relief there.

Professor Herschel—Except for the attraction of the rails underground.

The President—Yes; but it would take the shortest way where there was less difficulty in passing to the earth, which would be through the means of the engine house to the earth rather than going down the shaft to the earth.

Professor HERSCHEL—The earth alone is not a good recipient.

Mr. MORISON said, he would like to ask Professor Herschel whether lightning could light up gas underground unless it was in a thoroughly explosive condition?

Professor HERSCHEL said, it would have to be highly inflammable. In the laboratory they found that electricity did not succeed in exploding mixtures which were only approximately inflammable. Sparks from lightning would be more intense than sparks given off in small experiments, and on that account they would very probably be more dangerous.

A MEMBER said it had been mentioned that the Risca explosion occurred at about the same time, and there was a good deal of speculation as to whether that explosion was caused by electricity. As all life underground was destroyed, there was no evidence to show what did happen there; but the workings were very dry and dusty, and the result of the inquiry was, that the explosion had occurred in-bye, and that there had been an accumulation of gas, but there was no evidence to show how that gas had been exploded.

Mr. RYDER said, it had been mentioned that there were some traces of the lightning flash upon X at the daylight drift, Plate IX.; he would like to know of what character these traces were, and whether there was any damage done?

Mr. J. B. SIMPSON said, with respect to this question, there was no definite evidence as to its having gone out there. Some of the witnesses said there was a mark on the side of the drift which might have been caused by the lightning, but the Committee had no other evidence.

The PRESIDENT said, he would like to know whether any of the foreign engineers had made any statement as to their experience, or whether any member had any knowledge of anything having appeared in the Transactions of any of the Foreign Societies upon the subject?

Mr. MORISON said that both in Belgium and Germany, as a rule, they had lightning conductors on the top of the pulleys.

Mr. SIMPSON asked whether that might not be to save the surface buildings, and not to prevent the lightning going down the shaft? The surface buildings in Belgium were very large.

Mr. MORISON said, the conductors might not be put up to prevent the lightning going down the shaft, but would still have that effect.

Mr. BUNNING said, he had noticed that the use of lightning conductors abroad was very much more general than in England.

Mr. MORISON—It is very much more general.

Mr. MAY said, that at Harton Colliery, where they had two or three chimneys, and very high houses round about, they had them protected

To illustrate the paper "On particulars relative to the fact of Lightning having been seen in the Pit at Tanfield Moor Colliery"

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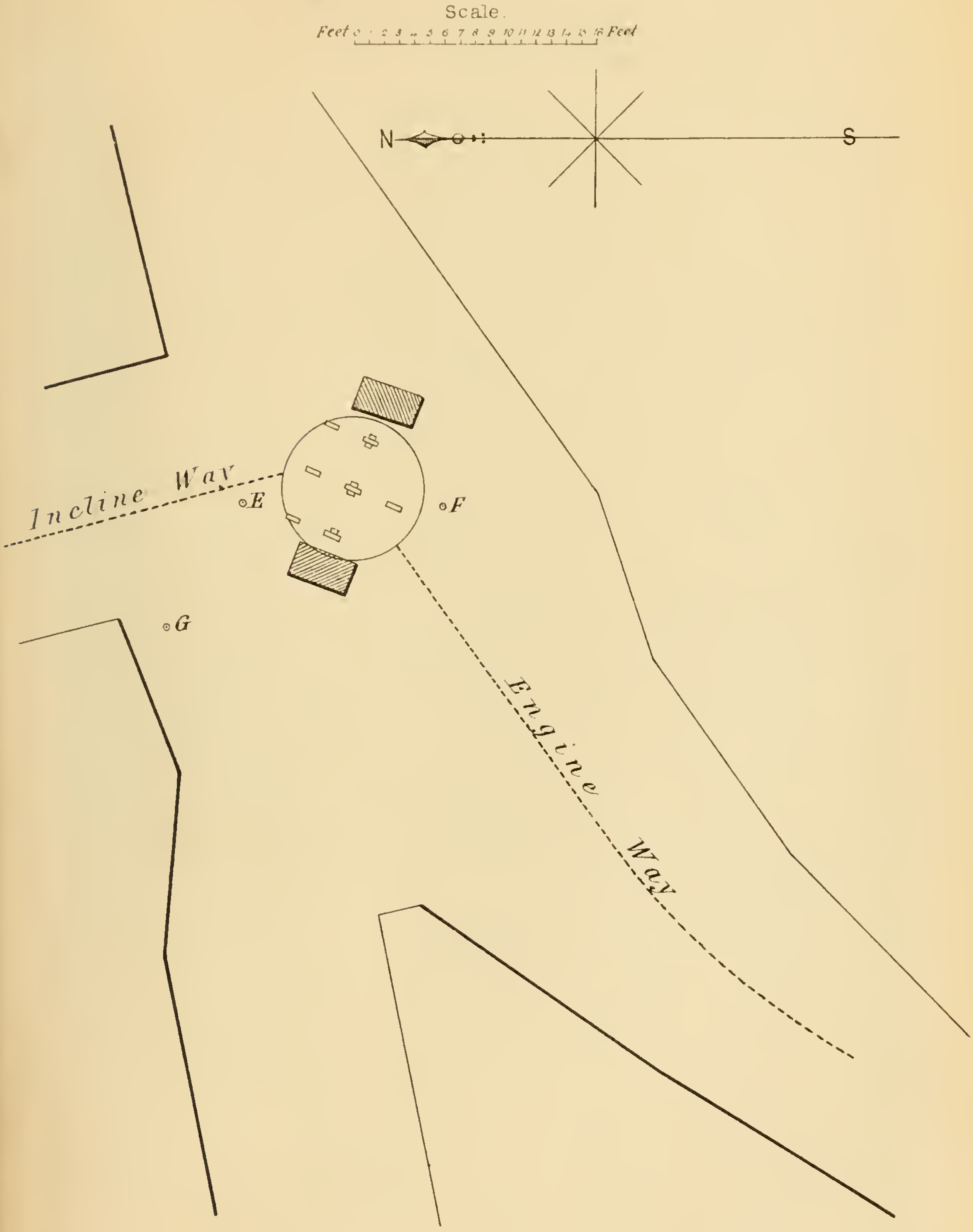

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Proceedings N.E.I. of M.&M.E. 1880-81

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FIG. 2

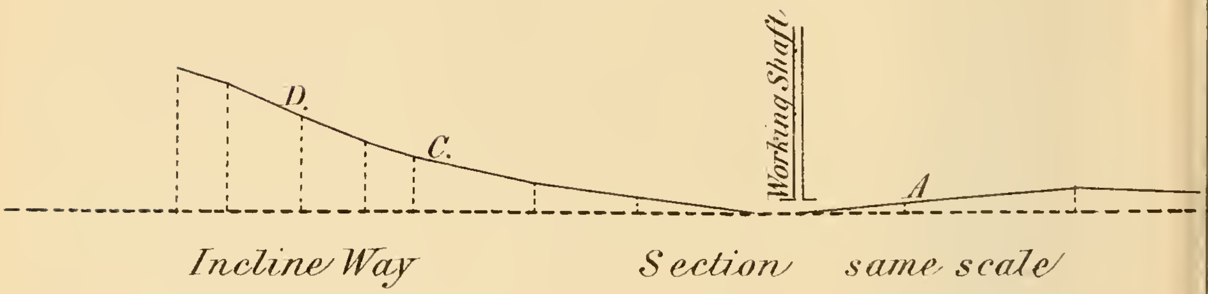
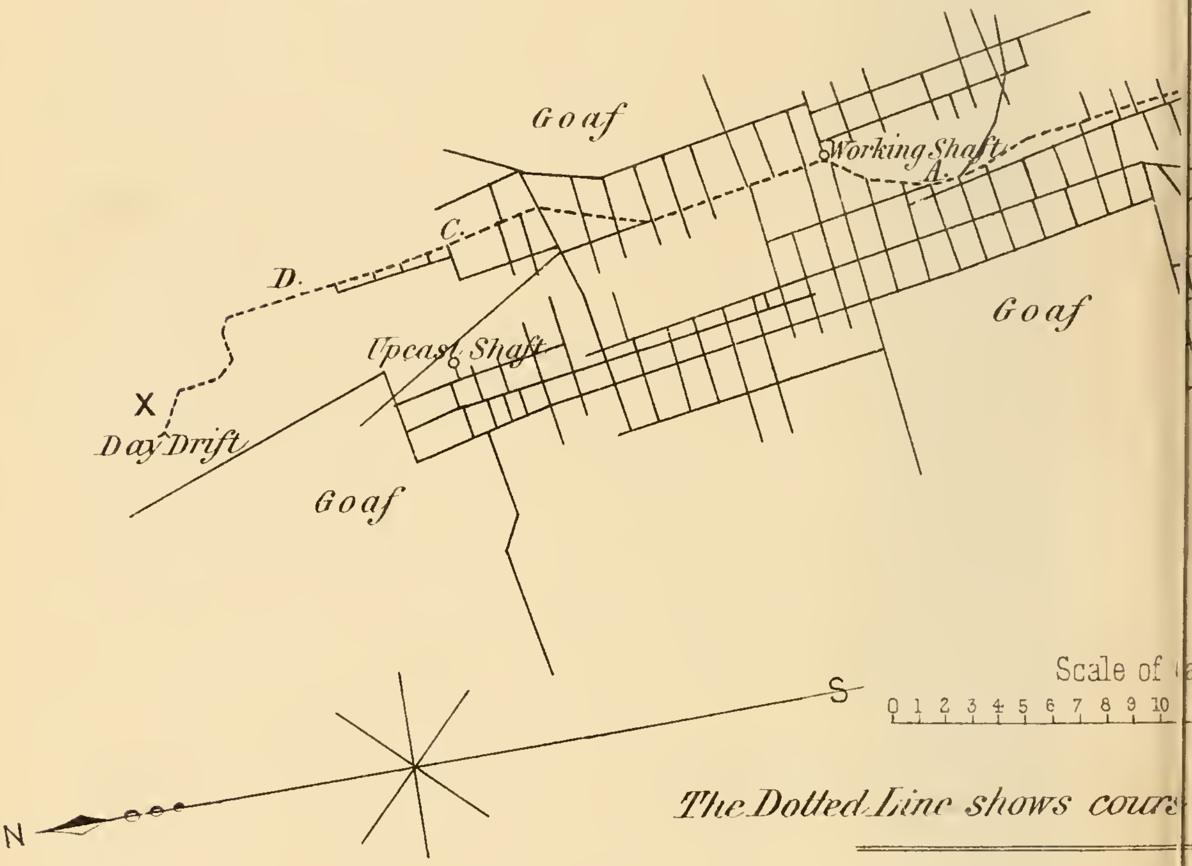


FIG.



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g having been seen in the Pit at Tanfield Moor Colliery"

COLLIERY,

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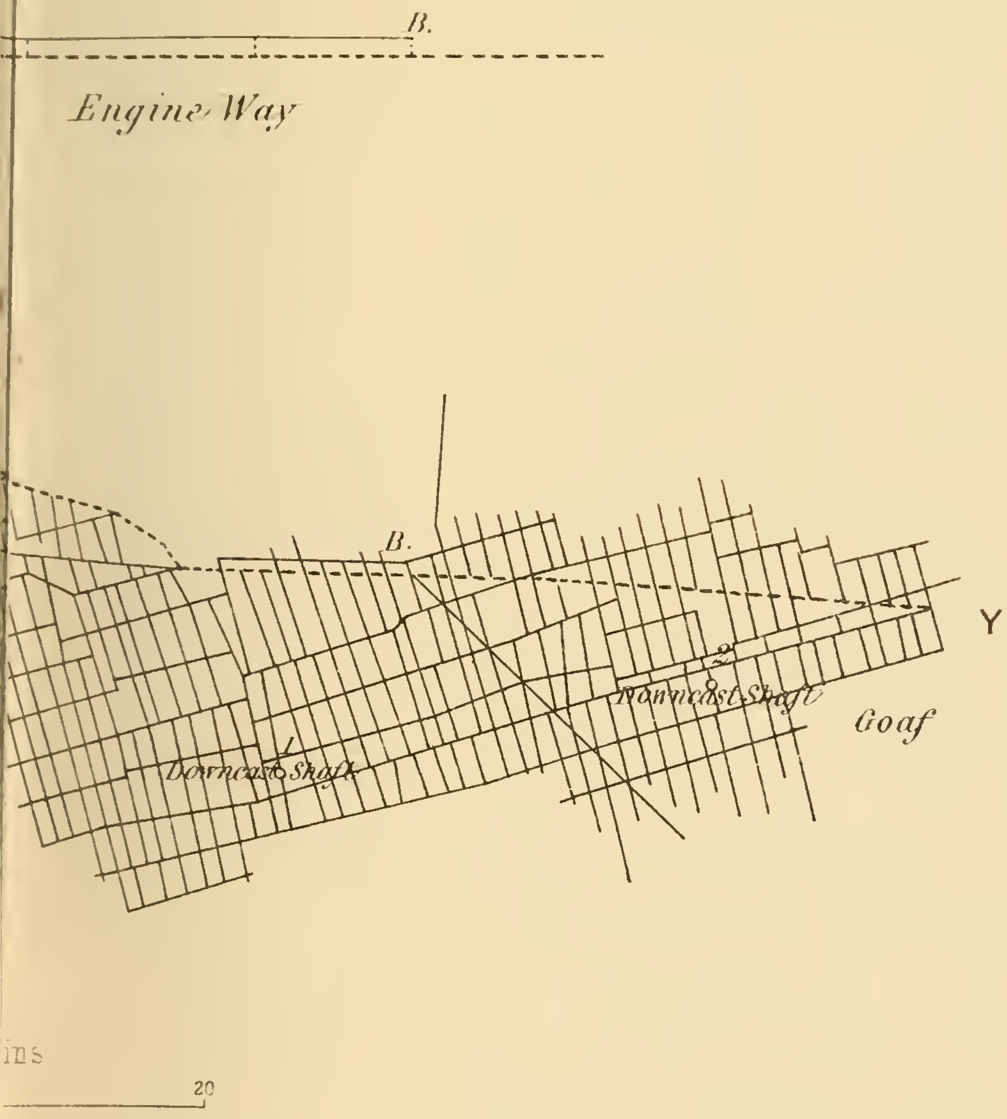


taken by lightning.

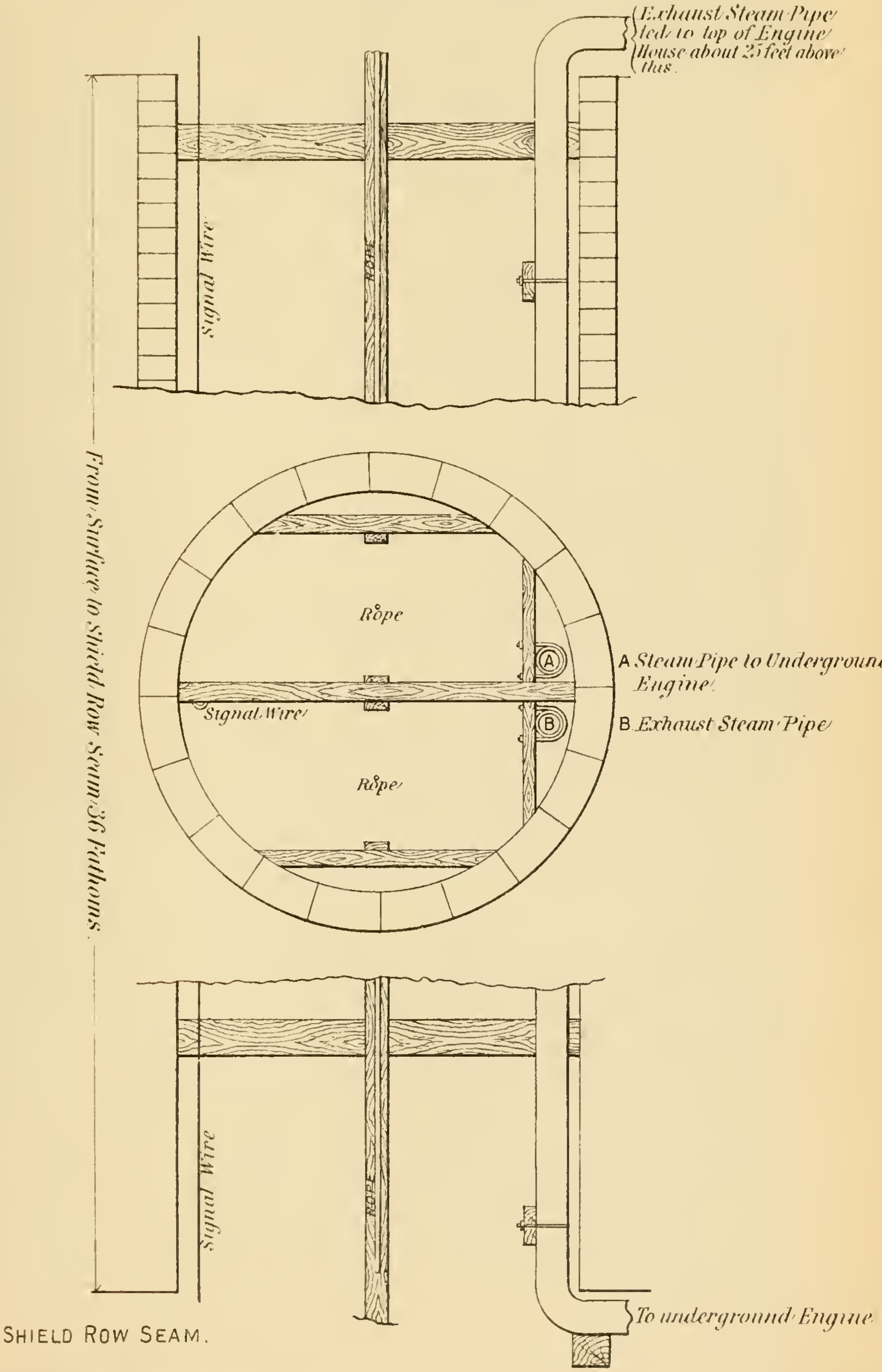
G. Crisp
G. Nicholson and J. Pyle
T. Crisp and J. Greener
T. Spring and J. Hagan

And^w Reid, Newcastle

To illustrate the paper "On particulars relative to the fact of Lightning having been seen in the Pit at Tanfield Moor Colliery."

WILLIE PIT SHAFT.

TANFIELD MOOR COLLIERY.



Andw Reid Newcle

by lightning conductors; yet still the electric fluid struck the wires which are only about 10 or 12 feet from the ground.

The PRESIDENT said, the matter had now been very fairly discussed, and he hoped it would receive the attention of those gentlemen who were more conversant with electrical matters than many of the members, and that they would endeavour to let it be known whether there was any possibility of an accident happening from an explosion of gas by lightning passing underground, and if so, whether the danger could be met by finding earth, as Professor Herschel had put it, without the lightning going in-bye. Perhaps this subject might receive consideration, and the members would be very glad to hear of it if any gentleman arrived at any satisfactory proposition.

The SECRETARY said that an electric signal apparatus for use at pits was now being exhibited at Messrs. Mills and Co.'s, Forth Banks, and those gentlemen would be very happy to exhibit it to any member of the Institute who liked to go round and see it at the close of the meeting.

The PRESIDENT moved a vote of thanks to the Committee of Investigation for the most interesting paper they had given, and also to Mr. Kendall for his paper.

Mr. STEAVENSON had great pleasure in seconding the motion.

The votes of thanks were then carried by acclamation, and the meeting terminated.

Since the discussion took place the Secretary has received the following communication from Mr. Heaviside, the Superintendent Engineer, Post Office, Telegraph Department, Newcastle-upon-Tyne:—

1, GRAFTON ROAD, WHITLEY, NEWCASTLE-ON-TYNE,
20th December 1880.

T. W. BUNNING, ESQ.

DEAR SIR,—Mr. Ryder has been good enough to favour me with a perusal of the accompanying proofs, and I beg leave to offer the following observations thereon:—

I have read the evidence and there can be no doubt that the pulleys, the steam pipe, and the signal wire were struck by lightning; and owing to the imperfect fishing of the rails, the charge, whilst in the act of dissipating itself over the various conductors which carried it to earth, experienced so much resistance in its course that heat and sparks were caused, accompanied by slight reports as described by the witnesses. I have no knowledge of the pit in question, but it almost follows that it must be a dry one, and also that the surface must have been dry at the time of the lightning discharge, otherwise the phenomenon would have taken place much more quietly.

Remarking upon Mr. May's observations. It is a law that all circuits must be complete within themselves for a current to flow, hence if the bells would not ring there must have been a break in the circuit, and Mr. May points out where the break was; namely, in the earth connection; for as soon as that was made good by connecting the 200 yards of unfished rails, the bells worked all right. Hence in the Harton pit also, if the earth connections at each end of the wire were perfectly made, there was no path, or a path of such very high resistance, owing to the dryness of the pit, that but a fraction of the current took the course intended for it, and that fraction was insufficient to work the bells. The whole question of the safety of the pit from being struck by lightning appears to depend upon the nature of the earth connections made on the surface. Now, with ordinary telegraph instruments, it is a well-known fact that where the earth is riddled with shafts and underground workings, or is artificially raised, as at the Ballast Hill at North Shields, a good earth connection is not obtainable. I can mention three cases in particular: Throckley, West Stanley, and the Ballast Hill at North Shields. At Throckley the "A B C" was fitted with a switch, so that each side of the line could be used independently of the other, but when the switch was turned to say line A, it was found that line B was also getting the message intended for A, what happened was this, owing to the imperfect earth connection, the current had three paths open to it, the one to line A, the other to the earth, and the last to line B, the current dividing inversely as the resistances of the three paths, probably the greater portion going by line A, and smaller portions by the earth and line B; this difficulty was got over by taking care to make the earth connection of large surface.

At West Stanley the wire was frequently being reported faulty and this was finally traced to a defective earth at West Stanley.

At the Ballast Hill, North Shields, the earth wire had to be carried down into the River Tyne, otherwise there was danger of failure of the Time Gun.

Mr. Steavenson's remarks as to the lightning probably striking the pulleys is a most pertinent one, and though the lightning would take every path open to it, the pulleys being so prominent and the rope continuous, that path would probably have the largest share of the charge to dispose of.

With regard to the chimneys at Harton being protected with lightning conductors and yet the telegraph wires 10 or 12 feet from the ground being struck by lightning, this is probably explained by the fact that the wires in question extend over a large surface of country, and no matter where struck the charge would be felt at Harton.

The practical point is how to prevent lightning discharges entering pits, and being a source of danger, the extent of which is not well understood: obviously, to protect the mouth of the shaft efficiently, lightning conductors should be fixed to all lofty chimneys and buildings in the neighbourhood, the various points upon a building being connected to the main conductor, and this conductor must be continuous and make good earth. To effect the latter, should the surface and pit be dry, it must be taken to some point, no matter how distant, where a good earth can be obtained, and nothing is better than the bed of a stream or the water mains.

At most collieries I have observed a reservoir of water, and in many cases a stream of some volume due to pumping operations, and in those cases there can be no difficulty.

Then there is one other point, the conductor or conductors must be tested from time to time so that it may be ascertained that they are intact and making good earth.

I have not specially studied the subject of lightning conductors, but it is a pleasure to comment upon so interesting a topic.—I am, yours truly,

A. W. HEAVISIDE.

VISIT TO THE WHITBURN NEW WINNING, NEAR SUNDERLAND.

On October 15th, the members of the Institute paid a visit to the new winning of the Whitburn Coal Company at Whitburn, for the purpose of witnessing the process of sinking by the Kind-Chaudron process, which had been adopted by the Company in order to carry the necessary shafts for working the coal through the water-bearing strata. This process was fully described in a paper by Mr. Warington Smyth, which was read before the members of the Institute, at a general meeting of the members in the Wood Memorial Hall, on the 6th of May, 1871; and will be found fully reported in the Proceedings of the Institute, Vol. XX., page 187. The process itself, however, had not previously been in operation in the North of England, the only other instance of its use in this country having been at Cannock Chase, in Staffordshire, where also, as at Whitburn, it had been adopted in order to overcome the difficulty of an enormous influx of water into the shaft, which rendered all the ordinary means of sinking unavailable at such a depth. A very large number of members of the Institute, including the President (G. C. Greenwell, Esq.) and several members of the Council, availed themselves of the opportunity thus afforded of seeing the process in operation, the majority of them leaving Newcastle by the 12·35 p.m. train for South Shields, where they arrived at a quarter past one. A train of carriages belonging to the Whitburn Coal Company waited at Westoe Bridge for the arrival of the visitors, and conveyed them along the Company's private line to the pit at Marsden.

The Whitburn Coal Company having obtained their royalty, commenced operations about five or six years ago; but the quantity of water encountered became so enormous that the sinking operations in the ordinary way had to be suspended. The quantity of water pumped at the time the ordinary methods of sinking were discontinued amounted to nearly 12,000 gallons a minute. In each pit water was met with at a depth of 110 feet, and the enormous difficulties then began. By means of incessant pumping upon a prodigious scale, a further depth of 36 feet was sunk; and then the excessive cost and the slow progress of the work decided the proprietors to discontinue the means which had up to that time been employed, and to resort to the Kind-Chaudron process, the use of which had been in successful operation in the North of France and Belgium. In the first shaft a preliminary pit, 6 feet in diameter, was sunk to a depth of 422 feet, and then the shaft was sunk to the same depth at its full diameter of 14·6 feet. Upon the completion of the first shaft to below the water-bearing strata, a second shaft, which is necessary in order to comply with the requirements of the Legislature, was begun. This second shaft is being put down, and is now sunk to a depth of 274 feet 7 inches, of which the lower part, or 164 feet 8 inches, has been sunk by the Kind-Chaudron process. At the time when the members of the Institute visited the pit one shaft had been completed to below the water-bearing strata, and the second was in course of sinking, and far advanced towards successful completion. In the first shaft the average rate of advance by the small bore was 2 feet 8 inches per day of 24 hours, and by the large bore 1 foot 4 inches. In the second shaft the rate of advance with the small bore was 1 foot 8 inches, and with the large bore it has been up to this time 1 foot 6 inches. The diameter of the small bore in the second shaft is 6 feet 7 inches, and of the large bore 15 feet 5 inches. The weight of the small *trepan* is 11 tons, and of the large *trepan* 20 tons. The *cuiller* contains 12 feet in depth, and 12 tons in weight of *debris* from the large bore.

When the visitors arrived the large *trepan* was in full operation. It was afterwards stopped, the "*balancier*" and "*trepan*" were withdrawn, and the engineers then commenced to lower the rods with which to withdraw the "*cuiller suspendue*" containing the *debris*. The rods were then attached to the "*cuiller suspendue*," which was withdrawn and the contents tipped into a trough. They consisted of very small pieces of limestone, the largest weighing only a few ounces, and these larger pieces being very few in number. It was expected that the second shaft would be completed by the end of the present year to below the water-bearing strata.

The *debris*, although from the limestone rocks, is of no commercial value; but the Company have a number of limestone quarries which they are working for commercial purposes. Samples of the different stones, the produce of the quarries, were exhibited at the pit; and consisted of broken limestone for chemical works and for road metal; of screened chips for carriage drives and for garden walks; of unslacked shells; of slacked lime; and of limestone for building purposes. The Company have also erected large limekilns.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, NOVEMBER 6TH, 1880, IN THE WOOD MEMORIAL HALL.

G. C. GREENWELL, Esq., President, in the Chair.

The Secretary read the minutes of the last meeting, and reported the proceedings of the Council.

The following gentlemen were elected members :—

Ordinary Member—

Mr. Richard Broja, Mining Engineer, Dortmund.

Associate Member—

Mr. W. A. Charlton, Manager, Tangye Bros., 25, Lincoln Street, Gateshead-on-Tyne.

Student—

Mr. Charles Chandley, Atherton Collieries, near Manchester.

The following were nominated for election at the next meeting:—

Associate Member—

Mr. John Morison, Newbattle Collieries, Dalkeith.

Students—

Mr. Septimus Heslop, Urpeth, Chester-le-Street.
Mr. Frederick J. Ferens, 220, Gilesgate, Durham.
Mr. Henry G. Pringle, Tanfield Lea Colliery, Co. Durham.

Mr. Henry Richardson read a "Description of a Sinking Set fitted with New Windbore Protector and Suction Regulator;"—

DESCRIPTION OF A SINKING SET FITTED WITH NEW WINDBORE PROTECTOR AND SUCTION REGULATOR.

COMMUNICATED BY HENRY RICHARDSON.

When a larger quantity of water is met with in a sinking shaft than can be drawn by a tub, the next means used is generally that of pumping it out, and the first thing to be observed in connection with this is to make in the bottom of the shaft what is generally termed a "sump," or, in other words, a portion of the shaft bottom is sunk down lower than the other, thus forming a kind of dish into which the water collects, and which is always allowed to be the deepest part.

Fig. 1, Plate XI., represents the shaft section, and shows the general arrangement of a hanging pumping-set used for the purpose of keeping the bottom clear of water and allowing the sinking to be proceeded with, the general method of conducting operations being as follows :—

The lowest casting No. 1, termed the windbore, consists of a pipe flanged at one end and closed and V pointed at the other ; about half its length is made larger in diameter than the other half, and is perforated with a number of small holes, into which the water enters when the pump is working. In consequence of the large number of holes in the windbore it often happens that two or three rows of holes are above the level of the water and therefore exposed to the atmosphere; such being the case, and supposing the pump to be started, the atmosphere would enter these holes, and the whole operation would consist in pumping air instead of water. In order to overcome this difficulty the holes above the water line have to be closed with wooden plugs driven tightly in, to prevent the air from entering.

The next part is the clack piece (No. 2, Fig. 1), bolted to the flange end of the windbore. Internally it contains the clack C, admission to which is obtained by means of a door bolted on as shown, and secured by strong wrought iron cross bars ; on its external surface two large projections are cast D E, one on each side, with a hole in each, in order to receive the wrought iron ends of the "ground spears" G S.

No. 3, Fig. 1, is the working barrel within which the bucket works.

No. 4 is named the "bucket-door piece," in which a similar door to that on the clack-piece gives access to the bucket.

No. 5 shows the ordinary pumps used above the foregoing pieces, and continued upwards until the surface or any other delivery for the water is reached.

The "ground spears" referred to, come down each side of the pumps, and are fixed to the clack piece 2 by means of cotters through the wrought iron ends bolted to them. The top ends are connected to the pulley blocks and ropes used for raising or lowering the whole set as occasion may require. The pumps are also secured to these spears by means of wrought iron clamps similar to that marked H H, Figs. 1 and 4. The wood framing marked B T is called a "collaring," its use being to steady the pumps and spears, and keep them in a vertical position; it likewise prevents the movement which would ensue from the vibrating motion imparted to the pumps by the action of the spears inside.

Fig. 2 shows an enlarged sectional elevation of the Windbore itself, and also of the Windbore Protector and Suction Regulator.

Fig. 3 is a plan and transverse section of the same.

Fig. 4 is a plan of the clamps and pulleys marked H H, Fig. 1.

The Windbore Protector and Suction Regulator is cast in halves, faced and jointed with $\frac{1}{16}$th sheet India-rubber, flanged and bolted, as shown, a little larger in internal diameter than the external diameter of the enlarged part of windbore. The top is flanged inwards a little in order to protect the neck ring from injury. The method of securing an air joint at the top of the Regulator is exceedingly simple, consisting only of a circular India-rubber ring Y placed in a small concave recess formed on the neck of the Windbore, in order to keep the axis of the ring perfectly horizontal and rolling on its outer surface.

The method of raising or lowering the Regulator is shown more clearly on shaft section; two chains, one on each side, are connected to the top bolt by means of a shackle, and passing up through the weights R R, Fig. 1, over the pulleys H H, and down again to the centre of the weights to which they are then connected. The chains thus serve two purposes, namely, to connect the weights, and thus balance the Regulator, and also to act as guides by passing up through them. From the bottom of the weights, chains B B pass downwards within reach of the sinkers, who can keep the Protector at any required height by simply connecting the loose chain to those suspending it by an S.

The particular action of the Regulator and its advantages will perhaps be best understood by stating the disadvantages of the present method and then the remedy proposed.

Having previously stated that the holes in the Windbore, which in a general way are above the water level, have to be "plugged," it follows that should the set settle down into any soft stratum, which might be exposed by the action of a shot when the sinkers are out of the shaft bottom, and the bottom holes become imbedded, the set becomes wiredrawn, and it is possible that so large a quantity of water may be given off as to prevent the men returning to remove the plugs, which would necessitate lifting the whole set and all its appliances, and cause serious delay.

By using the Protector the plugs are entirely dispensed with, and the difficulty arising from the set settling down is overcome. The necessity for lifting the whole set is done away with, and the fact of the water being so high that the men cannot get into the bottom is rendered of no importance to the proper performance of the pumping apparatus.

By referring again to Fig. 1 the Regulator is shown in position, and its action may be explained as follows :—The set is supposed in the first instance to be resting on hard strata at X ; the Regulator is supposed to be in its normal position, with its bottom covered by water, and two rows of holes in the Windbore exposed. W and Z are two shots supposed to have been just fired, and having broken up the strata X, have entered the softer strata Y, thus removing the pump foundation or support. Immediately, therefore, the pumps begin to settle down into the softer stone, the Regulator is brought into action, and inasmuch as it is still above in the strata X, and its bottom of a larger area than the Windbore, it is only reasonable to suppose, instead of going down along with the Windbore, it will be caught by some of the broken fragments of rock, and thus arrested in its downward movement. Supposing this to be so, the chains begin to slacken, and the pumps still continuing to move downwards, the previously covered holes are exposed to the water; and even should those at the very bottom be choked by their being imbedded in the soft strata at Y, the pump is kept going, and when the sinkers return to the bottom they can regulate the descent of the Regulator as they may require by simply removing the loose pieces of rock supporting it, until it resumes its original position.

The advantages to be derived from the use of the Protector are obvious:

1.—It protects the Windbore from the blows caused by the detonation of the shots, and is not likely to be damaged itself by any blows because of the entire absence of any weak or working parts.

2.—It renders plugging of windbore holes unnecessary, and when called into action such action is automatic, and the time of the sinkers is economised.

3.—The absence of working parts and the consequent reduction of wear and tear.

4.—The travel of the ring being only half the surface exposed, its action is reduced to a minimum. The joint is always tight, and is unaffected by any blow from shots.

5.—It cannot be rendered inactive by corrosion.

6.—The ease with which it can be fixed either to new or to present working sets by being cast in halves.

7.—Its comparatively small cost.

The PRESIDENT said, that when the paper was published along with the drawings the members would have a better opportunity of obtaining all the information they needed, and it would therefore be advisable to delay any remarks.

Mr. RICHARDSON said, he had recently been engaged in sinking, and had experienced the very trouble he had described. He had not yet adopted the improvement, but should he do so, he would communicate to the members the result of the application.

The PRESIDENT moved, and Mr. E. F. BOYD seconded, a vote of thanks to Mr. Richardson for his communication.

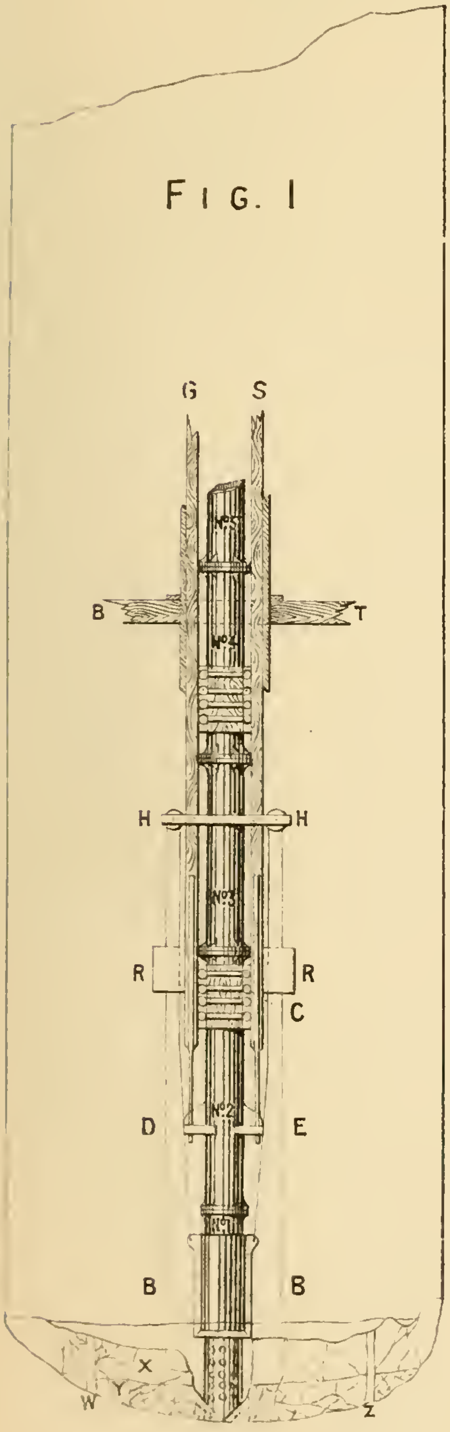
The SECRETARY then read the following paper "On the Gypsum of Nova Scotia," by Mr. Edwin Gilpin :—

To illustrate the Description of a Sinking Set fitted with new Windbore protector and Suction Regulator: communicated by Mr. Henry Richardson.

PLAN OF SINKING SET WITH WINDBORE PROTECTOR AND SUCTION REGULATOR

Scale_8 feet to 1 inch

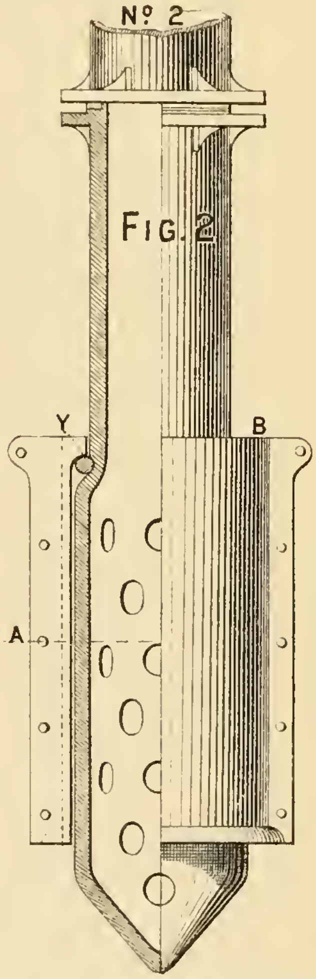
Fig. I



SHAFT SECTION

Scale_2 feet to 1 inch

Fig. 2



VERTICAL SECTION & ELEVATION

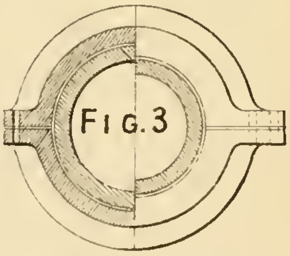


Fig. 3

SECTION A _ FIG. 2

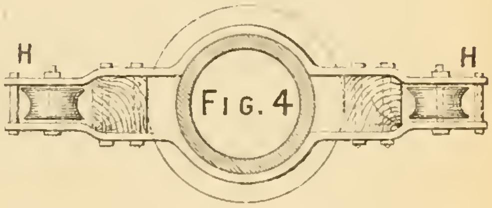


Fig. 4

ENLARGED VIEW OF H.H

Proceedings N°E. Ins. M.&M.E. 1880-81

THE GYPSUM OF NOVA SCOTIA.

By EDWIN GILPIN, A.M., F.G.S., Inspector of Mines.

The writer ventures to lay before the Institute the following remarks on the gypsum found in the Maritime Provinces of Canada, gathered from his own notes as well as from the experience of others.

The beds of this mineral attain in these provinces, the Acadia of the early writers, dimensions which arrest the attention of the geologist and traveller. It contributes an important item to the little list of mineral exports, and with its associated limestones and marls, gives to large districts of Nova Scotia a fertility seldom surpassed in the northern part of the temperate zone.

Rising in cliffs from fifty to one hundred and fifty feet in height, it looks down on the mud-laden tides of the Bay of Fundy, and the blue waters of the Gulf of St. Lawrence, or forms a striking feature on the beautiful Bras d'Or Lake, a little inland sea, "running away into lovely bays and lagoons, leaving slender tongues of land and picturesque islands, and bringing into the recesses of the land the flavour of salt and the fishes and molluscs of the briny sea."

The traveller meets it surrounded by dense growths of spruce and hemlock shadowing some quiet pond in the woods, or standing like some ruined castle of marble on the side of a fertile river valley.

AGE OF THE GYPSUM.

So far as the writer is aware, the gypsum deposits of Nova Scotia are the largest and most extensive in the world, and the only ones occurring in measures of the Carboniferous age.

Dr. Dawson in his classical work on "Acadian Geology" has separated the Carboniferous of the Maritime Provinces into five divisions:—

1.—The upper, or Permo-Carboniferous Coal-Measures, not holding beds of workable coal.
2.—The true or productive Coal-Measures.
3.—The Millstone Grit.
4.—The marine limestone or gypsiferous formation.
5.—The lower, or false Coal-Measures, holding many characteristic coal fossils, but destitute of workable beds.

In Nova Scotia the gypsum and associated strata were long considered of Permian age from their resemblance to these rocks in other countries and their somewhat obscure relations to the succeeding measures ; and it was only by a careful study of sections, and a comparison of fossils that the labours of Sir Charles Lyell, Dr. Dawson, and Mr. R. Brown, relegated them to their true position as forming part of the Carboniferous marine formation. Their stratigraphical position is now undoubted, and Davidson affirmed the fossils, especially the brachiopods, to be in many cases identical with those of the Mountain Limestone of England. De Koninck stated " that the fauna completely recalled that of the Carboniferous limestone of Visé in Belgium."

Yet, as Dr. Dawson remarks, it is true that the rocks themselves, the limestones, the red sandstones, the marls, and the gypsums, have much the aspect of Permian strata, and the fossils, although Carboniferous, have, especially in the upper beds, many forms common to the Carboniferous and Permian, suggesting that there may have been here what M. Barrande would have styled a " colony" of Permian forms in the Carboniferous age.

This formation in the Lower Provinces is made up of red and grey sandstones, arenaceous and argillaceous shales, conglomerates, limestones, gypsums, and marls; the various members predominating in different districts.

The formation extends in an irregular form from the Tobique river, in New Brunswick, through the northern and eastern parts of Nova Scotia to the Sydney coal-field of Cape Breton. The gypsiferous deposits of Newfoundland and the Magdalen Islands also belong to the same series of rocks, and are isolated patches of the northern and eastern edges of the great mass of Lower Carboniferous sediment which stretches under Prince Edward's Island and great part of the gulf of St. Lawrence, over an area of not less than 100,000 square miles.

ASSOCIATED STRATA.

The following section, measured by the writer, in Pictou county, shows in a general manner the succession of these strata:—

	Ft.	In.
Red fissile shales	15	0
Compact bluish limestone	4	6
Gray marl, with nodules of limestone	21	4
Gray laminated sandstone	6	0
Gypsum, with a few layers of arenaceous matter	17	3
Brown marl, with veinlets and crystals of gypsum	30	6
Arenaceous limestone, fossiliferous	3	10
Gypsum	8	0
Calcareous, fissile sandstones	11	5

They follow no regular order, but it is frequently observed that the gypsum rests in the beds of marl, in other cases it rests on beds of dark limestone, alternating with beds of gypsum and anhydrite.

The limestones and shales are characterised chiefly by numerous brachiopods, especially Productus cora, Athyris subtilita, and Terebratula sufflata, with other marine invertebrates.*

The limestones present every shade of composition, varying from arenaceous and argillaceous to the almost chemically pure mineral, according to the varied modes and conditions of its deposition. The thickness of the beds varies from 6 inches to 50 feet; the greatest continuous section being about 300 feet. These limestones are very free from magnesia as a general rule. Out of twenty limestones from this formation in Pictou county, that the writer has analysed, but two contained notable percentages of this mineral, viz., 10 and 10·5 per cent. as carbonate of magnesia, the average percentage being 2·5. Dr. How, of King's College, Windsor, mentioned finding considerable traces of magnesia in a gypsum deposit of that locality, and in one instance a large percentage in a limestone contiguous to gypsum, but other limestones in this district are very free from magnesia. The writer finds no mention of magnesian limestones occurring in any other Nova Scotia district, except a memorandum, perhaps not altogether reliable, of a bed one foot thick met in a chisel borehole made in Antigonish county some years ago. Three limestones associated with gypsum, near Mabou, in Cape Breton, gave but traces of magnesia on qualitative examination. Two limestones, however, presented by Mr. Fletcher, of the Canadian Geological Survey, from the vicinity of the gypsum beds of Judique, Cape Breton, gave 15 and 21 per cent. of magnesia carbonate. In other parts of the island, according to Mr. Fletcher, the limestones are non-magnesian.

The marls are, so far as the writer has had opportunities of observing them, made up of a siliceous or argillaceous base with limestone, gypsum, bituminous and carbonaceous matter in various proportions. They are frequently penetrated by veins and nodules of gypsum and limestone and in some cases hold the fossils characterising the formation.

The sandstones are of the usual gray and reddish colours, generally much broken by slaty cleavage. The conglomerates are composed largely of the older rocks, and in some cases hold pebbles of the preceding beds of the same formation. In many places they show marks of metamorphism, and occasionally are united by ferruginous cements, which, through weathering, have formed deposits of bog ore.

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* Dawson's "Acadian Geology."

THICKNESS OF THE LOWER CARBONIFEROUS MARINE LIMESTONES.

The thickness of this formation varies in the different districts. In Cumberland county, Sir W. Logan estimated the thickness of the upper part at 1,658 feet; adding the lower members, there would be a total thickness of about 2,500 feet.

In Pictou county no complete sections have been measured, and the passage to the Millstone Grit is obscure ; the writer is inclined, however, to consider it as somewhat greater than in Cumberland county, and ventures to approximate it at 3,000 feet.

In the Eastern parts of Cape Breton the officers of the Geological Survey, have, as the result of a careful and systematic survey, been enabled to estimate its thickness at 4,637 feet. In these dimensions they have included the great beds of conglomerate lying at the base of the formation, part of which may belong to, or be an equivalent of, Dr. Dawson's lowest or fifth division.

In Western Newfoundland, Mr. A. Murray, the chief of the Geological Survey of that Island, estimates the thickness of the Lower Carboniferous marine formation at 2,150 feet, not including 1,300 feet of coarse conglomerate, corresponding to that found at the same horizon in Eastern Cape Breton.

HORIZON OF THE GYPSUM.

The gypsum occurs in this great volume of measures, so far as is at present known, at no fixed horizon. In the vicinity of Hillsboro, in New Brunswick, Mr. G. Matthews states that the gypsum occurs with regularly stratified bituminous limestones and marls directly overlaid by the Millstone Grit. In this district, he marks the occurrence of a series of limestones lower down in the measures, which do not appear to be gypsiferous. In Cumberland county it occurs about the middle of the series. In Pictou county it is found in the lower part of the formation, and frequently only a few yards from the Silurian strata, but does not form as prominent a feature as in many other districts.

The researches of Mr. Fletcher in Cape Breton have shown that in Sydney Harbour, it occurs a few feet below the Millstone Grit, and that on Boularderie Island, the base of the Boisdale and St. Anne's Hills, it occupies the same position, being "overlaid almost immediately by the gray sandstones of the Millstone Grit, containing characteristic fossils." About the Strait of Canso and near Baddeck, it occurs low down in the Carboniferous Limestone.

On the western shore of Cape Breton, at Mabou and Broad Cove it is found quite close to the coal beds, but this is evidently caused by faulting, and affords no key to its proper position in the limestone formation. A similar association occurs in the sections of the Little River coal-field of Richmond county.

In Newfoundland, Mr. Murray (Report of Progress, 1873, p. 15), places the leading exposures of gypsum in the lower part of the limestone formation, division B, and states that they are underlaid by over 1,000 feet of conglomerates corresponding to those already mentioned as occurring at the base of the Sydney Carboniferous. The associated strata are similar to those found in Cape Breton; the limestones being in many cases crowded with characteristic fossils. At a higher horizon, a short interval below measures which represent the Millstone Grit of Cape Breton, Mr. Murray found smaller deposits of gypsum associated with magnesian limestones, marls, and calcareous or dolomitic sandstones.

VARIETIES OF THE GYPSUM.

The gypsum in this great series of deposits presents every variety of colour and state of aggregation, and a corresponding difference in its composition.

On the Tobique river, in New Brunswick, it may be characterised as an impure earthy gypsum of a red and greenish colour seamed with layers of pure white and crystalline gypsum, and holding nodules of limestone in the red coloured portions.

At Hillsboro it forms generally a pure white snowy alabaster; other portions are cream-coloured, or with a shade of blue, and are translucent. At the works of the Albert Manufacturing Company there is a quarry face composed of the last-mentioned varieties, 400 feet long and from 25 to 75 feet high. Selenite, though met in veins and small crystals, is rare. The anhydrite occurs here in beds underlying the gypsum, and is of unknown dimensions.

At Sussex, New Brunswick, selenite occurs as single and grouped crystals containing symmetrically disseminated sand, and the process of formation seems to be still going on.

In the Windsor district, three ranges of gypsum are worked, the most northerly of which runs in an almost unbroken line to Maitland, 30 miles distant. From the quarry in the town of Windsor, considerably over a million of tons have been extracted, and the deposit shows no signs of exhaustion. Here the gypsum is white and blue with large quantities of selenite; in some quarries small beds of limestone and anhydrite are found in the gypsum. At some points in the district large deposits of transparent selenite are found in the quarries, and on several occasions cargoes of it have been shipped for special purposes.

On the Shubenacadie river the gypsum occurs in beds 10 to 15 feet in thickness, generally with anhydrite at the base, and in some cases dark laminated limestones holding Conularia, Terebratula, etc.

In Pictou county the gypsum is white and red, holding much anhydrite. Like some of the Bras d'Or gypsum it is associated with deposits of spathic ore. In a paper read before the Halifax Institute of Natural Science, in March, 1879, on the "Marine limestones of Pictou county," the writer has noticed this point more fully.

In Antigonish a noted exposure consists of a beautiful white alabaster, 100 feet thick, with veins of fine-grained gypsum, and anhydrite and crystals of calcspar.

At Plaster Cove, where an exposure is met, 80 feet thick, the mass is for the greater part an intimate mixture of gypsum and anhydrite in varying proportions. In some parts of the bed rounded grains of limestone are found.

On the Bras d'Or Lake it is essentially white, but tinted and spotted with red, blue, green, and other shades. The stratification of the gypsum is frequently undistinguishable from weathering, but in many cases it appears as a regular bed forming many thick and shaly layers in which crystals of selenite are frequently found, of a dark colour, scattered through the mass so as to give it a porphyroid appearance, or arranged in rude star-shaped forms. In some cases wedges of sandstone are found penetrating it, and layers of earthy matter, especially on the planes of bedding.

Mr. Fox, collector of customs in the Magdalen Islands, has kindly furnished the writer with much information relating to the gypsum of that locality. It appears to underlie large areas at several points, especially on Grindstone and Amherst Islands. The gypsum is white, red, and variegated, associated with the usual marls and limestones, and presents the same faces as that of the mainland.

The gypsum also occurs of varying degrees of hardness, from a crumbling mass to blocks which can be carved for indoor ornamentation. The gypsum is also found fibrous and granular in red and white colours, a striped gypsum, and occasionally as black gypsum. The following analysis of the latter is by Dr. How of Windsor :—

Gypsum	80·45
Anhydrite	2·84
Bituminous matter	1·53
Sand and clay	7·94
Carbonate of lime and magnesia, with alumina and protoxide of iron	7·23
	99·99

The anhydrite occurs in fibrous, lamellar, granular, and impalpable masses of irregular form, and as orthorhombic crystals.

The following analyses show generally the composition of the gypsum and anhydrite found in these provinces, the state of aggregation being due rather to the forces and modes of its deposition than to any decided change in composition by mixture of foreign bodies :—

GYPSUM.	SO_3	CaO	H_2O	SiO_2	Al_2O_3	Fe_2O_3
Granular white	44·16	33·83	21·00	...	...	...
Fibrous „	45·51	32·10	29·96	3·21	...	...
Compact „	45·76	31·87	19·90	2·80	·60	
Compact red	46·50	31·99	21·56	...	·45	

ANHYDRITE.	SO_3	CaO	H_2O	SiO_2	Al_2O_3	Fe_2O_3
Crystalline	55·80	40·68	2·91	·23	·25	
Coarse	56·77	41·40	·94	·26	·03	
Fine	58·01	40·21	·65	·09	...	

MINERALS ASSOCIATED WITH THE GYPSUM.

Among the more common may be mentioned Glauber salt, common salt, calcspar, magnesia carbonate, and arragonite. The writer has also observed carbonate of iron, limonite, and in one instance a few crystals of silica, and at Cheverie inspissated bitumen. Sulphur also occurs in small quantity in the gypsum of Wentworth, near Windsor, as crystals associated with the mineral ulexite to be noticed below. Mr. H. Louis, in a paper on "Additions to the Mineralogy of Nova Scotia," read before the Nova Scotia Institute of Natural Science, mentioned finding crystals of sulphur in a quantity of soft grayish gypsum, near Truro. The quantity present, being small, was not considered of economic value.

Brine springs issue from many points in the Lower Carboniferous of Nova Scotia, and from some of them salt of good quality has been manufactured to a small extent. These springs are frequently in the vicinity of the gypsum deposits, but do not appear, as a rule, to be immediately connected with them. The presence of these springs suggests the possibility of beds of salt being found intercalated in these measures. Their detection would be a very valuable discovery in a country which is so largely engaged in fishing, but no explorations have ever been made for the purpose of settling the question. When the extensive denudations of the Nova Scotia marine limestones, and the changes of level incidental to the great thickness of succeeding measures are considered, it is to be feared that ancient systems of drainage have dissolved out these deposits, if they ever existed. But the matter can be settled only by proper boring explorations, similar to those which disclosed the valuable salt beds of Goderich, Ontario.

The late Dr. How made, some years ago, an interesting discovery of compounds of borax in the gypsum and anhydrite of Windsor.

These minerals occur in crystals and nodules up to two inches in diameter, and in some cases form a considerable percentage of the rock. The nodules are sometimes pearly white, compact, and hard; in other specimens they are made up of acicular tufts of prismatic crystals, colourless and transparent.

The following table shows the composition of these interesting minerals, and also of another discovered by the same gentleman. The latter appears to have been produced by alteration of the ulexite by selenite, as it occurs partly and completely replaced by the selenite, retaining the same nodular form :—

Component Parts.	Natroboro Calcite. Ulexite (Dana).	Cryptomorphite.	Silicoboro Calcite. Howlite (Dana).	Wentworthite.
Water	34·49	19·72	11·84	18·00
Lime	14·20	15·50	28·69	31·14
Sulphuric acid ...	...	...	...	31·51
Silicic „ ...	...	...	15·25	4·98
Boracic „ ...	44·10	59·10	42·22	14·37
Soda	14·20	5·68	...	...
	106·99	100·00	98·00	100·00

The ulexite is a very pure form of the Peruvian boratetiza, which the writer believes is found only in these two countries. It has been largely exported from Peru into the United States for the manufacture of borax, and for glazing operations. Should these Nova Scotia deposits be found to occur in quantities of economic importance, they would form a valuable article of export, and materially aid the output of the associated gypsum.

ORIGIN OF THE GYPSUM.

It is a comparatively easy task to account for the origin and mode of formation of most of the sedimentary non-metamorphosed rocks. But among the short list of those whose history is not quite understood must be placed Gypsum.

Several theories have been advanced to account for its presence in the geological sequence; none of these, however, are applicable to every condition of its occurrence.

Dr. T. S. Hunt, in the report of the Geological Survey of Canada, 1857-58, gives a detailed account of some interesting experiments made with a view of throwing light on the formation of Canadian dolomites. From these experiments, which may be considered an extension and modification of the researches of Haidinger and Mitscherlich in this connexion, he deduces the following views. First, that in lakes or sea basins not having an outlet, the mutual decomposition of bicarbonate of lime and sulphate of magnesia gives rise to carbonate of magnesia and sulphate of lime, which are successively deposited on concentration; explaining the constant association of magnesian rocks with stratified gypsum. Secondly, that in sea basins the action of waters containing bicarbonate of soda causes the separation of the lime as carbonate, and the formation of a very soluble bicarbonate of magnesia, also deposited on evaporation. This mixture when heated under pressure, readily forms the double carbonate constituting dolomite.

This theory offers a means of accounting for the origin of the gypsum of Ontario, thus described by Sir W. Logan, "Geology of Canada, 1863:"—In the Onondaga, Upper Silurian, measures of Ontario, between the Niagara and Grand rivers, gypsum occurs as lenticular masses, varying in horizontal diameter, from a few yards to a quarter of a mile, and from three to seven feet in thickness. The strata above them are crushed and broken, while those beneath form a level floor. These deposits are associated with dolomites and marls, and at Goderich, Ontario, with beds of salt up to 60 feet in thickness. At various points in this formation there are springs yielding from three to four thousandths of free sulphuric acid; but Sir William Logan affirms the gypsum to have been contemporaneous with the strata, and to be unconnected with the acid springs of the present day: and also illustrates the origin of the magnesian portion of the Newfoundland Lower Carboniferous.

It does not, however, apply to the gypsiferous measures of the Lower Provinces. These deposits as already described, occur as regular beds, of enormous size, accompanied by measures abounding with the remains of a vigorous marine fauna, and essentially non-magnesian. To meet these differences of condition, Dr. Dawson, in his "Acadian Geology," has proposed to account for their formation in the following manner:—

That volcanoes in the Pre-Carboniferous rocks, surrounding the ocean in which the marine limestones were forming, poured out rivers of sulphuric acid which, flowing into the sea, changed the limestone into gypsum: the lessened acidity of the waters, and the deposition of detritus in some cases, allowing part of the gypsum to be mixed with the limestones and marls, and at other points causing the total conversion of the limestone.

There are some objections to this view, among which may be mentioned the following:—The older rocks now present no traces of the origin or action of the acid, nor do the marls, sandstones, and shales associate with the gypsum, and it is evident that they must have occasionally also been subjected to its action. It may be questioned how long a stream of sulphuric acid would remain sufficiently undiluted to allow of an uninterrupted action producing such enormous masses of the mineral, and it is evident that over so vast an area the whole mass of water could not have been acidulated to any degree.

Dr. Dawson quotes the cases of several volcanoes of the present day giving rise to sulphuric acid and forming gypsum by acting on beds of limestone, but they appear trifling and local when compared with the extent of the effect now under consideration, and are moreover sub-aërial.

When the great extent of the Acadian gypsiferous formation is considered, it will almost appear that the two theories noticed above can have acted only in isolated cases. The anomalous character of these deposits and their associates opens a new field to the chemical geologist. The writer is not aware of any other theories that have been advanced to account for this abnormal local development of gypsum. There are, however, two agencies that may have assisted in their formation.

Springs containing carbonate of lime and sulphate of magnesia, and holding free carbonic acid would form sulphate of lime, which, when escaping at the sea bottom and partially relieved from pressure, would lose carbonic acid and deposit sulphate of lime. Similarly, springs holding sulphuretted hydrogen, passing into water holding carbonate of lime and free carbonic acid, will gradually form sulphate of lime in both fresh and salt water.

Some of the Iceland gypsum is apparently deposited in the latter manner, and the gypsums of Nova Scotia are in some instances connected with springs yielding small percentages of sulphuretted hydrogen. Such springs, when rising in comparatively undisturbed waters, would gradually form large masses of gypsum of great purity. When, however, currents prevailed, particles of the gypsum would be carried to one side and form gypseous marls, and become mixed with the limestones.

This force is perhaps justly considered unequal to the effects now seen, but it must be remembered that it was synchronous with the slow growth of the limestone beds of that period, and great masses of limestone composed entirely of shells as at Windsor, Brookfield, Shubenacadie, and other places, and that the springs issuing on lines of pre-existing fractures would become shifted by the dynamic changes of pressure of accumulating strata, and gradually traverse considerable areas.

This apparently insignificant power may thus have produced effects similar to the fall of the leaf, which has preserved to our use masses of vegetable matter now compressed into beds sometimes 30 to 40 feet in thickness.

These deposits, however formed, were gradually buried by the succeeding sediments, and under heat and pressure probably became anhydrated. In the march of time, when the strata were again exposed to the weathering of the atmosphere, water, etc., the anhydrite once more became hydrated.

This would appear from crystals of anhydrite occurring with their edges converted into gypsum, and from the lenticular masses of anhydrite embedded in the gypsum. This is also confirmed by the action of anhydrite from a deep boring at Goderich, Ontario, which, when placed in fresh or salt water at ordinary temperatures, rapidly became hydrated. Silliman found that the gypsum of the East River of Pictou, like that of South Virginia, contained one atom of water to two of sulphate of lime, and gave the following analysis :—

Sulphuric acid	54·7
Lime	39·4
Water	5·9
	100·0

This compound may illustrate the transition stage. The writer believes the gypsum forming marine boiler incrustations sometimes presents a similar composition.

The veins and irregular masses of gypsum and selenite found in the associated limestones and marls, and in the triassic sandstones, and occurring as films and plates in the coal seams, are probably a later deposit from aqueous solutions.

The broken and dislocated appearance of the strata immediately surrounding the gypsum was formerly considered a proof of their intrusive origin, and is now generally considered to be due to the expansion caused by absorption of water by the gypsum. This disturbance of the strata may perhaps be more readily explained by the action of water which has dissolved or worn away portions of the gypsum, and allowed the shales, etc., to occupy the cavities thus formed. The gypsum frequently presents deep funnel-shaped holes, which contain water, and on examination yield bones of deer and other animals.

The hydration of the gypsum a short distance below the surface would be a comparatively slow operation, even now not completed at its outcrop, and the expansion would be spent more in binding the strata than in its fracture.

APPLICATION OF THE GYPSUM.

The uses to which gypsum is put are so much the same in every country that a detailed list would merely express the information already possessed by the members. The soft blue and white varieties are largely exported, to be ground for agricultural purposes. It is considered in the Southern States to be a valuable adjunct to the growth of cotton and tobacco. It is also much used as a top dressing, in the Northern States and the Provinces of Quebec and Ontario.

In Nova Scotia itself certain districts have been well served with this enricher in a remarkable manner. In the Bay of Fundy, which separates Nova Scotia and New Brunswick, the tides rise to a height of from 40 to 60 feet, and from the rapidity of their movements exert a powerfully erosive effect on every stratum exposed to their action.

Great part of the Lower Carboniferous marine limestone formation of Nova Scotia is penetrated by it, or drained by its tributaries; thus large quantities of the limestone, gypsum, and marl have been denuded and re-arranged in large meadows covering many thousand acres. These have been protected from inundation by large dykes, and present a soil of unsurpassed fertility. Constant additions are being made to these meadows by the unceasing denudation.

In addition to this, its dissemination, together with limestone and clay through the overlying soils, have rendered large districts in Cumberland, Pictou, Hants, and Antigonish, and parts of Cape Breton, capable of producing, when efficiently worked, more than average crops of the more common grains and roots.

The compact white gypsum and selenite is used for finishing walls, for cornices, etc. No more suitable place than Nova Scotia could be selected for the manufacture of those cements into which gypsum enters, as the mineral is cheap and of every grade of quality.

There are numerous gypsum mills scattered through Canada, and a rapidly increasing amount, which cannot be readily ascertained, is annually ground for domestic use. A large mill at Hillsboro, New Brunswick, has been working for a number of years on the deposits of that locality, already mentioned as being of the greatest purity.

The principles involved in the manufacture of gypsum are so well known, that the chief interest centres in the comparison of cost. At this establishment, a forty-five horse-power engine furnishes the power necessary for driving the stones, revolving pans, making barrels, etc. Four cauldrons are used, each holding 18,000 lbs.; in the course of a day each boiler will yield three charges. At present this mill is working at only one-fifth of its capacity. From what information the writer has been able to acquire, the cost of the calcined gypsum is about 3s. per barrel of 300 lbs., barrel and paper lining included. This price would of course be materially reduced were the mill working up to its capacity.

The cost of quarrying the gypsum varies from 1s. 5d. to 2s. 6d. per ton; the selling price on board varies from 3s. 6d. to 4s. 9d., including a short haulage, interest, etc.

The mineral is all held in fee simple, and pays no royalty to the government, and is so abundant, that, as yet, operations have been confined to the outcrops of the beds nearest to the available shipping points. This, of course, materially reduces its price, and the capital charges of the quarry owners.

The vessels employed in carrying the gypsum to the neighbouring ports of the United States, are of small burden: up to 400 tons. When shipping from the Bay of Fundy ports, they sail up with the flood tide, and lie in the soft mud at the wharves when the tide falls; thus, alternately afloat and aground, they receive their cargoes.

The term "inexhaustible" is seldom applicable to the treasures of the earth, as they appear in any one district; but it may be justly enough applied to those deposits as developed in Nova Scotia. The extent of the trade, which, although considerable, falls far short of the facilities nature has offered for its prosecution, may be gathered from the following

STATISTICS.

The town of Windsor may be considered the head-quarters of the gypsum trade, as three-fifths of the total amount shipped is raised in the surrounding quarries. The total amount shipped from Windsor since 1833, is about 2,544,376 tons, of 2,240 lbs., valued at about 2,200,000 dollars.

The following table will show the average volume of the total export of the province, during the last twenty-five years:—

Year.	Tons.	Value. Dollars.
1855	95,301	80,875
1860	105,431	85,936
1865	56,155	45,088
1870	98,050	75,650
1873	120,693	120,693

In 1877, year ending June 30, Canada exported 101,376 tons, valued at 96,175 dollars; of which Nova Scotia exported 96,440 tons, valued at 89,488 dollars. In 1878, Canada exported 100,134 tons; of which Nova Scotia exported 94,607 tons, valued at 85,049 dollars. In 1879, Nova Scotia exported 95,126 tons, valued at 74,923 dollars.

The total exports from Nova Scotia since 1854, are about 2,300,000 tons, valued at about 1,900,000 dollars.

Very little ground gypsum is exported from Nova Scotia, but about 5,000 tons, or 20,000 dollars worth, is annually exported from New Brunswick to the United States. The imports of raw and manufactured gypsum into the western parts of Canada, from the United States, are of an annual value of about 10,000 dollars.

The United States do not impose any duty on raw gypsum, but the ground or calcined article is subjected to 20 per cent. duty, which is practically prohibitive. There is no duty on foreign gypsum coming into Canada except when ground, then the duty is 20 per cent.; or when calcined, in which case it pays 15 cents per hundred pounds.

From the Provincial census of 1861 it would appear that 75,387 tons were quarried for domestic use. The Dominion census of 1871, gives only the quantity exported, viz., 96,544 tons. It may, however, be assumed that the quantity used for domestic purposes has not decreased. This would make the total quantity quarried in Nova Scotia, in 1879, about 150,000 tons. Mr. Hunt gives the quantity raised in England, in 1878, at 74,908 tons, valued at £22,472.

The writer thinks that the foregoing, necessarily imperfect, account of an important Canadian mineral may prove of interest, and that, if of no other value, it may indicate where unlimited quantities of a valuable agricultural material can be procured, should at any time the progress of invention and discovery allow its introduction into England.

The **President** said, he was sure they would all be willing to record the obligation they were under to Mr. Gilpin for his very interesting communication. There were several points in it, however, which would certainly admit of considerable discussion. Foremost amongst these was the alleged position of the gypsum in the strata of Nova Scotia, which was certainly an uncommon one, and not in accordance with the experience of geologists in this country. The writer made statements as to some of the uses to which gypsum was put, but had omitted one or two others. For instance, gypsum was made use of to make cotton heavier, and sometimes it was used to adulterate food. As to the question in relation to geology, he would be very much obliged to Mr. Lebour if he would state his views, for he did not know of any gypsum in England out of the new red sandstone.

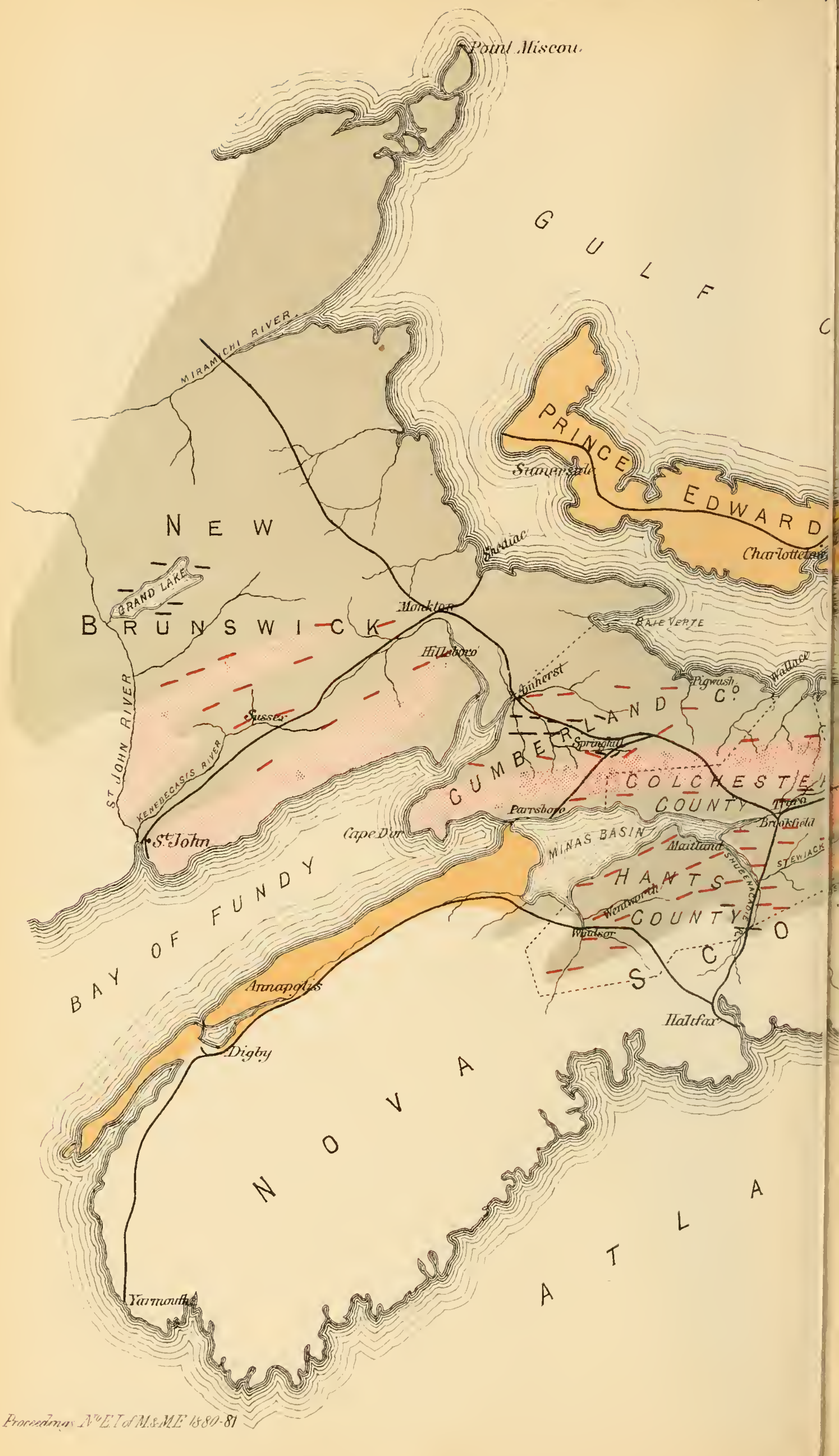
Mr. **Lebour** said, that in Britain most of the gypsum certainly occurred at much higher horizons, but they had it in small quantities in older beds. They had it in the Old Red Sandstone in Scotland, and in the Silurian of Scotland, but he did not know of any so low down either in Wales or in England. With regard to the Nova Scotian Carboniferous beds, it had been held for many years that the whole series of those deposits have in them very many Permian characteristics. They had in a large part of the Carboniferous series, in the north-east of America, a very marked representation of the passage from the Carboniferous to the Permian series. Mr. Gilpin noticed the occurrence of certain fossils which in this country were only found in the Carboniferous Limestone; but he (Mr. Lebour) did not think, at such a great distance as that, it was at all fair to attempt to synchronize deposits by fossils only; for it was possible that those mentioned had been deposited while Permian beds were being deposited here. The term Permo-Carboniferous, suggested by Dr. Dawson, was an excellent one, descriptive of the theory he (Mr. Lebour) alluded to—that many of the so-called Carboniferous rocks of Nova Scotia and Newfoundland were really the representatives of the time which elapsed between the Carboniferous series of this island and the Permian; in fact, they were the representatives of the gap which existed in England between the two series. He would not say they were lower, but he thought they were. In Spain there were gypsum works going on in rocks of undoubted Carboniferous age, and he believed in other parts of the continent, gypsum was also found in rocks of that age; but, as a rule, Mr. Gilpin was right in stating that such cases were rare.

Mr. E. F. **Boyd** said, that the author of the paper had suggested much which ought to be carefully considered. Dr. Dawson's idea as to the formation of the gypsum from the quantity of sulphuric acid emanating from volcanoes, if an actual fact, would to a large extent account for the amalgamation which had produced thin beds of gypsum; but when they came to beds of 100 feet in thickness, it was difficult to refer them to a liquid converted into rock by extra pressure and heat. He proposed a vote of thanks to Mr. Gilpin for his paper.

Mr. LEBOUR seconded the vote of thanks and it was unanimously agreed to.

The meeting then terminated.

To illustrate Mr Edwin Gilpin's



Proceedings Nº E. I. of M. & M. E. 1880-81 per "On the Gypsum of Nova Scotia"

SKETCH MAP.

Approximate distribution of the

CARBONIFEROUS SERIES OF
NOVA SCOTIA & NEW BRUNSWICK.

🟧 *Post-Carboniferous*

▨ *Carboniferous*

🟥 *Pre-Carboniferous*

— *Gypsum Beds*

— *Coal Beds*

Andw Reid, Newcastle

PROCEEDINGS.

GENERAL MEETING, SATURDAY, DECEMBER 4TH, 1880, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

WILLIAM COCHRANE, Esq., Vice-President, in the Chair.

The Assistant-Secretary read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were elected :—

Associate Member—

Mr. John Morison, Newbattle Collieries, Dalkeith.

Students—

Mr. Septimus Heslop, Urpeth, Chester-le-Street.
Mr. Frederick J. Ferens, 220, Gilesgate, Durham.
Mr. Henry G. Pringle, Tanfield Lea Colliery, Co. Durham.

The following were nominated for election at the next meeting :—

Associates—

Mr. Thomas Reader Smith, M.E., Rockingham Colliery, near Barnsley.
Mr. Edward J. Wardle, M.E., Craghead Colliery, Chester-le-Street.

Students—

Mr. Arnold Pike, Silksworth Colliery, Sunderland.
Mr. J. Greig, Brancepeth, Durham.

The following paper "On Boiler Accidents and their Prevention," Part IV., by Mr. D. P. Morison, was read :—

ON BOILER ACCIDENTS AND THEIR PREVENTION.

By D. P. MORISON.

PART IV. AND CONCLUSION.

ON THE CONSTRUCTION OF BOILERS.

In this, the concluding section of the writer's remarks, he desires to notice those points of *boiler construction* which might tend to occasion or to prevent accidents, rather than the general mechanical scope of the subject, which has already been so ably handled in volumes, pamphlets, and contributions to this and other Societies.

The first question which naturally occurs to a works manager is, how, with every advantage in the way of coal and labour, to obtain a boiler of which the construction shall afford every facility for rapid and regular generation of steam, and yet be safe; and the second inquiry is, to whom to look for this information. The replies to these two inquiries might occupy more space than would be available in these Transactions; but the writer suggests the following heads, under which information is practically within the grasp of every one interested in the question.

1.—OF WHAT MATERIAL SHOULD THE BOILER BE CONSTRUCTED?

Cast iron, wrought iron, steel, and copper are the materials which in various epochs and stages of steam civilisation have been employed. Cast iron and copper may be at once dismissed from practical consideration: the former on account of its unreliability and weight (besides many other apparent drawbacks), and the latter from its relative and intrinsic expense. There remains, then, to be dealt with—

(*a.*)—Malleable or wrought iron.

(*b.*)—Steel.

In both cases plates have to be made, and these have to be regulated in size by the cost attending their production, as compared with the cost of riveting them together, and also by the facility with which they may be moulded or adapted to the various shapes of boilers recommended by different engineers.

(*a.*)—Iron ; of this material, rolled in plates or sheets, of areas and thicknesses varying according to the class of boiler to be constructed, "Best Yorkshire" plates, as represented by the Low Moor, Farnley, Bowling (Plate XIII.), and two or three adjacent firms, are considered by far the most suitable for boiler purposes, for many reasons, such as their fire-resisting properties, tensile strength, regularity in contraction and expansion, freedom from blisters, scales, etc., and facility in moulding, flanging, dishing, etc. In fact the term "fibrous," which has been so much objected to as unscientific, is the term which can most correctly be applied to plates possessing these requisite qualities. In other words, "fibrous" infers all the essentials of resistance to shocks and strains, whether produced by smiths, by the incidents of daily work, or by the jointing, drilling (punching as sometimes even now resorted to in certain yards), riming, riveting, caulking, testing, or other strains. Many other species of iron are employed, Swedish and Russian, ranking first, real Staffordshire plates of the old "best best" and "treble best" brands, Shropshire, Tudhoe best, and a few Scotch makes, all of which may be reckoned good ; "Crown" plates, and "best best" of ordinary makers, and plates down so low as ship builders' plates, which, some few years ago, the writer detected being used in a boiler-yard which shall be nameless.

(*b.*)—Steel, which ranks in nature between cast iron and malleable iron, has not yet, in the writer's opinion, been constructed in plates of sufficiently uniform consistency and ductility to inspire the same confidence as the Yorkshire best plates ; but this is more a question of future test and use than of past experience. His own personal observation has not, so far, been in favour of steel ; but this may be attributed to local accident, such as inferior coal or bad water. If thickness is sacrificed for weight, as is often done in the case of steel plates, the effects of deteriorating agencies are aggravated. It might also be worthy of remark, that steel is more potently affected by changes of temperature and less liable to recover from any "shock to the system."

2.—OF WHAT FORM SHOULD THE BOILER BE CONSTRUCTED?

Space would fail to describe all the antique forms of boilers ; some of these the writer has already illustrated in Plates VI. to XIII., Vol. XXIX., they have varied from spherical to balloon, haystack, wagon, etc., now all nearly exploded (not in a literal sense), so that the consideration of the members may be mainly, though briefly, directed to the types at present in use.

1.—*The Marine Boiler.*—Plates XIV. and XV. Perhaps no class of boiler has assumed at different times such varied shapes as this. When pressures were low and quantities of coal varying from 5 to 15 lbs. to each indicated horse-power had to be burned, these boilers assumed such formidable dimensions that they had to be made expressly to suit the form of the boat they were intended to propel; at present, however, when higher pressures are used and the consumption reduced to somewhere about 2 lbs. per indicated horse-power, forms more in accordance with science are adopted, and the result has been a combination of the two forms of boiler which have been most successful on land, viz., the Lancashire and the Locomotive.

Generally a marine boiler may now be considered, as far as its outside shell and fire tubes are concerned, as of the Lancashire type, and as far as its take-up and small tubes are concerned, of the Locomotive type.

The front and back of these boilers are usually flat. The front is flanged to receive the fire tubes, and both front and back are flanged to receive the shell plates; the top parts above the small tubes are secured together by massive through stays, screwed at each end, secured by nuts and washers on each side of the plates. The centre portion of the front is secured by the small tubes, a certain number of which are stay tubes—that is, they are secured by nuts after the manner of the long stays, and the bottom portion of the front is secured by the fire tubes and by gusset plates, while the centre and bottom of the back are secured by screw stays closely placed together after the manner of the fire-box of a locomotive.

The fire tubes are mostly in rings, welded together longitudinally with flanged joints at either end, but their mode of construction differs considerably with the varied experience or caprice of the maker. The takes-up which lead from the fire tubes to the small tubes are flat-sided, and are secured to the back shell and to each other by screwed stays after the manner of a locomotive, and the small tubes are so arranged and proportioned above the fire tubes that they absorb sufficient heat from the products of combustion to reduce the inconvenience of a dry smoke-box front to a minimum. On the top these boilers are usually provided with a large dome from which the steam is taken.

2.—*The Locomotive Boiler.*—The general construction of this form of boiler is not varied nearly so much as that of the Marine type, and for carrying high pressures for periods of moderate duration under most difficult circumstances, which expose it to strains perfectly unconnected with its functions as a steam producer, it may be said to be the most perfect and safe boiler ever invented.

In one of its most usual forms, Plates XVI. and XVII., the fuel is consumed in a rectangular copper fire-box, open at the bottom and stayed in every direction to the shell, except where the tubes are connected to it, by a number of copper screwed stays very closely set together; on the top the communication between these stays and the shell is not direct but is maintained by means of strong bars of iron, which, as it were, bridge over the crown of the fire-box, and rest on its front and back edges, and these bars in their turn are secured to the shell by means of links and angle iron brackets. The back portion of the shell corresponds in shape to the fire-box which it covers, except at the top, where it is semi-circular; the remaining part of the shell which contains the tubes is a cylinder with a flat end which forms the back portion of the smoke-box. The bottom portion of this plate and the fire-box are connected by the tubes, usually made of some alloy of copper, which act as stays to both surfaces, while the top portion is strengthened with gussets, or stays, running from end to end of the boiler.

As the draught in this class of boiler is mainly produced by the action of the exhaust steam in the chimney, the fuel is urged to an intense pitch of incandescence, and the evaporative power of the boiler may be said to be enormous. Strange to say, the fire-box, although square, is the most reliable portion of the boiler, because it is accessible at all times to minute examination, and shows signs of fatigue long before it is so weakened as to become dangerous. The cylindrical portion, which cannot be so minutely examined without withdrawing the tubes, is subject to grooving and other deteriorations, from unequal expansion and from the constant jars and frequent shocks it is subject to. Of course if properly inspected it rarely gives way, but if a rupture takes place anywhere in the boiler it is usually here, the fire-box remaining intact and forming an almost safe screen from the effects of the explosion to the engine-driver who may be behind it.

3.—*Lancashire* and *Cornish* boilers, Plates XVIII. and XIX., practically represent the same system; the former having, however, two internal flues, and the latter only one. They may be fired underneath (the flues acting as return flues) or in the flues themselves, the heat being conveyed back round and under the boiler. Many different modes of communicating the power of these internal flues to the external and circulating water have been adopted, so as to utilise to the highest degree the heat of the fire. Galloway and other tubes, conical, straight, and of various forms, have been suggested and employed, and all to some extent successfully; the main idea being to keep the water in such a state of motion that it will, at some stage of its circulation, impinge upon the direct heat of the furnace.

4.—*Hawksley and Wild's* improved *Lancashire* or *Cornish* boilers, Plate XX., have been extensively examined and tested by the writer, and his experience tends to confirm what the makers claim, namely, that boiler accidents are reduced to a minimum by the adoption of their flanged boilers.

To quote the words of a reviewer on these boilers :—

> Hawksley, Wild, & Co.'s flanged flued boiler is undoubtedly one of the best contrivances yet carried out for making a strong, elastic, and safe flue. As might be expected from a study of this arrangement of flanging, it appears that while thousands of these boilers are working in various parts of the country, a good number of which have been down 13 or 14 years, not an explosion has occurred, or life, or limb, or property been injured, although on one or two occasions at least, from causes too common in boiler management, these boilers have been allowed to run short of water, and flues been red hot. On one of such occasions the ogee flange (see woodcut and *a. a.* Fig. 5, Plate XXI.) was evidently put upon its trial. With a full fire and the flues bare of water, such was the remarkable resistance to collapse, that the flanges elongated until the first flanged ring came down on to the back wall of furnace, while the seam itself stood to its circle without a rivet hole being broken. By the flange giving such extreme latitude, coming as stated above on to the furnace wall, and turning the draught out at the fire-hole door, the situation was thus discerned, and life and property saved, which, with other classes of flued boilers, it is perhaps not too much to say would almost certainly have been sacrificed.

> The Bowling hoops, thus,  were it not that they make two seams where there should only be one, as also Adamson's flange, are, like the rings, of Tee iron, good as a means of stiffening a flue, but in a case of shortness of water, as described above, they are useless, as however stiff and rigid the flue or the boiler may be, something must give way; then it is that the great superiority and safety of the ogee flue are maintained; the extra length of plate in the flange naturally in such a crisis allows the ring to bend almost double without straining the seams, which, with other flues, break, and cause explosion.

5.—*Plain cylinder* boilers, although inferior in economy of coal, possess many advantages in facility for examination and cleaning, and if constructed of good iron and fair workmanship, necessitate few or no repairs. In point of fact, where small or refuse coals are obtainable, at a price of, say, three shillings a ton, and no extreme pressure is required, the writer would not unhesitatingly condemn the past opinions of many eminent engineers in their favour. They further admit of being easily accommodated to flues of coke ovens or furnaces, and are relatively stronger and safer than any of the internally fired boilers.

6.—*Multitubular* boilers, where water is comparatively pure and free from salts or other deteriorating matters, and skilled attendance is available, are doubtless unrivalled for rapid and economical production of steam. The frequent stoppages and expenses necessitated by repairs to tubes, and the unequal strain render them, however, rather unsuitable to those to whom the writer's remarks are principally directed; but they offer many advantages in underground workings, due to the small space they occupy and the minimum of weight per horse-power of steam expended, as well as the rapidity with which steam is raised.

Messrs. Hawksley, Wild, & Co. have constructed a sectional boiler, working pressure 120 lbs. (Plate XXII.), which is made up of a number of comparatively small shells, rendering impossible explosions such as from time to time occur with large diameter boilers, yet the construction is so plain and accessible to thorough external and internal inspection and cleaning, entirely free from intricate, complicated, and dangerous parts, that it stands unique among high pressure boilers for stable working and safety from explosions and other accidents.

Similar somewhat to these are also the Roots, Perkins, and other boilers, all being a kind of compromise between the multitubular and the internal flued boilers. For ordinary colliery work, however, the advantages of simplicity of construction and facility of examination and repair have induced the writer to pass over this latter class of boilers perhaps rather too cursorily.

Having determined upon the form of boiler most likely to suit his requirements, the next question which will occur to the employer is—

3.—HOW SHOULD A BOILER BE CONSTRUCTED?

The construction of boilers forms a very wide subject to treat generally, as the demand for marine, locomotive, or stationary purposes involves so many differences as to need specific modification to meet each case.

Enormous external shells of great thickness are found prudent for marine work, which would be needless expense and risk on shore. The locomotive or portable boiler must be light as a whole, with very large evaporative surface to secure a supply of steam under ever-varying demands, without the necessity of a large store of highly-heated water, which, in ordinary boilers, conveniently provides for changing needs.

It would be well, therefore, to consider stationary boilers, as worked under ordinary circumstances. First and foremost, in every way, is the selection of the most suitable material; but here the choice must be influenced by the nature and permanence of the work to be done and the materials in the market. The very best material for boiler work can hardly be described by any one word, such as iron or steel, it must be a material containing sufficient strength to require only a small thickness to resist the strain from pressure, yet tough and ductile enough to accommodate itself to all the vicissitudes of shaping, punching, riveting, and caulking. Many samples might be given of boilers worked safely until nearly corroded away, although made of iron of no famous brand. On the other hand, modern examples might be named of steel boilers which gave way, before any steam pressure was put upon them, from the mere strain of getting up the fires. A well-known authority (D. Lenner) describes suitable material as any "stuff" which had the above qualities, and named particularly a certain material sometimes called "mild steel," but so manipulated as to be sent into the market with the strength of steel and the toughness of leather, so that a vessel of it could not be burst by rupture, but was only rendered useless by the elongation of the rivet holes and the consequent leaking of the joint, making further pressure impossible. An experimental vessel, 4 feet diameter and $\frac{1}{4}$ inch thick, was shown to the Institution of Mechanical Engineers last summer, at Barrow, under a pressure of 400 lbs., which bore out the previous descriptions of its probable behaviour. If all boilers were of such material, explosions from over pressure would be rare, except that the public would at once rely on the material and increase the pressure, so, possibly, bringing up the risk to its present amount.

It is most important to so design boilers as to leave the material as much as possible "in repose;" that is, with only a fair strain in the direction of its greatest strength without repeated side strains in addition, causing bending backwards and forwards as in a boiler or tube out of circle, and constantly struggling to assume the true circle under varying pressures. It is almost impossible to avoid the need of adjustment or accommodation in the most carefully built boiler, but the yielding material above described will give way until each part takes up its fair share, and makes the fabric as a whole secure, without, as in a harder material, one part being strained beyond endurance before it is assisted by surrounding parts. It must be remembered that a boiler is not a vessel only to resist pressure, but that it has, at the same time, to support the strains due to unequal expansion owing to its various parts being unequally heated; this produces constant movement in all its parts, which soon "over fatigues" the hard and brittle metal, but leaves comparatively uninjured the soft and ductile quality recommended.

Having secured the best material it must be put together judiciously. The exigencies of boiler work, where the shells are exposed to fire, preclude the strongest form of riveted joint, and leave only the single riveted joint practicable, on account of the danger of burning off the outside lap. The single riveted joint in soft and ductile metal is more difficult to make tight under great strain than that in unyielding iron, but it is much safer than that in the harder iron, which rips from hole to hole, often without showing it, until it suddenly parts altogether.

The simplest boilers are still very complicated fabrics, and the ponderous Lancashire double-flued boilers, with various internal cross tubes, are still more complicated ; but long experience has enabled the makers to adjust proportions and allow for expansion and alterations of shape during work, so that the whole becomes a machine upon the behaviour of which any one may calculate with tolerable certainty, while poor imitations often give great trouble because supposed improvements to add strength have destroyed the balance arrived at by experience, and too great rigidity of the ends has caused contraction between the tubes and shell, soon inducing local failure. The prevailing practice is to provide a very large margin between the working and the bursting pressures of boilers, but it is not so great as many suppose, as modern experiments on ordinary riveted joints, and joints purposely cut from boilers, show that their strength, as compared with the solid plate, is much less than that often given in books. Some recent careful experiments by the Board of Trade may be worth quoting, as embodying concisely some recent information on the subject.

In calculating the strength of a boiler made with single rivetted lap joints, some engineers erroneously adopt 56 per cent. of the strength of the solid plate, whilst others regard 34,000 lbs. per square inch as the ultimate strength of the joint, irrespective of the diameter and pitch of the rivets, or the injury arising from punching. The latter value is generally given upon the authority of Sir William Fairbairn. I have, however, a difficulty in ascertaining upon which of his experiments this value is based. Referring, however, to his "Useful Information for Engineers," First Series, page 283, it will be seen that, remarking upon the experiments he had carried out with some single rivetted lap joints having the material between the rivets equal to some solid plates, also tested, he states that the strength of the joints was only equal to 76 per cent. of the strength of the solid plate. The loss of 24 per cent. he attributes not to the metal punched out, but to the injury the plates sustained by punching, and to the effects of the form of the joint upon the breaking strain.

FIG. 1.

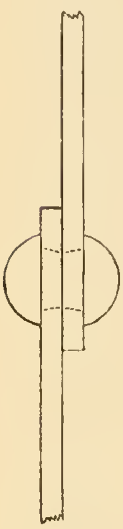


FIG. 2.

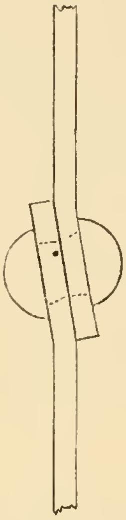
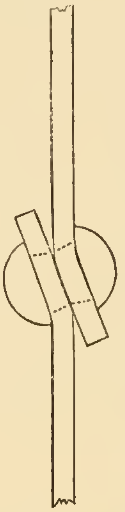


FIG. 3.



When a single rivetted lap joint is tested to destruction it is found that the joint does not retain the form in figure 1, but first takes that in figure 2, and finally, if the plate is ductile, that in figure 3; the result is that the metal at the weakest part is subject to cross-breaking, and gives way at a lower stress than a straight plate of equal section. It is to this cross-breaking action, and the injury to the plate caused by punching, that the loss of 24 per cent. is to be attributed. Sir W. Fairbairn remarked that, in addition to this loss, there is the loss of strength due to the material actually punched out. In this boiler, one the reviewer has described before, this is 44 per cent., which, deducted from 76 per cent., leaves the strength of the joint equal to only 32 per cent. of the solid plate. In some experiments which were made about two or three years since with single rivetted lap joints, made of plates of about the same thickness as those in the exploded boiler, the loss due to the punching and the effects of lap jointing was found to be about 19 per cent. Adopting this as the loss of strength, so as not to err on the severe side, we have the value of the joint in the boiler as compared with the solid plate equal to only 39 per cent. The mean tensile stress of the lower shell plates tested in the direction of the strain on the longitudinal joints of the boiler, and which broke at sound parts, is 19·04 tons per square inch. Taking 39 per cent. of this gives 16,633 lbs., or less than half of 34,000 lbs., which is thus shown to be far too high. With the value of 16,633 lbs., we find, by the usual calculation, that the bursting pressure of this boiler for plates $\frac{3}{8}$ inch thick was only about 104 lbs. per square inch. As one wide plate where fracture occurred was, however, reduced by corrosion at the rivet holes, the bursting pressure through this part would probably not exceed 88 lbs. per square inch.

These pressures are calculated upon the assumption that the material is only subject to the strains arising from the pressure inside, and that its strength is not reduced by overheating or other causes. Even under such conditions the ratio of the bursting pressure to the working pressure of 88 to 41, or about 2, is far too little. The boiler, however, did not work under these conditions. The plates were subject to considerable heat, and to the strains arising from differences of expansion caused by intense heat playing first on one side and then on another, and again to the effects of occasional sudden blasts of cold air as the iron was charged or withdrawn from the puddling furnaces. Under these circumstances, the bursting pressure of the boiler when at work must have been less than stated above, and the margin or factor of safety less than 2; to what extent, however, it is difficult to say, although the effects of the causes I have mentioned are known to be often very great.

Persons not well acquainted with the strength and properties of metals are sometimes apt to wonder why the bursting pressure of a boiler being stated to be, say 88 lbs. per square inch, should have burst at a lower pressure. Sometimes the plate may be injured, and the boiler may come under the influence of strains which it is impossible to calculate, and which are sometimes overlooked. There is, however, another reason. The bursting pressure alluded to is that which suffices to burst the boiler upon the first application; the pressure, of course, being applied slowly. A smaller pressure, if above a certain limit, would, however, burst it, if continuously or frequently applied, owing to the destructive effect of overstraining upon the material. To allow for this, for corrosion, defects in the plate, etc., and strains which cannot be calculated, the best authorities recommend that in steam boilers the working pressure shall, according to circumstances, be *from one-sixth to one-fourth* of the bursting pressure.

It is not expedient to give here the details of proportion of rivets, holes, pitch or lap, such as would be suitable for a boiler maker's manual, and derived from what has been done in the acknowledged best practice.

The real and true principles involved in vessels with riveted joints are certainly not settled and are still open to considerable discussion.

It is comparatively easy with unlimited means to lay down a set of boilers where the risk will be at a minimum, but the problem is seldom so simple as this; for in some cases the means are crippled and in others space is an object, or waste heat from some manufacturing process has to be made use of, and then perhaps the feed-water is middling, and would destroy the best material at such a rate as to be unsuitable for any but the simple plain cylinder boiler.

The purpose for which the steam is needed may not be permanent, so inferior boilers may last long enough; but, unfortunately, in this case they are often purchased without due examination, and worked after having become unfit for further service.

Closely following on good manufacture of boilers, is judicious repair. Repair too often weakens a boiler far more than is supposed. It is nearly impossible to adjust the new work so as to take its proper strain, owing to new plate generally yielding more than old, so that a much-repaired boiler becomes a very treacherous machine and often deceives the most experienced. After a certain amount of repair each patch is one more weakness.

GENERAL SUMMARY.

The writer has progressively found the impossibility of reducing within reasonable compass the varied and complicated problems which the too comprehensive title of his paper would include; but he will not consider even this a matter of regret if the various heads in which he has sub-divided his subject should elicit from other members of the Institute more detailed expressions of opinion on any one or more of the points of interest.

These may thus be briefly recapitulated :—

1.—Is extraneous inspection desirable?

2.—Should this inspection be undertaken by Government or by private firms?

3.—Should assurance be combined with inspection?

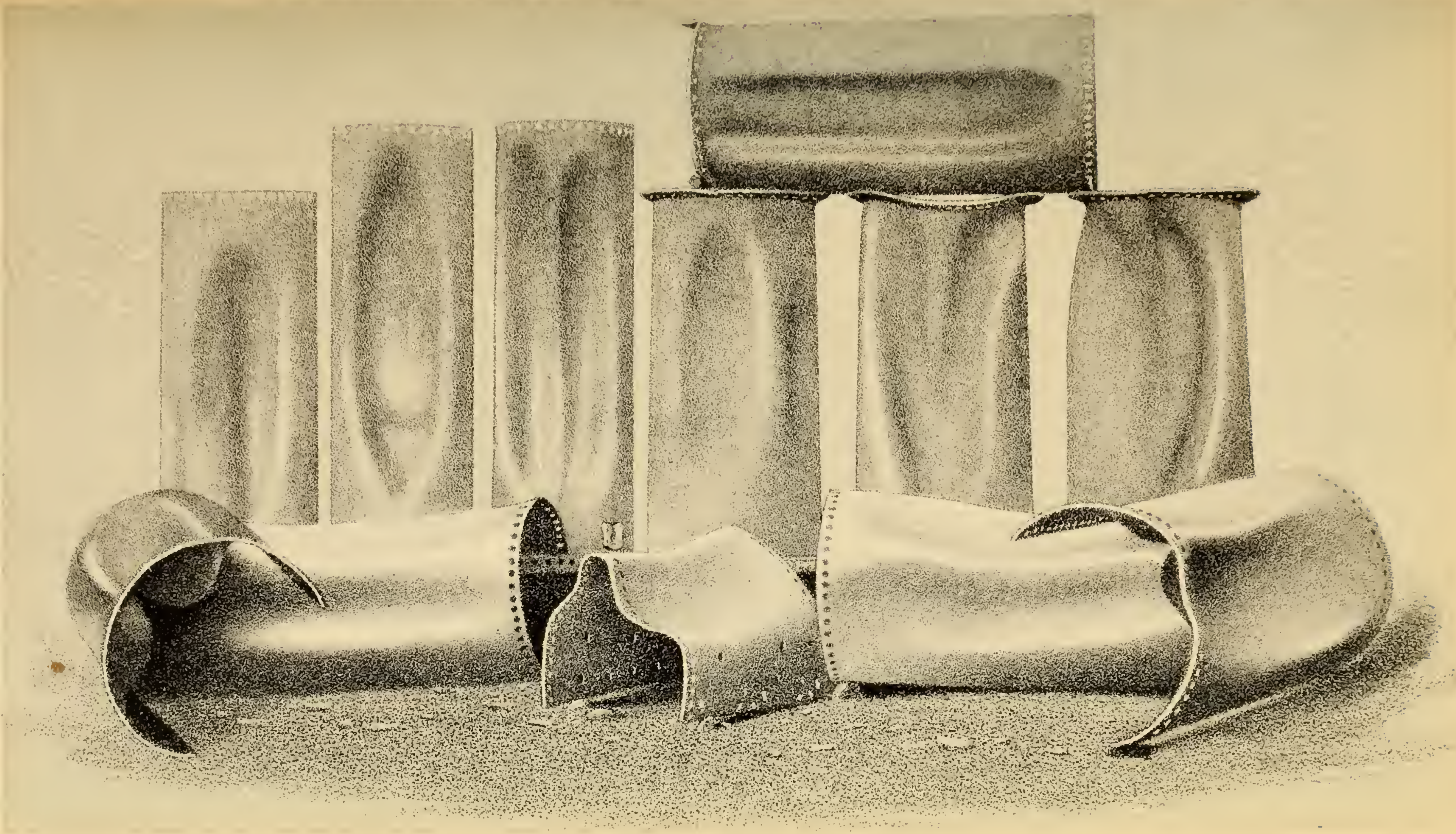
4.—What improvements can be effected in the heating of boilers?

5.—Of what material should boilers be constructed?

6.—Of what form should they be?

7.—How should their construction be carried out?

Any one of these topics treated singly, would of itself afford scope for much theory and still more practice, and the writer trusts that the opening

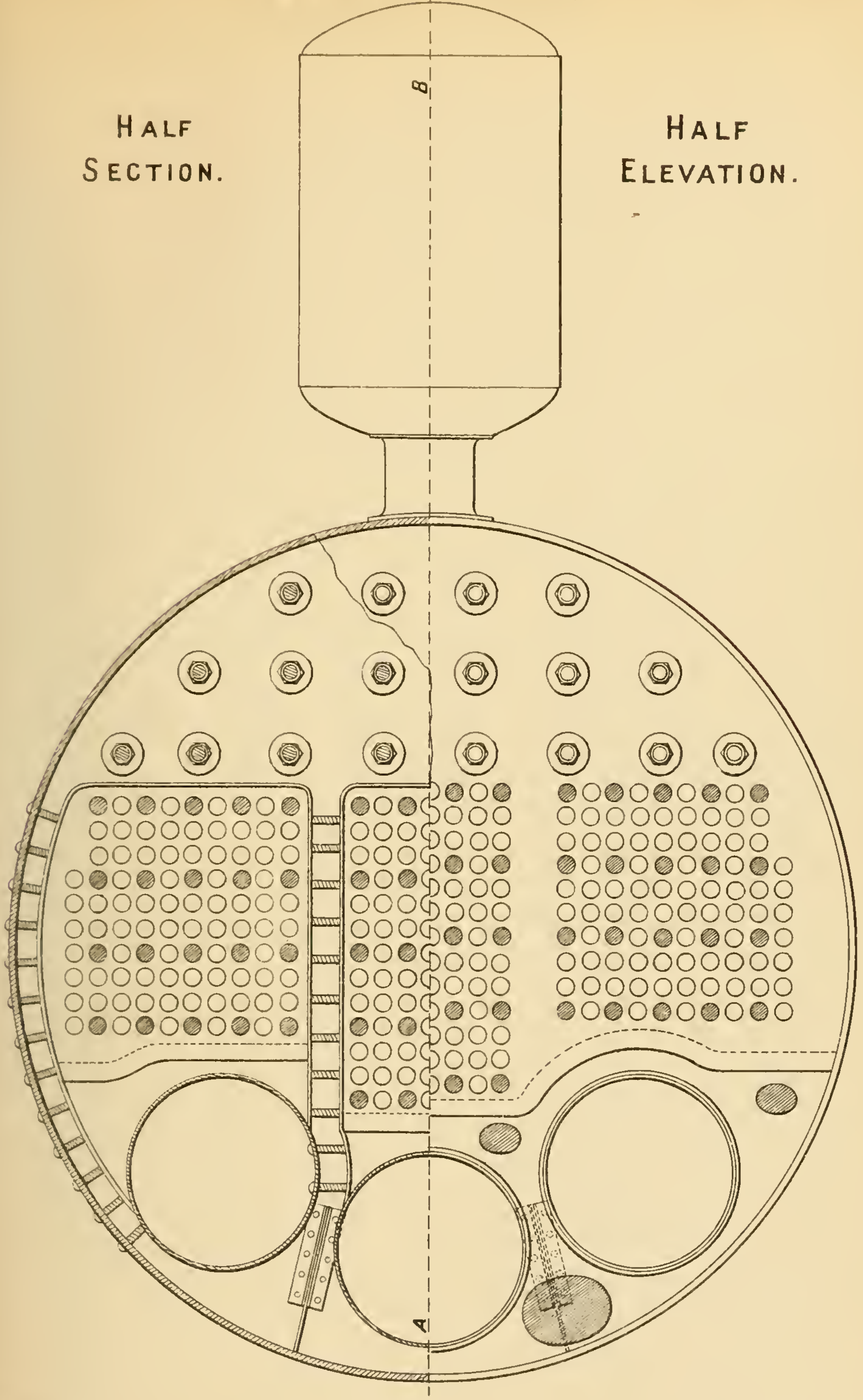


SAMPLES OF BEST YORKSHIRE (FARNLEY) TUBES COLLAPSED WITHOUT DAMAGE.

Andw Reid Newcastle

To illustrate Mr. D. P. Morison's paper "On Boiler Accidents and their prevention."

MARINE BOILER.



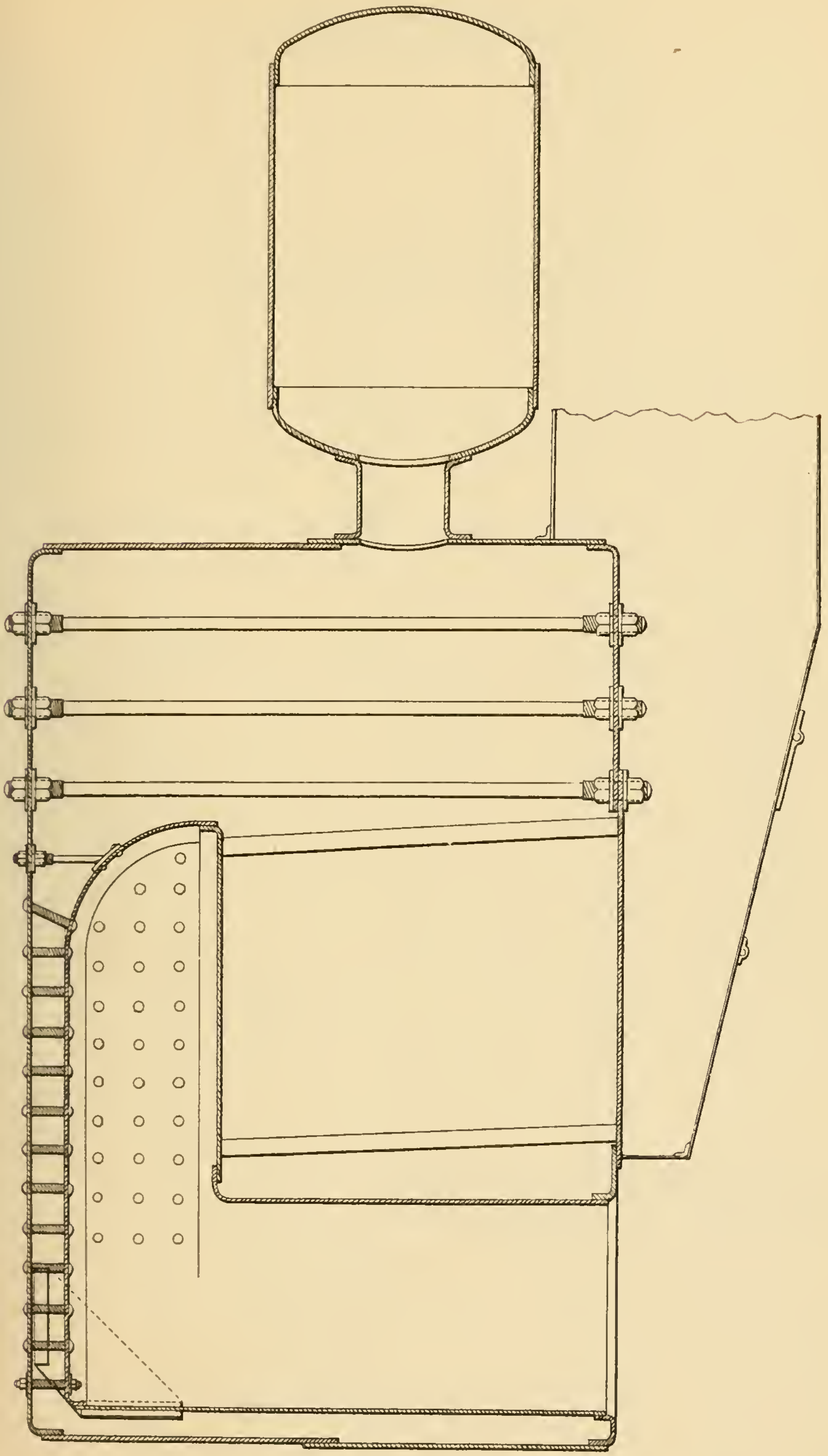
BOILER SHELL – WORKING PRESSURE 75 POUNDS PER SQUARE INCH.

Shell plates 1" Thick.
Horizontal seams triple riveted 1¼ rivets 4⅞ pitch, drilled holes.
Circumferential seams single riveted at ends of Boiler 1¼ rivets 2½ pitch,
centre seam double riveted 1¼ rivets 3¾ pitch, punched holes.
Dome plates ½ thick.
Dome single riveted, 1 rivets 2½ pitch, Front & Back single riveted, 1⅞ rivets 3 pitch.

Andw. Reid Newcastle

To illustrate Mr D.P. Morison's paper "On Boiler Accidents and their prevention"

MARINE BOILER.



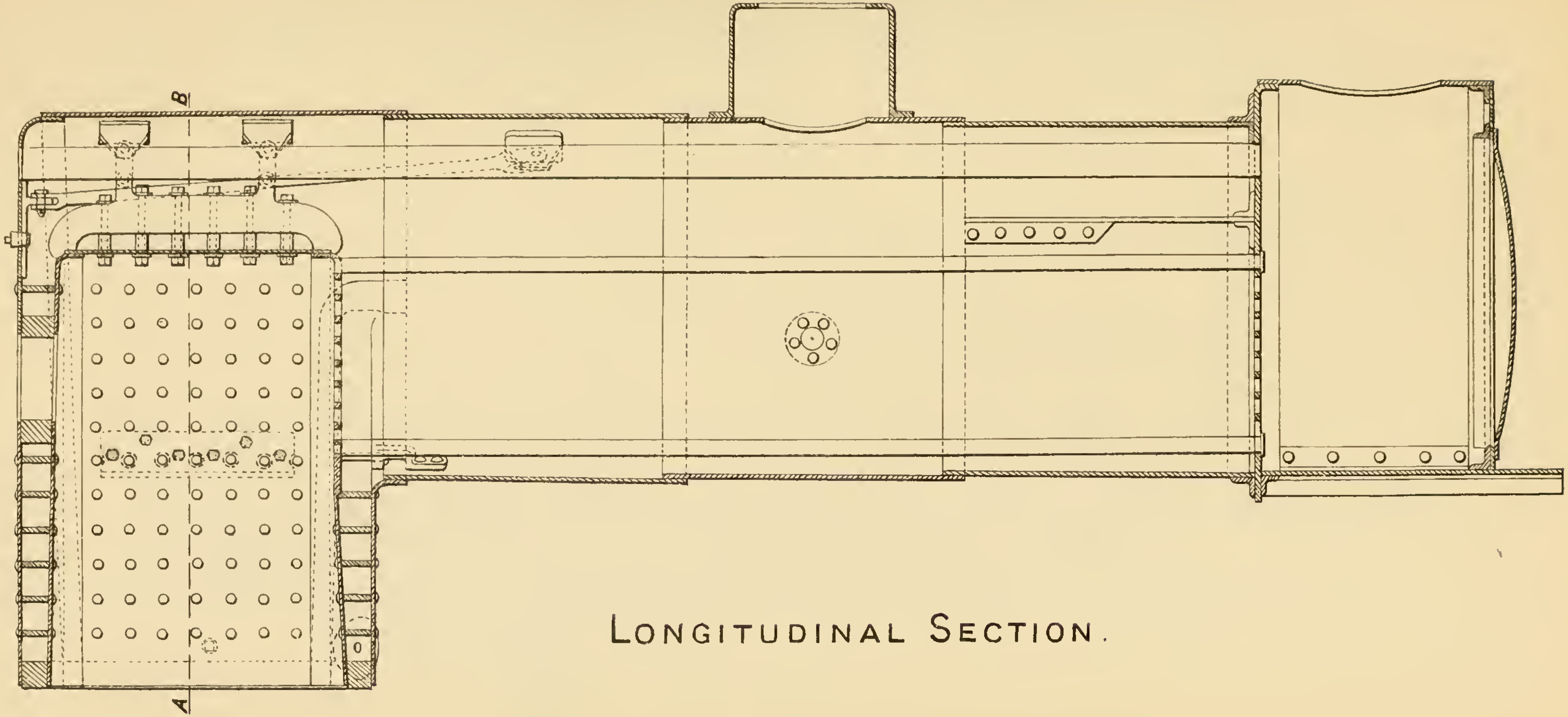
LONGITUDINAL SECTION ON LINE A.B. *Plate XIV.*

Proceedings N. E. I. of M. & M. E. 1880-81

Andw Reid Newcastle

To illustrate M^r. D. P. Morison's paper "On Boiler Accidents and their prevention."

LOCOMOTIVE BOILER.



LONGITUDINAL SECTION.

Proceedings N. E. I. of M. & M. E. 1880-81

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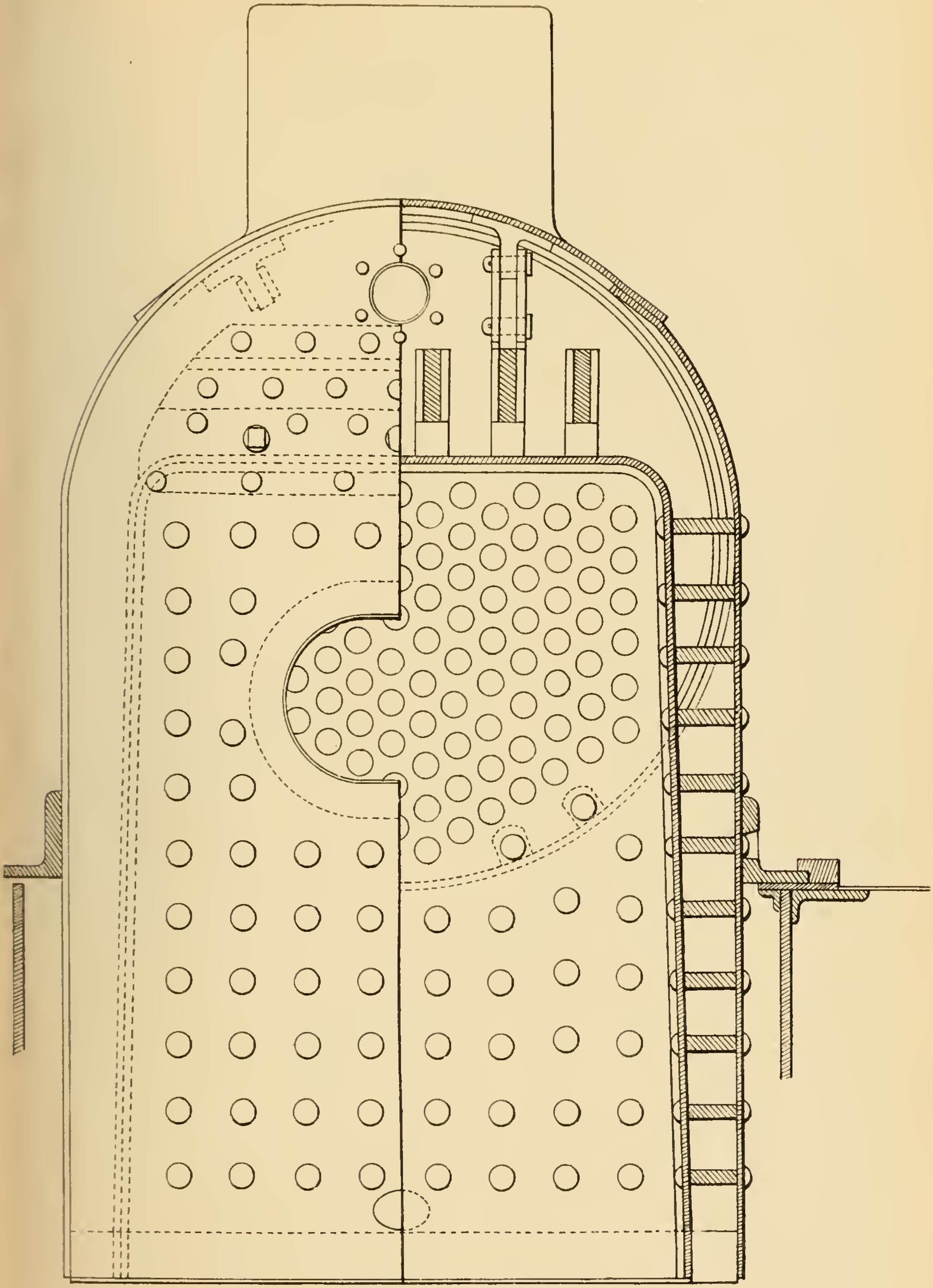
LOCOMOTIVE BOILER.



HALF END
ELEVATION.

HALF SECTION
ON LINE A.B.

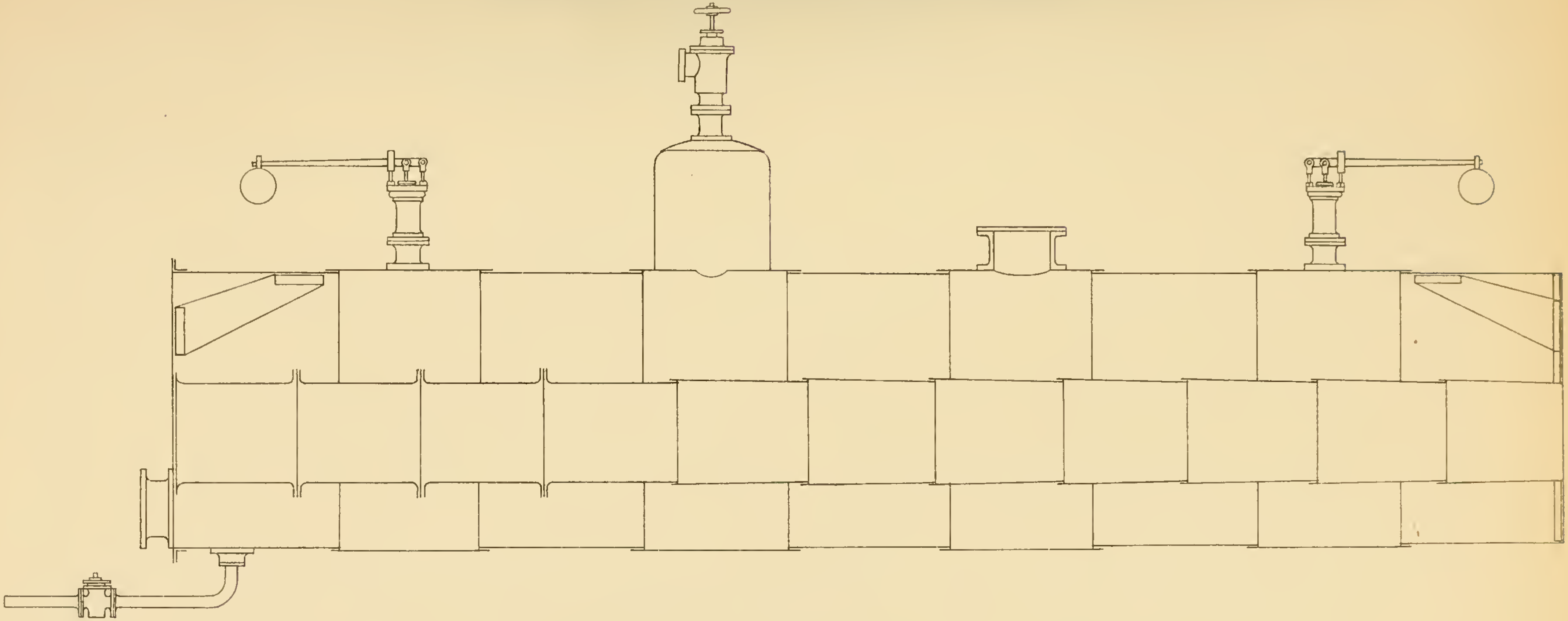
Plate XVI.

Proceedings N.E.I. of M.& M.E. 1880-81

Andw Reid, Newcastle

To illustrate Mr. D. P. Morisons paper "On Boiler Accidents and their prevention."

LANCASHIRE OR DOUBLE FLUED BOILER.

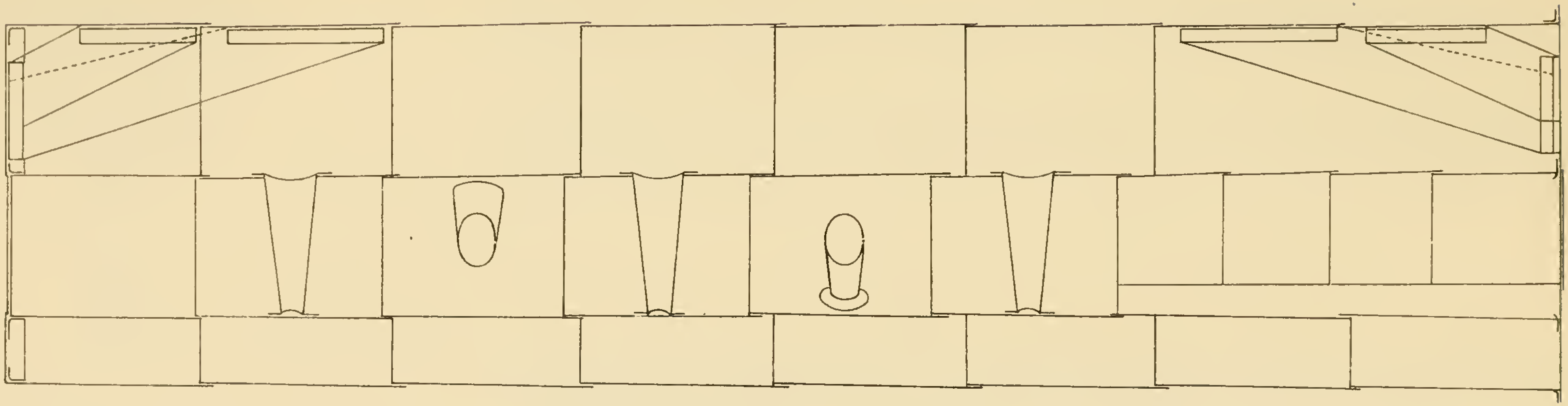


SIDE ELEVATION.

To illustrate Mr. D. P. Morison's paper "On Boiler Accidents and their prevention."

LANCASHIRE OR DOUBLE FLUED BOILER WITH GALLOWAY'S TUBES.

GENERAL ARRANGEMENT.

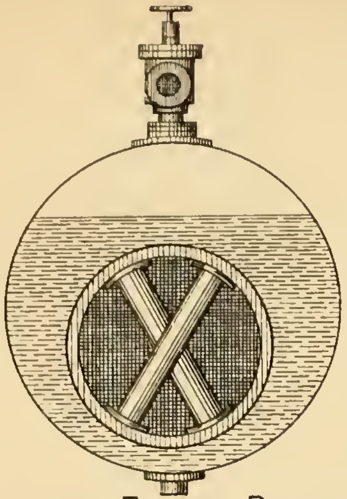


CROSS SECTION.

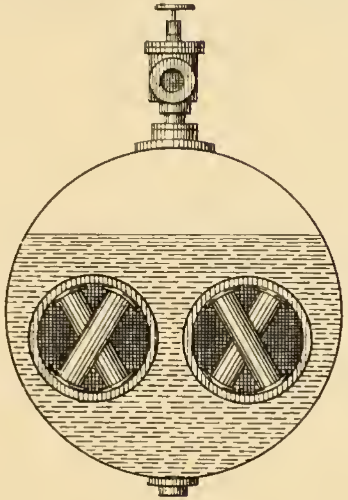
Andʷ Reid Newcastle

To illustrate Mr. D. P. Morison's paper "On Boiler Accidents and their prevention"

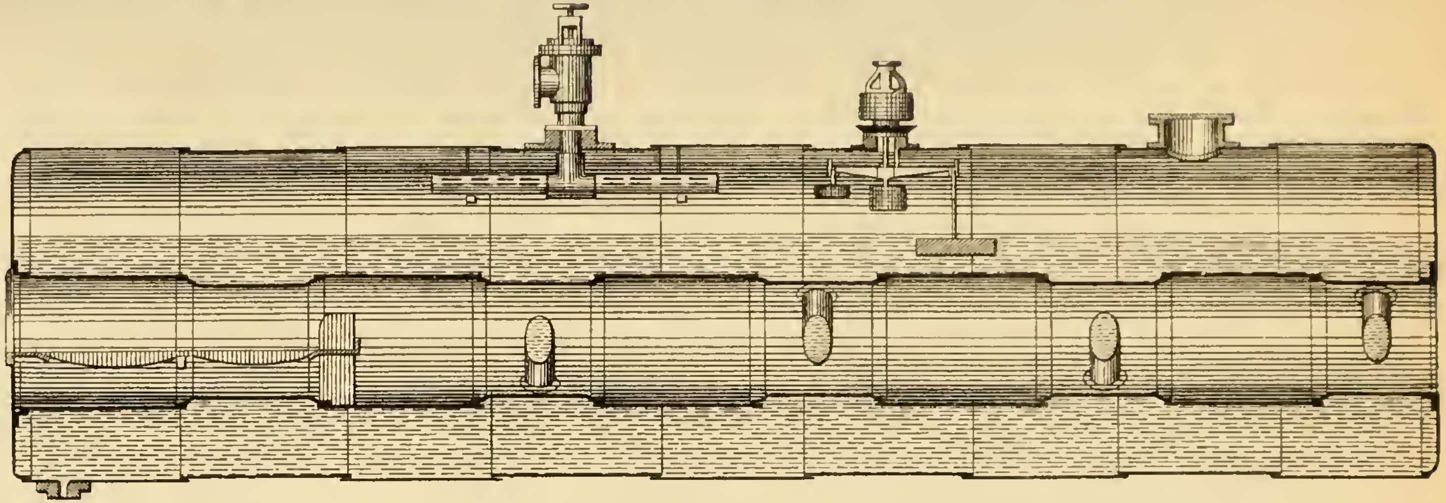
HAWKSLEY, WILD & Co's FLANGED FLUED BOILERS.



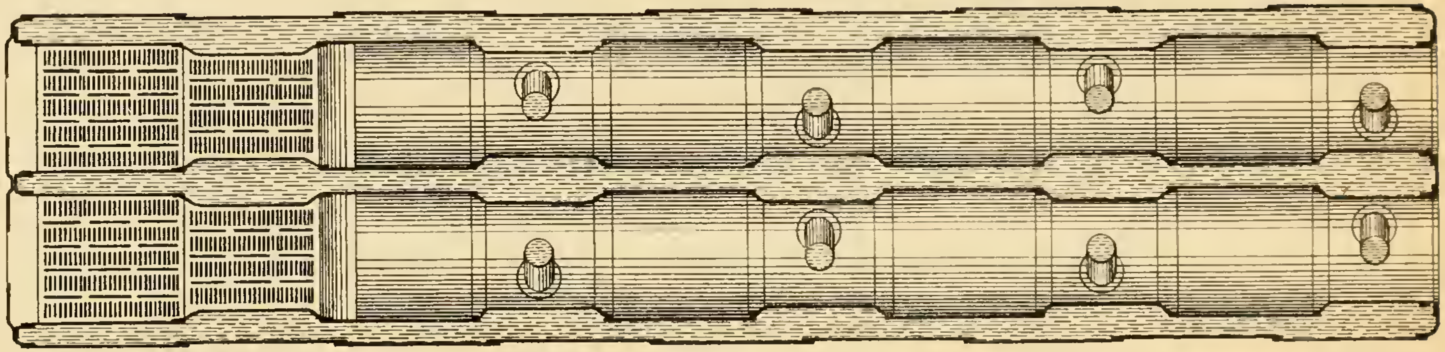
SINGLE FLUED BOILER.



DOUBLE FLUED BOILER



LONGITUDINAL SECTION OF DOUBLE FLUED BOILER.



SECTIONAL PLAN OF DOUBLE FLUED BOILER.

[illegible] Newcastle

To illustrate Mr. D. P. Morison's paper "On Boiler Accidents and their prevention."

OVERHEATING
ORDINARY FLUED BOILERS.

FIG I.

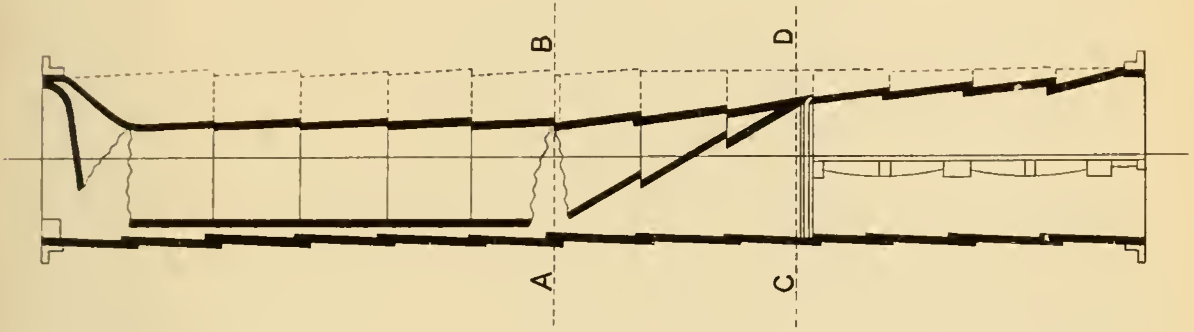


FIG. 2
END ELEVATION.

FIG. 3
SECTION AT A.B.

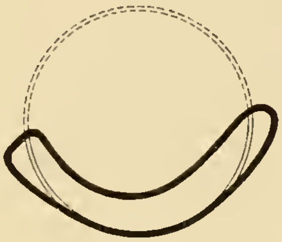
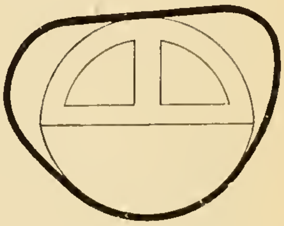
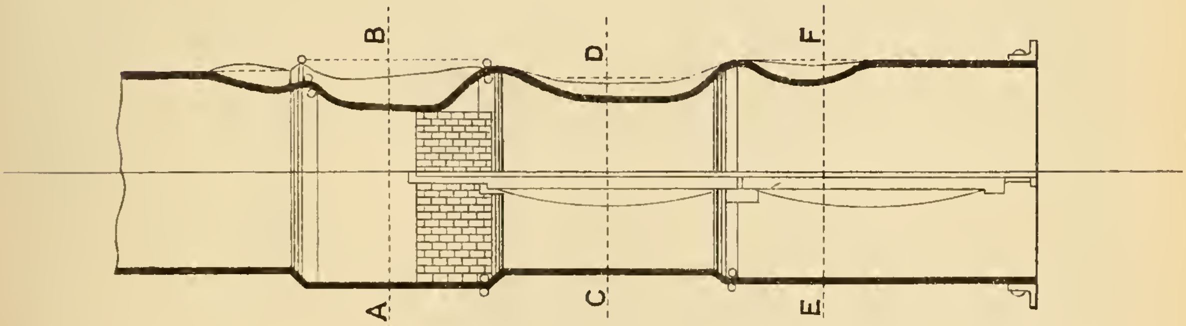


FIG. 4
SECTION AT C.D.

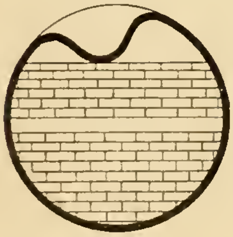


OVERHEATING
HAWKSLEY, WILD & Co's FLANGED FLUED BOILERS.

FIG. 5

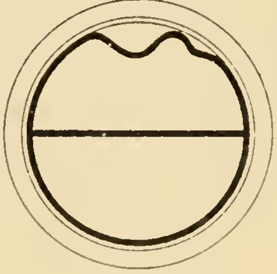


SECTION AT A.B.
FIG. 6



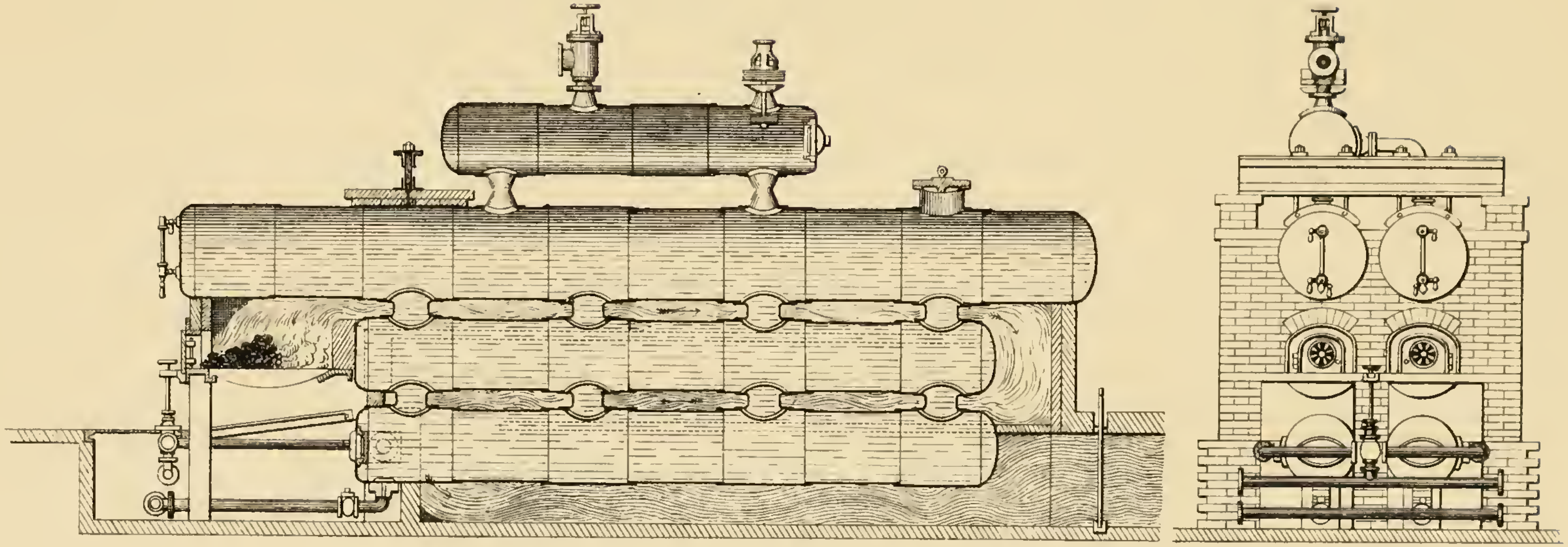
SECTION AT C.D.
FIG. 7

SECTION AT E.F.
FIG. 8



Andw Reid Newcastle

To illustrate Mr. D. P. Morison's paper "On Boiler Accidents and their prevention."



HAWKSLEY, WILD & C^os.

SAFETY STEAM BOILER, WORKING PRESSURE 120 LBS. P. SQ INCH.

Andw Reid Newcastle

thus made by him may be wedged out by others into a series of technical and useful contributions to the Transactions, and concludes with the following extract from the writings of Sir William Fairbairn:—

> It has ever been the province of the philosopher and man of science to investigate and elaborate, for the good of mankind, all those physical and mathematical truths which bear upon the wants of civilized society, and the development of those laws which through a succession of ages have been handed down to us. These truths have been still further extended by the inventions and discoveries of the mechanician and those men of practical science whose lives have been devoted to the pursuit. To the researches and labours of those benefactors of the human race, we are indebted for most of the comforts and enjoyments we now possess; but these are of no avail unless properly used, and carefully managed; and it is to the management of one of these ingenious discoveries—the safe and economic production of steam—that I would, in conclusion, direct your attention. To the combined discoveries and inventions of the mechanic and man of science we are indebted for the steam-engine; and it remains with the possessor to determine to what extent he will make it safe and efficient, for in the management of so docile and so powerful an instrument depends its security as well as its effect.
>
> In the faithful discharge of this very important duty, many circumstances concur to render the uses and appliances of steam-power profitable and secure; and I will avail myself of this opportunity to enforce upon your consideration the following suggestions, which, if carried into effect, will doubtless secure to the owners the most important and satisfactory results.
>
> In the steam-engine the boiler is the source of all power, and the quantity of work performed depends upon the quantity of water evaporated, and the quantity of fuel consumed.
>
> Its generative powers, and the way in which those powers are used, are therefore matters of considerable importance; and those who would work with economy will require to attend to two things—the perfect combustion of the fuel on the one hand, and the transmission as well as the retention of heat on the other. In a well managed concern we never hear of safety valves and feed pumps being out of order, there is no tampering with such vital organs of safety; everything is in its place, and the self-acting moveable parts of the apparatus, such as valves, stuffing boxes, and bearings, are kept in the most perfect order, well oiled and cleaned, so as at all times to be ready and fit for service. In the steam-engine also the same regularity and system of management are preserved, and the result is a ponderous piece of machinery working with a degree of precision at once the admiration of the employer as it is the pride of the engineer.

The CHAIRMAN said, they were very much obliged to Mr. Morison for the great care he had taken in compiling the four comprehensive and valuable papers on boilers, of which that now read was the last.

Mr. J. A. G. ROSS asked if he was right in understanding that Mr. Morison wished it to be supposed that double riveting did not add to the strength of a boiler. If so he should be glad to have some further explanation, since this opinion seemed somewhat at variance with the experiments of Fairbairn and others, which he thought went to prove that single-riveted joints did not present sufficient crushing surface in the rivets, which defect was remedied by double riveting; for boilers generally gave way from the weakness of the rivets and not from that of the plates.

Mr. A. L. Steavenson asked why best Yorkshire plates were the only plates mentioned for making boilers? In the North of England three-fourths of the boilers were made of other brands, one of which, the Weardale, made from the best ores in England, was, he thought, equal to any iron produced.

Mr. Morison said, that Mr. Ross had scarcely caught the spirit of his remarks, which meant that he did not insist upon double riveting except in cases where extra pressure was required, when it was unquestionably of great use; but he thought that at ordinary working pressures double riveting had, if anything, a tendency to increase the probabilities of the plates not being of uniform strength. In reply to Mr. Steavenson, he certainly would not like to say that best Yorkshire was the only plate that boilers could be made of; he only instanced best Yorkshire as a sample of the plates that would stand best; and if boiler makers could afford to use nothing but best Yorkshire plates, no doubt they would do so; but as these plates were about double the price of other brands, they were only used over the fires, and not always even there. He believed that some of the local plates were formerly equal to best Yorkshire, but they were not so uniform in quality. Some of the boilers which had been at work for forty or fifty years, although exceedingly cheap, were made of plates better than those now obtainable. The plates they bought now were either not so well rolled, or the iron was not so carefully prepared as in past times.

Mr. W. Green asked, what was the average age of the boilers which were going now? He recollected an Inspector saying that some of the boilers made thirty years ago were better than others made at the present time, and that bore out what Mr. Morison said.

Mr. Morison replied that he knew of some boilers in this neighbourhood which by report were eighty years old. The average, however, would not exceed fifteen to twenty years. He hoped that in this discussion the advantage of drilling over punching would come out strongly.

A unanimous vote of thanks was then accorded Mr. Morison for his valuable paper.

The paper on "Jefferson's Automatic, Free-Falling, Hydraulic Boring Apparatus" was then discussed.

The CHAIRMAN remarked, that he had not read the paper through, but in the last clause the writer said, "although the design has not been actually tried, yet as it is a combination of methods which have been in actual use, the inventor believes that he has warrant for stating that it would be found cheaper than any existing method, and second only to the Diamond Rock Drill in speed." This was subject for regret as difficulties always arise in practice. The principal feature of the invention seemed to be forcing water down outside the bore rod, and then up through the centre of the bore rod, instead of forcing it down through the rod and up between the rod and the side of the hole. Mr. Jefferson was present, and perhaps would like to make some remarks.

Mr. JEFFERSON said, that in opening the discussion the Chairman had pointed out what was certainly a very great difficulty in arriving at a conclusive decision as to the practical merits of the apparatus, namely, that it had not been at work; but the apparatus had only been invented a short time, and borings were not commenced every day, therefore it was difficult to get it tried. He had not patented the apparatus because he did not think that any one system was in all cases the best, but that the choice of apparatus should depend greatly on the character of the strata to be passed through. The arrangement he had brought before them readily allowed of a variety of tools being used at the bottom of the two-inch piping, and either a rotatory or percussive action of the tool being employed. The apparatus could readily be removed, and the ordinary grappling tools attached in the case of breakage, whilst a breakage of the rods was often fatal to the Diamond drill. He considered there were three principal parts in this apparatus. First, there was what they knew as the free-falling arrangement; the second was the mode of producing rotation; and thirdly, there was the current of water down the outside and up the inside of the rod. This free-falling arrangement was not exactly new, but was a modification of one invented by Degousée thirty or forty years ago, which had been tried and found to work very well in practice. The arrangement for producing rotation is an arrangement which is common in all boring machines for hand-boring; and the use of a current of water down the outside of the apparatus and up the inside was one which had been extensively used in Germany; he had seen it in use there himself bringing up pieces of rock from one to one inch and a half long and one inch thick. With regard to the details, the shoe was shewn attached by a screw, but he thought it would be better to have the upper part of the shoe turned taper, and fastened with a cotter. In Plate XLVI., Vol. XXIX., the apparatus was arranged for boring continuously, but this was not necessary. They could tell almost immediately by the rods when passing from any other strata into coal, and for ordinary use he would suggest that the chisel should go right across the borehole, and not as shown in the plate.

The CHAIRMAN said, that with respect to the last suggestion, he would ask what diameter of hole an apparatus like the one under discussion would be capable of boring, so that the whole of the *debris* should be washed up from the bottom. He was informed by his friend Mr. Bewick that the Diamond Borer was not always to be relied upon in getting up a core when going through coal, and he wished to know from Mr. Jefferson if there would not be the same difficulty with the new borer. He would also like to have some particulars as to the cost of boring.

Mr. LEBOUR said, he could confirm the Chairman's statement as to the Diamond Boring and its occasional faulty indication with respect to coal. He had a strong proof of that two years ago, when he delivered a lecture on "Coal and Coal-getting" at the annual congress of the Gas Managers' Association. He happened to mention that in boring with the Diamond apparatus, in some cases coal had been gone through with little or no record of it, and this, he thought, might be attributed to the action of the water. That lecture was fully reported in a good many papers, and he afterwards received a letter from an official of the Diamond Boring Company on the subject. He had praised the Diamond Boring system very much in the course of his lecture; for this his correspondent thanked him, but added that he was very sorry for what he (Mr. Lebour) had said as to the defects of the system when recording coal, and stated that whenever they came to coal they ceased boring with the Diamond and used the ordinary apparatus. The writer of the note also remarked that experienced borers knew by the touch of the rods what they were going through to a certain extent. The depth indicated by the cores and *debris* raised by the Diamond apparatus was very great in the Sub-Wealden boring, which was sunk with the greatest care; but there, owing to the large amount of soft rock and clay, it was found that, on the average, for every 15 feet of rock bored through, they got only 14 feet of core. With that before them, they had a proof that the process was not a perfect one whenever they got to soft, and especially light, rock.

Mr. MORISON said, that with respect to boring and detecting coal by the ordinary hand-process, it used to be a kind of superstition among the old North-country borers, that they could always tell when they touched coal, because the *debris*, sand, or mud, sank immediately to the bottom of the hole, but he did not find this always a fact. In one case, 3 feet of coal was entered in the boring book as 10 inches of sand. He did not think they could rely upon the bore-rods alone for knowing what they were going through; but both the Diamond Borer and the invention of Mr. Jefferson would certainly give more reliable results than could be obtained by the old process.

Mr. T. J. Bewick said, that so far as the Diamond Borer was concerned, the percentage of cores depended very much upon the nature of the strata. The Sub-Wealden boring mentioned by Mr. Lebour was certainly a good example; but in passing through coal the core as a rule was more than what he had indicated. It depended upon the size of the hole put down, which, with the Diamond Borer, might easily, he believed, be made so as to give a core of from 10 to 12 if not 14 inches in diameter. In ordinary rock the average brought up was sometimes as much as 95 per cent. of the depth bored. They could distinguish when passing through some kinds of coal with comparative correctness, but if the coal was soft no apparatus could indicate with accuracy its thickness by the *debris* raised, because it got mixed with sand. What this apparatus of Mr. Jefferson's could do it was impossible to say.

Mr. Lebour said, the instance he gave of the Sub-Wealden boring in the South of England was confessedly a very extreme one, as it was chiefly in clay and soft rock, and would not apply to the strata of the North, which were chiefly compact shale and hard rock. He could agree with what Mr. Bewick said as to Diamond boring.

Mr. Merivale said, a hole was being put down near Port Clarence by Messrs. Bell Brothers, for salt. The Diamond apparatus started away at 26 inches diameter, which was reduced now to about 16½, and they were losing about 10 per cent. of core. It is almost entirely through red sandstone. It did not seem very friable, but he had only observed the cores from the hard rock.

The Chairman said, they had been told that some time ago an agent of the Diamond Company said that when they came to coal they abandoned the idea of getting a core. Could Mr. Bewick tell them if this was so now?

Mr. Bewick said, that was not so, they always exercised the greatest care in securing cores of coal. As soon as they thought they had reached the coal the quantity of water was materially reduced, or perhaps the boring was continued dry with the view of getting the whole of the coal out, but he did not know what success had attended recent efforts.

There had been many inventions to bring out a solid core when boring through coal.

Mr. Lebour said, he received his information from Mr. Vivian.

The Chairman invited Mr. Bailey, Jun., who was not a member of the Institute, to speak on the subject.

Mr. T. H. Bailey said, that at the Perry Sinking near Birmingham, the Company had within the last three years put down a hole with the Diamond Borer. They commenced with a 7-inch hole terminating with a 4-inch, at a depth of 1,700 feet, but at that depth the boring-rods unfortunately broke in the casings, and they were unable to recover them, so the scheme was abandoned. From the whole depth they obtained only 1,100 feet of core. He thought the loss was principally occasioned by the quantity of water forced through the boring-rods and core tube, and round the end of the Diamond crown, which washed away a great proportion of the strata forming the core with the *debris* which would otherwise have choked the crown in its work. They found in passing through the softer strata, of which there were many, that they were all but washed away time after time, the core tube coming to the surface with very little in it. The men said that in one of four holes bored into the coal measures they passed through 8 feet of coal without a vestige of core, and the only way they could tell there was coal was by the colour of the water. The boring was through the new red sandstone.

The Chairman said, that Mr. Bewick had told him if the discussion was adjourned he would get particulars of the percentages of the core through various strata, which would be valuable information ; the question was, whether Mr. Jefferson, who no doubt had come here at some inconvenience, would like the discussion adjourned for further information.

Mr. Jefferson said, he had no objection to have the discussion adjourned. His attention had been specially drawn to boring whilst studying at Clausthal in Germany ; he had been much struck with the ingenuity displayed by the French, Belgian, and German engineers in boring, and had followed the various inventions with much care. Two years ago he was in Germany, and he went to see Herr Köbrich, who was the chief Boring Inspector for the German Government. The Government owned the minerals in Prussia, and spent a certain amount of money every year on boring. Herr Köbrich was boring at Schönebeck with an apparatus which he had invented, and which was very successful. At great depths, however, it was most exhausting for the workmen to twist the boring-rods, and he thought it possible to design an apparatus which would work automatically. One reason for bringing this matter before the North of England Institute of Mining and Mechanical Engineers, was because the Institute occupied a peculiar position. Although called the North of England Institute of Mining and Mechanical Engineers, its Transactions went all over the world, and it was really a national Institute; and he thought if this apparatus was described in the Transactions there would be some chance of having it tried. With regard to the question of size asked by the President, he doubted whether it might be arranged for boring out shafts on the Kind-Chaudron principle, but he saw no reason against the possibility of boring holes 30 inches diameter or more with it. It was an advantage of the design, however, that it was not necessary to begin with very large diameters to attain a considerable depth, and it allowed a bore-hole being widened out with very great rapidity.

In boring for coal the main object is to ascertain the depth, thickness, and quality of a bed of coal, and not to obtain cores all the way from the surface to the coal. The character and thickness of the various strata passed through are given with all practical accuracy, by the ordinary methods (*i.e.*, by the *debris* brought up), and quite near enough for making the estimate of the cost of sinking shaft. The Diamond drill failed to bore cores in coal, and consequently it seemed to him that the speed of the Diamond drill is its greatest advantage, whilst the readiness with which it bores out cores in hard ground, is a more apparent than real advantage.

As to the cost, it was estimated from information given to him by Herr Köbrich, and from the actual cost of a number of borings, executed with various free-falling instruments. On the next page will be found a comparative table of costs, taken from the paper on boring in the Transactions of the Midland Institute, from which it will be seen that the cost by the Diamond drill is upwards of three times as great as by the other methods. The new apparatus, taking the speed of the apparatus of Herr Köbrich as basis, will have a speed approaching that of the Diamond drill. In boring through coal, he would suggest that the shoe which he had shown, should be changed as soon as it was supposed from the feel of the rods that coal was reached, and the core taken out by rotation with a special tool. If they were boring for coal they should have the cores brought up now and again as a sort of assurance that they were right as to the material brought up, but he did not think it was really necessary to have the core bored all the way down.

The CHAIRMAN said, they would all join with him in thanking Mr. Jefferson for his valuable contribution to their Proceedings. The discussion would be adjourned, and Mr. Bewick had promised some information as to the percentage of the cores.

COMPARATIVE TABLE.

	ROPE.		FAUVELLE'S	RIGID RODS.			THE DIAMOND ROCK DRILL SYSTEM.		
	Average of a Series of 37 Borings.*	Beyreuth.		Sudenberg.	Malkowitz.	Sperenberg.	Rheinfelden (Basle).	Liebau (Silesia).	Böhmische Brod.
Advance per 12 hours. Excl. Bye-work.	..	..	..	3 ft. 1·8 in.	3 ft. 4·1 in.	Hand power. 3 ft 5·3 in Steam power. 7 ft 0·5 in	..	..	..
Advance per 12 hours. Incl. Bye-work..	2 ft. 9 in.	8 ft. 4 in.	12 ft.	2 ft. 5·3 in.	1 ft. 10·2 in.	Hand power. 1 ft 10·8 in Steam power. 2 ft 6 in	11 ft. 10·2 in.	6 ft. 5·1 in.	4 ft. 10·4 in.
	2 ft. 9 in.				2 ft. 4·2 in.	2 ft. 9 in.		7 ft. 8·5 in.	
Ratio of Advance ..	1·16	..	..	..	1	..	..	3·25	..
Strata	Various — trias (variegated sandstone), carboniferous, greywacke, slate, basalt, &c.	Permian strata (red conglomerate).	Various.	Permian and carboniferous strata	1,000 ft. Permian, the rest carboniferous and Silurian strata.	Gypsum, anhydrite, and rock salt.	Variegated sandstone, chalk, diorite, hornblende, slate, with quartz and granite veins and red granite	Permian and carboniferous strata	Permian strata, consisting of metamorphosed hardened slaty clay, sandstone slates, and quartz and gneiss conglomerate.
Maximum Advance per 12 Hours	..	..	..	..	6 ft. at a depth of 1,400 ft.	..	65 ft. at a depth of 300 ft. 38 ft. at a depth of 950 ft.	Between 13–16 ft. at depths of 1,500–1,700 ft.	Between 16–26 ft. at depths of 1,000–1,100 ft.
Total Depth	From 80–1,300 ft.	1,000 ft.	1,206 ft.	1,290 ft.	1,857 ft.	4,170 ft.	1,422 ft.	1,761 ft.	2,207 ft.
Diameter of Bore-hole. At Surface ..	..	12 in.	..	18 in.	21 in.	..	7 in.	7 in.	..
Diameter of Bore-hole. At Bottom ..	..	..	2½ in.	..	7 in.	..	3½ in.	3 in.	..
No. of Hours occupied. Excl. Bye-work.	..	..	..	4,749 hours.	4,896 hours.	Hand power. 3,286 hrs. Steam power. 5,275 hrs	..	..	3,768 hours.
No. of Hours occupied. Incl. Bye-work..	..	..	..	1,368 ,,	3,912 ,,	Hand power. 2,464 ,, Steam power. 9,563 ,,	..	..	1,680 ,,
Total No. of Hours..	..	1,440 hours.	..	6,117 ,,	8,808 ,,	20,588 hours.	1,440 hours.	3,288 hours.	5,448 ,,
Total Days	..	120 days.	62 days.	510 days.	734 days.	1,713 days.	120 days. At Erlbach 1,000 ft. deep.	274 days.	454 days.
Cost per Foot	41/3	22/†	..	36/	48/4	41/‡	£5 8 0	£4 12 0	£5 0 6
					£2 1 9				
Total Cost	..	£1,100†	..	£2,322	£4,489 8 0	£3,567 15 0	£5,400	£8,093 3 0	£11,100 0 0

* These do not include any sunk with the apparatus of Messrs. Mather and Platt.

† Estimated.

‡ The surface arrangements have been employed on a second boring, which has attained a depth greater than at Sperenberg. Owing to this the figure given is really too high, the cost of surface arrangements being divided between the two borings.

Mr. Richardson's paper "On the Strength of Wrought Iron in Compression" was then discussed.

The CHAIRMAN said, such an important paper coming from a gentleman of such experience as Mr. Richardson was a most valuable record—it was one on which only gentlemen who had had extensive practice could offer any opinion. If his conclusions are correct, then the strength of girders is very materially increased beyond that derived from the usual formulæ. Perhaps Mr. Richardson might have further observations to make.

Mr. RICHARDSON said, he had nothing further to add to his paper, but he hoped to be able afterwards to submit to the Institute the results of some experiments on the question. He suffered from a severe illness about the time the paper was read, and he fully intended to have some experiments made, not to establish data, because such experiments could only be made by gentlemen who could devote special leisure to the subject; but simply to ascertain what amount of foundation there was for the conclusions he had arrived at. He had less doubt in his mind than when he wrote the paper, because it had elicited letters from friends in various parts of England, and, in fact, of the world; he had had even a letter from South Africa; and he found a unanimity in support of his views which almost startled himself. The views he propounded were, to a certain extent, in direct contradiction of the figures and data, and deductions which had appeared in almost every text-book published for the last twenty years. Reflecting upon these with humility, and knowing that what had been written in text-books had been deduced from experiments, and knowing that Sir William Fairbairn was a painstaking and careful test-maker, it seemed to him that the erroneous deductions had been developed in the mathematical deductions derived from the experiments. He thought that Sir William Fairbairn had not sufficiently appreciated, in his mathematical formulæ, the difference between a factor and a function, and so had been led into errors, which, so far as he could see, were patent upon the face of what that gentleman had written in explanation. In the data given for calculating the strength of materials and structures, whether in wrought or cast iron, it was usual to make the strength of the column decrease inversely as the length, which meant, if it meant anything, that if a column was a certain strength, it would be half that strength if made twice as long, and *vice versa*. Common sense showed that not to be the case. He should be inclined to think that in wrought iron, or any other substance that had elasticity, both in compression as in tension, an increase of the surface through which the strain took place, must, within limits, instead of decreasing, actually increase the strength of the structure.

The CHAIRMAN said, that he hoped Mr. Richardson, by the experiments which he had promised to make, would be able to maintain his views, which, if correct, would prove a very great boon to all who had large iron structures to erect, and that he would communicate the result of his experiments to the Institute.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, FEBRUARY 5TH, 1881, IN THE WOOD MEMORIAL HALL.

T. J. BEWICK, ESQ., VICE-PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were elected members :—

ASSOCIATE MEMBERS—

Mr. THOMAS READER SMITH, Engineer, Rockingham Colliery, near Barnsley.
Mr. EDWARD J. WARDALE, M.E., Craghead Colliery, Chester-le-Street.

STUDENTS—

Mr. J. GREIG, Brancepeth, Durham.
Mr. J. ARNOLD PIKE, Silksworth Colliery, Sunderland.

The following gentlemen were nominated for election at the next meeting :—

ASSOCIATE MEMBERS—

Mr. JOSEPH PRINGLE, Manager, Coxlodge Colliery, South Gosforth, Newcastle-on-Tyne.
Mr. WALTER MERIVALE, C.E., Engineers' Office, Central Station, Newcastle-on-Tyne.

Mr. THOMAS J. BEWICK read the following "Notes on Diamond Rock Boring :"—

NOTES ON DIAMOND ROCK BORING.

By T. J. BEWICK.

To the members of an Institute such as this, comprising both Mining and Mechanical Engineers, rock boring is especially interesting, inasmuch as it combines mechanical skill and appliances with a knowledge of various strata and the minerals occurring therein.

Having at the meeting of the members, held on the 4th December last, undertaken to furnish some particulars on the questions raised in the discussion upon Mr. Robert Miller's paper on "Jefferson's Automatic Free-falling Hydraulic Boring Apparatus," with especial reference to the results obtained in boring through various strata by the Diamond Rock Borer, the writer now begs to submit the following:—

AS TO CORES.

In the early experience of those using the Diamond Borer the percentage of cores obtained naturally varied much in different strata, but in the coal-measures formation as much as 95 per cent. of core was not unfrequently brought out. At that time soft beds of shale, marl, and coal did not yield cores, owing to the fact that the holes put down were so small in diameter.

For some time after the first introduction of the system the holes were under 2 inches diameter, and the cores produced were about ¾ inch. This smallness in the size of the holes rendered it most difficult to secure cores of the softer strata, but in limestones, sandstones, hard shales, and such like, the results were most satisfactory.

The experience gained in carrying on the operations led the engineers in charge to observe that the larger the diameter of the hole the more certain were the results. This, and the fact that for very deep borings large holes were necessary to admit of the application of lining tubes, gradually led to an increase in the diameter, until holes have been put down up to 26 inches, yielding cores 23½ inches diameter.

In many cases where the diameter of the hole is sufficiently large, and even in comparatively small holes, absolutely the whole depth bored through has been brought to the surface in cores, however soft the rock may have been. The following are a few examples of what has, from time to time, been done :—

1.—At Caerphilly, South Wales, in 1874, a hole was put down to a depth of 1,007½ feet, from which "the cores brought up showed a complete section of the strata passed through, and the samples of coal were satisfactory, being such" (in the opinion of the gentleman for whom the hole was put down), "as it would have been impossible to obtain by any other means of boring."

2.—In the same year two holes were made for the London and South Wales Coal Company at Risca, in South Wales, from which "perfect cores of the strata were obtained, thereby giving a most reliable section of the nature of the ground passed through."

3.—At Clapton, in 1875, in a boring through coal, the following results were obtained :—

	Depth Bored.		Strata.	Core obtained.		Percentage.
	Ft.	In.		Ft.	In.	
	1	2	Coal		9	64·3
		5	Soft fire clay		2	40·0
	6	6	Clift	6	0	92·4
		6	Coal		3	50 0
	7	9	Black shale	7	6	96·7
	4	7	Coal	3	9	81·8
	2	0	Coal and shale	1	0	50·0
	3	2	Coal	3	0	94·7
Total	26	1	Total	22	5	Average 86·0

"Besides the borings washed up, which in themselves gave as good an evidence of the strata passed through as could otherwise have been obtained."

In this case the total thickness of coal bored through was 9 feet 5 inches, of which 7 feet 9 inches, or 82·3 per cent. of core was got out of the hole.

4.—In 1876, the Vancouver Coal Mining and Land Company had a Diamond Borer in operation, and at a depth of about 500 feet passed through a seam of coal reported to be 9 feet thick, from which the "coal core extracted was of fair quality."

5.—At Rheinfelden, in Switzerland, in boring through Permian strata at a depth of from 738 to 1,454 feet, 80 per cent. of the cores were obtained with a crown 3⅛ inches diameter.

6.—At Aschersleben, in Saxon-Prussia, where several borings for rock salt have been made, cores of potash salt easily soluble were got out, samples of which were submitted to the meeting.

One hole was bored 902 metres, equal to 2,959 feet, and from this 100 per cent. of cores were drawn, of which some were salt cores 2·2 metres, or over 7 feet long in one piece. This hole was commenced 12 inches diameter at top and finished 3 inches at bottom.

In another hole 405 metres, or 1,329 feet in depth, "perfect cores were drawn." The diameter in this case was from 10½ to 3 inches.

From a third hole 361 metres, or 1,184 feet in depth, "perfect cores were drawn," amongst them being some of potash salt 2 feet long in one piece. The hole was commenced 10½ inches diameter and finished 4 inches.

Considering that these holes were in what is generally considered as soft rocks, the results cannot be looked upon otherwise than with satisfaction, and go to prove that with even moderate-sized holes solid cores are obtained by the Diamond Borer.

7.—In connection with the Sub-Wealden borehole, near Hastings, the scientific geologists forming the sub-committee appointed to report on the results obtained by that boring, state that the determination at which they arrived with reference to the position of the strata was "due to the manner in which large cores were brought to the surface by the Diamond Rock Boring machine, so that a number of fossils were obtained entire, the species of which could be accurately determined."

This hole was put down 1,906 feet through the Purbeck series, the Kimmeridge clay, Coralline oolite, and Oxford clay, and, had funds been at command, might have been continued to a further depth. At the commencement this hole was 7 inches diameter and the core therefrom 5¼ inches.

8.—In a boring for the New River Water Company, in the neighbourhood of London, the total depth reached was 1,010 feet, the diameter of the hole was 18 inches, and the strata consisted partly of gault clay, very soft and readily affected by water, yet every bit of core was obtained. Had this hole been only 3 or 4 inches diameter, it is estimated that not more than 20 per cent. of core could have been got out.

9.—From a borehole put down at the Chatham Dockyard, commenced 23 inches diameter at top and finished at a depth of 910 feet, 15¾ inches diameter, all the core was obtained, the strata in this case being chalk and gault.

10.—At Northampton, from a hole 23 inches diameter at top, and 15¾ inches at a depth of 840 feet, all the core was secured, although the lias clays were passed through.

11.—The following are examples of borings through coal, viz.:—

No. 1.

Total Depth from Surface.		Thickness of Coal.		Core obtained.		Percentage of Core.
Ft.	In	Ft.	In.	Ft.	In.	
410	6		6		3	50·0
576	0	4	1	3	2	77·5
590	0		6		2	33·3
623	0	2	0	1	8	83·3
626	0	1	0		8	66·6
628	4	2	4	1	10	78·5
732	0	3	6	2	8	76·2
830	0	6	2	5	0	81·0
	Total ...	20	1	15	5	Average 76·8

No. 2.

Total Depth from Surface.		Thickness of Coal.		Core obtained.		Percentage of Core.
Ft.	In	Ft.	In.	Ft.	In.	
861	0		4		3	75·0
880	6	2	0	1	5	70·8
1,020	0		3		2	66·6
1,086	0		2		1⅜	68·7
1,105	0		7		3	42·8
1,332	1	1	6		10	55·5
1,458	0		4		2	50·0
1,514	0	2	1	1	7	76·0
1.563	1	2	1	1	3	60·0
1,586	9		9		8	88·9
1,605	6	3	11	2	8	68·1
1,615	11	1	11	1	2	60·9
1,672	0	5	8	4	6	79·1
	Total ..	21	7	15	0⅜	Average 69·6

Colonel Beaumont, R.E., in a communication received a few days ago on this, remarks :—"I have never known a proved instance of a boring through coal being inaccurately recorded. Indications from the water and the action of the machine enable the thickness and position of the bed to be identified; but in many instances, especially with small-sized holes, cores cannot be obtained—the character of coal, especially in many thin seams, is friable, and it washes to powder. By taking proper precautions, actual samples of any strata can be obtained, and in all cases (even the most disadvantageous to the Diamond Drill) the samples are more correct with it than with the percussive system; because, while the means of extracting a sample in soft strata is in either case the same, the Diamond Drill has the advantage of a comparative immunity from the walls of the hole being shaken down during the boring."

The following are taken as examples of boring through soft strata at varying depths in different holes :—

Total Depth from Surface.	Strata.	Depth Bored.		Thickness of Core.		Per- centage.	Size of Core.
Ft.		Ft.	In.	Ft.	In.		In.
650	Coal measure shales ...	58	4	52	3	89·5	3½
745	Sandy shales	16	0	15	3	95·3	3
760	Whin and sandstone ...	15	2	12	8	83·5	3
822	Sandy shales	55	0	49	7	90·2	3
893	Shaly sandstone and shales	23	11	19	0	79·4	3½
977	Shales	55	10	49	2	88·0	3
1,330	Fire clays and shales ...	193	5	160	0	82·7	3
1,457	Do. do. ...	105	4	92	0	87·3	2¾
1,500	Sandstones and shales ...	48	7	46	0	94·6	2¾
1,580	Shales and fire clay ...	58	0	49	0	84·4	2¾
1,666	Do. do. ...	50	7	43	5	85·8	2¼
		680	2	588	4	86·5	

In another case of boring through red shales in Cumberland, in 200 feet nearly all the cores were obtained, the hole commenced at 9 inches and was afterwards reduced to 8 inches diameter.

From the preceding it appears that, with the Diamond Borer in holes of sufficient size, the entire depth passed through can be brought out in cores even in the softest strata, and that in small holes, from 80 to 95 per cent. of the core is obtainable.

To this, however, the Port Clarence hole, referred to in the discussion which took place on the 4th December last, is an exception, inasmuch as it is the largest-sized hole the writer has heard of, and yet in the rock only 90 per cent. of the core has been obtained. It was commenced in July, 1880, and at 31st December had reached a depth of 930 feet, the first 200 feet being in gravel, sand, and clay, the remainder in the New Red Sandstone formation. The hole at the commencement is 26 inches, and at 930 feet 18¾ inches diameter. It may be that the reason a smaller proportion of core has been got out than is usual in large-sized holes is because it is unimportant, and the same care may not have been exercised in preserving it.

AS TO THE COMPARATIVE COST BY THE ROPE, RIGID ROD, AND DIAMOND DRILL SYSTEMS.

So much depends on the various circumstances surrounding each particular case that it is difficult to arrive at a correct conclusion as to which is the cheapest, inasmuch as, not unfrequently, time forms an important element in the calculation, and this may be equivalent to money. In the tabular statement furnished by Mr. Jefferson, the Diamond Drill appears at a considerable disadvantage as regards cost; but the contrary is shown by the following quotation, which is extracted from a letter written by the manager of the Vancouver Company before mentioned. By the "old system" of boring (which, however, is not explained) the Company put down a hole of 240 feet at a cost of £560, which is equal to £2 6s. 8d. per foot; a second one of 363 feet cost £1,100, or £3 0s. $7\frac{1}{4}$d. per foot; and subsequently, with the Diamond Drill, 497 feet were bored for £320, equal to 12s. $10\frac{1}{2}$d. per foot, or only from about one-fourth to one-fifth the cost by the old system. In this same case the question of speed formed an important element, as the first hole by the old method occupied twelve months, or at the rate of 20 feet per month; the second one seventeen months, or $21\frac{6}{17}$ feet per month, whilst the 497 feet bored by the Diamond Drill was done in three months, giving an average speed of $165\frac{2}{3}$ feet each month, which is about eight times as fast as by the old system, and that, too, in a deeper hole. It may be that untoward circumstances occurred in prosecuting the two holes by the old system, causing delay in their execution and augmenting the cost; and, on the other hand, the Diamond Borer may have on this occasion been more than usually successful both as regards time and cost.

Fuller details of strata and other circumstances are necessary to enable a full comparison to be made; but the case is brought forward to show how impossible it is to arrive at a correct conclusion on the merits of the several methods.

On this Colonel Beaumont says:—"I should consider the Diamond system would always be cheaper than the Free-falling system except in ground where there was a very heavy Diamond expenditure, in which case it is difficult to form an estimate; but on the average, taking the actual cost of boring, I fancy that more work has been done, for the same amount of money spent by the contractors, by the Diamond than by any other system."

The first hole at Middlesbrough, bored by Mather & Platt's system, was 1,200 feet deep, it occupied a long time, and cost about £10,000, equal to £8 6s. 8d. per foot. If this had been done by the Diamond

Borer, it would probably have been finished within twelve months and at one-third the cost.

It cannot, however, be doubted that, amongst other advantages, the Diamond Drill system is superior—

Firstly—In the rate at which borings can be accomplished; and,

Secondly—In more correctly showing the exact character of the strata bored through.

No opinion can be fairly formed as yet as to the depth which can be reached by the different systems. It is true that at present the deepest known hole has been bored by rigid rods, viz., that at Sperenberg, in Brandenburg, which reached a depth of 4,170 feet, and occupied nearly $4\frac{3}{4}$ years in sinking. On the other hand, the Böhmische Brod hole, put down by the Diamond Drill, reached 2,207 feet, and was then stopped because the object in view had been attained. It is also true that this hole was little more than half the depth of that at Sperenberg, but it took only $1\frac{1}{4}$ years in its accomplishment, which is about one-fourth the time taken up by the Sperenberg hole. More recently, by the same system, a depth of $1{,}207\frac{1}{4}$ metres, or nearly 4,000 feet, has been attained by a boring for salt near Lübtheen, in Mecklenburg, and this was done in less than six months, which can only be looked upon as a marvellous success in deep boring. From this hole 100 per cent. of cores was obtained, one piece of salt rock being over 20 feet long.

It has been alleged that, in case of the breakage of the tubes or rods used in working the Diamond Drill, there are difficulties in recovering them which often prove fatal to the further prosecution of the hole. This, so far as the writer has been able to ascertain, is not correct, for as a rule, in cases of breakage, the rods, or the crown itself, can be fished up without much difficulty, and in practice, there are extremely few breakages of this character which cannot be remedied.

On this Colonel Beaumont remarks :—"There are many instances of the breakage of the rods, but at this moment I cannot charge my memory with more than one case in which the hole had to be abandoned. The mere breakage of the rods can be got over with proper recovering tackle so simply that it is not considered a serious matter; and in this instance the hole could have been continued had the boring not been abandoned owing to the colliery being stopped."

A remarkable case is on record in the Transactions of the South Wales Institute of Engineers, where a borehole at the brewery of Messrs. Meux & Co., in Tottenham Court Road, London, had been put down from the bottom of a well 265 feet from the surface, by the boring appliances of Messrs. Mather & Platt to a further depth of about 435 feet. This hole was 13 inches diameter, and for 151 feet was sunk vertically, but the remaining 284 feet was much out of truth—*i.e.*, crooked—first going more than its own width to one side, and then back to the opposite side of the vertical line to even a greater distance. At this depth the boring head of the machine, weighing 10 cwts., becoming detached, had to be left in the hole, and the boring abandoned. At a later period the hole was made vertical from the bottom of the well by the Diamond Borer, and continued to a depth of 879 feet, making the total from the surface 1,144 feet. Of this 879 feet, 607 feet were 13 inches diameter, and the remainder 9¼ inches, the last 70 feet or thereabouts in palæozoic rocks, the strata above being in the chalk and green sand formations. In putting down boreholes through sand or soft strata, lining tubes are necessary, but in such a case as that described it would be impossible to insert lining tubes.

In simplicity and fewness of parts in the hole itself the Free-falling apparatus cannot compare with the Diamond Drill, in which there are absolutely no parts that can become detached except it be the diamonds, and in such cases, otherwise than by increasing the cost of the boring by the loss thereof, the operation is not affected. On the other hand, looking at the drawings accompanying Mr. Miller's paper (Plate XLVI., Vol. XXIX.), it appears there are many parts of the apparatus near the bottom of the hole which may easily become deranged and interfere seriously with the effectiveness of the borer and the rapidity with which the hole can be put down.

One of the merits claimed for Mr. Jefferson's apparatus is the passing of the current of water down the outside and up the inside of the hollow rods. This in practice is, as a rule, disadvantageous, inasmuch as the water not unfrequently gets away in fissures in the rock, and thus the pressure is not maintained, and it has been found that solid cores of rock cannot by this means be brought up inside the rods simply by the action of the water.

Colonel Beaumont on this remarks:—" It is quite impossible to get solid cores up the inside of the rods. The best pattern of rod is one which is flush inside, necessitating joints in the hollow part which would prevent cores rising. Assuming there be no difficulty from this cause, in my opinion the system proposed is altogether useless, because in many instances hydraulic pressure could not be put on owing to the water finding its way into the strata through cracks. I think there cannot be a doubt of the very great importance of having nothing complicated at the bottom of the hole. Irrespective of the non-liability of the Diamond Drill to get out of order, it has the enormous advantage of being, comparatively speaking, readily withdrawn in the event of the ground closing in over the tool, which with a Free-falling apparatus would probably be the cause of serious difficulty. Another advantage of the Diamond Drill is, that with proper care the hole can hardly get out of truth, whereas with the Free-falling rope system there are instances of holes inclining so far from the perpendicular as to stop the boring. I remember one case, bearing out this remark, of a deep boring in the Barrow district."

At the discussion referred to, Mr. Jefferson stated that the Diamond Drill failed to bore cores of coal; in answer to this the writer has made inquiries of engineers who have had great experience with this borer and is assured that this assertion is not borne out by fact. Figures have already been given showing that solid cores of coal have been got out, and although it is difficult to obtain such cores, they being for the most part in possession of the parties for whom the work was undertaken, the writer has succeeded in obtaining the loan of two, which are submitted for the inspection of the members. A part of one of these it will be observed is very friable; it is from South Wales, and was brought from a depth of about 300 yards from the surface by a borehole 3 inches diameter.

For most of the figures and circumstances brought before the members the writer is indebted to his friends, Colonel Beaumont, R.E., one of the original patentees of the application of the diamond for rock boring purposes in this country, and to whom its subsequent introduction and much of its success is due; to Mr. John Vivian, who has been connected with the system from its first commencement; to Herr Schmidtmann, who successfully applied it on the Continent in putting down several deep holes; and to Mr. J. K. Gulland, whose connection with the system has extended over several years.

Mr. J. B. Simpson said, he would like to ask whether the Company had ever put a pit down near the place where they had made a boring, and whether the thickness of the seams had turned out the same as shown by the boring? Although no doubt the Diamond Rock Boring apparatus was very good for going through hard rock, yet, so far as his experience went, he did not think it was adapted for ascertaining the exact thickness of coal seams, especially if the coal was tender. At the present time a three-feet seam was worth working, but if the boring apparatus only brought up 70 per cent. of this it might prevent the proprietor from sinking to what might nevertheless be a profitable seam.

The CHAIRMAN said, he was not in a position to answer the question, but perhaps Mr. Vivian or Mr. Wild would be able to do so. When he spoke of 70 per cent. it was of solid coal brought out; in addition to that there was the disintegrated coal obtained with the water, and the two together would pretty clearly denote the thickness of the seam passed through. He would not say that mistakes had not arisen in this matter, but the system adopted by the Diamond Drill was quite equal to any other for ascertaining the thickness of the seams, for as soon as it touched coal it gave indications of the fact not to be mistaken by an experienced borer.

Mr. SIMPSON—Is it possible to detect bands an inch thick in the seams passed through when the coal is tender?

The CHAIRMAN—Yes, if a solid core is brought out, but not otherwise; and it will be seen by specimens on the table that solid cores can be obtained from very friable coal.

Mr. A. L. STEAVENSON thought they must admit that if the Diamond Borer did not give the entire thickness of the seam, at all events it gave a closer approximation to it than any other system. He had been present when coal had been bored through by other systems and not a single ounce of *debris* obtained, in cases where both gas and water were present. The Diamond Borer, on the contrary, would pass down and show the thickness of any fault, and any inferiority in the seams would be shown in a distinct manner. The comparative facility with which the Diamond Borer went through hard rock was also a great advantage, for some holes put down in the neighbourhood of the river Browney were abandoned on reaching a bed of basaltic rock at about 70 fathoms, whereas if the Diamond Borer had been used the holes might have been carried through the basalt without difficulty.

Mr. T. W. BENSON said, his father had a borehole put down by the Diamond Rock Boring Company in the beginning of 1875 to prove the mountain limestone coal, near Coastley, about three miles west of Hexham, in a plantation on the north side of the main turnpike. This hole was put down to a depth of about 200 feet, and abandoned in consequence of getting into broken strata. The depth of the second hole was about 767 feet; it was sunk further up the burn on the south side of the road, about 100 yards away from the first hole, and coal was passed at 760 feet and recorded as follows:—

	Ft.	In.
Coal	2	0
Sandstone		2
Coal		9
Shale		1
Coal		2½
Shale		4
Coal		3
Total	3	9½

The cores varied from two to four inches diameter ; but the coal that was got out was all in dust and small pieces, no piece being much larger than a marble. The diameter of core in passing through the coal was two inches. The result not being satisfactory a pit was not put down, but the record proved that a band of coal an inch in thickness could be detected. So far as he could recollect, the cost of the two holes was about £1,850, or about £1 18s. per foot. The nature of the coal was soft and friable, and scarcely likely to give a good core in so small a hole, but since the early part of 1875, when these holes were put down, he understood that the size of the holes had been considerably increased.

Mr. J. D. KENDALL said, it might be interesting to know what had been done with regard to the two systems of boring in use in Cumberland —the Diamond Rock boring system and the rigid rod percussive system. He found that for holes of 600 feet in depth the Diamond boring system cost 22s. per foot, which was 75 per cent. dearer than the other system ; for a hole 700 feet deep, the Diamond system cost 24s. per foot, which was 68 per cent. in excess; for 800 feet and over, the cost of the Diamond system was 25s. per foot, and exceeded the other by 50 per cent. But it must be borne in mind that the Diamond Boring Company gave a guarantee that the holes they put down should go to the depth that was required, or forfeit their claim for payment. In connection with the other system, they frequently found that after the hole had gone a certain distance, and was not paying the contractor, he threw it up, because there was no guarantee given whatever as to how far he would go, and this was an important consideration. In the matter of speed, the Diamond machine could bore more than twice as fast as the other machine, besides obtaining infinitely better samples.

Mr. VIVIAN said, he had been connected with the Diamond boring from its commencement, having worked out the patents of Colonel Beaumont, and brought the system up to its present position, in company with others. When they first started, it was in a small way, as was the case with most inventors; for they commenced with a hole one inch and a half in diameter on the side of a Welsh mountain. In about a dozen hours they got some rods screwed together, and in the next thirty hours they went down about 200 feet, and told an engineer who was conducting some tunnelling operations, the nature of the strata he would have to traverse. They came next to the Cleveland district, and put down a hole, but unfortunately they started with one that was too small, and met with difficulties. They then made up their minds to have larger holes and telescope them, and put in tubes to keep back the *debris*. The object in boring for coal was, of course, to get the very best sample they could, and keep up the reputation of the Company. He was afraid some gentlemen here condemned the system, because they did not quite understand it. A pit was sunk near Manchester, under the direction of Messrs. Higson, Mining Engineers, some 720 yards, on the assumption that coal was there; and when this depth was reached and no coal was found the partners were disappointed, and determined to have a bore opened from the bottom of the 720 yards shaft. The Diamond Boring Company fixed their plant at the bottom of the shaft, and bored 1,040 feet in four months, and the samples brought up were so far satisfactory, that they were now pushing on the sinking, and had passed through several seams of coal without hearing any complaints. The Company had bored two holes in Ayrshire for Mr. Galloway. There were several whinstone dykes running through the coal there, and in boring they had frequently to pass through them. In the coal-measures they got 60, 70, and as much as 80 per cent. of core, even when the coal was thin and friable. Mr. Galloway was so satisfied with the first sinking that he employed them to sink other holes. The Company had just finished a hole for the Shotts' Company, at Roslin, near Edinburgh, and from the coal they got 60 to 70 per cent., and in the soft shale and sand they got 80 and 90 per cent. core. They now obtained cores eight, nine, and ten inches outside diameter, according to the probable depth of the boring. He always desired to know before starting what was the depth required, and the Company bound themselves to go down and finish the hole to that depth. As to Mr. Jefferson's Free-falling tool, from his experience, and apart from any interest he had in boring, he would not like to trust it for getting samples; he did not believe in its retaining the small core. The action described by Mr. Jefferson had not been tried, and was only theoretical at present; but he was sure that the action of the borer would destroy the section it happened to retain in the bottom. They all knew that any machine, however good, would not do good work if placed in the hands of unskilful workmen, and unfortunately in busy times the Diamond Borer had sometimes been badly used, but in the last ten years they had only lost two holes. They had on an average six to eight machines at work, and they expected each machine to do from 2,000 to 3,000 feet yearly. The quantity of work the Company got, too, was a guarantee that they did their work satisfactorily, and also that they did it quickly. They did not look upon the breakage of rods as a serious matter. They preferred a break to a jam, as causing the least delay. Most of the jams in the Cumberland district were caused by lumps of limestone falling down on the rod whilst rotating 300 or 400 times in the minute; sometimes a piece of stone so falling would jam the rod and break it, but if the jam was not very serious they soon got the rods out and continued the boring. Mr. Kendall's experience of their system had shown that the cost was not very much in excess of the other system, but he (Mr. Vivian) thought that the guarantee given by the Company was worth 25 per cent. of the cost at least, and besides there was the extra speed, and the extra certainty of samples, so that they would see that with the Diamond Borer they got value for their money.

The CHAIRMAN asked Mr. Vivian if he could answer Mr. Simpson's question as to whether sections of coal indicated by the borer have actually been verified by subsequent sinking on the same site?

Mr. VIVIAN—Yes, in several cases. At Ashton Moss and other places, sinking has confirmed the indications of the borer most satisfactorily.

Mr. SIMPSON said, with respect to one case which he had to investigate, the boring was so unsatisfactory that they felt they could not place dependence upon it, for they were not sure whether the samples were right or not. In fact no actual samples came up, but only water with coal-dust in it, and in consequence no sinking was attempted.

Mr. COULSON said, he understood that in some cases the only proof there was that the Diamond Borer was passing coal was the colour of the water coming to the surface, but sometimes the water escaped by gullets existing between the bottom of the hole and the top; how in that case could there be any reliable means of knowing if coal had been passed when neither cores or *debris* had been obtained?

The CHAIRMAN said, that in such cases there could not be any certainty, the same causes of failure would tell equally against all systems. The discussion of this subject would be adjourned, and the members would be glad if, at a subsequent meeting, they could be favoured with the views of Mr. Coulson, who was the oldest and most experienced borer in the North of England, and possibly in this island. They would have great pleasure in handing down Mr. Coulson's views in the Transactions of the Institute.

Mr. COULSON promised to read some notes on the subject.

Mr. J. W. WILD mentioned that, with regard to the hole put down at Port Clarence, for the first 120 feet no core was obtained, for the simple reason that they were passing through clay and gravel, but subsequently they got 90 per cent. of core for the entire depth of the hole. At Wollaton, near Nottingham, a hole was put down, and they bored through 2 feet 6 inches, 3 feet, 5 feet, and 6 feet seams of coal, and a pit was sunk afterwards which completely verified their indications.

Mr. SIMPSON said, he would be much obliged if Mr. Wild could supply them at the time of the next discussion with particulars of both the boring record and the strata passed through by the pit, so that they might be compared together, for one simple fact was worth a thousand off-hand statements.

Mr. J. W. WILD said he would furnish to the Secretary the details required.

Mr. MARLEY, in reply to the remarks made by Mr. Bewick in his paper respecting the Middlesbro' borings, was glad to find they were not founded on the paper which he had written on the subject, and remarked that he thought it was true that the Middlesbro' well sinking for water might have cost Bolckow and Vaughan the large sum stated, although the boring itself did not cost anything like so much. They bored many hundred feet, 18 inches diameter, at not a greater cost than £1 per foot, instead of £8 per foot as quoted. He was glad that Mr. Coulson had been induced to promise to provide some statistics and information on the subject of boring; and he thought Mr. Simpson should also produce some statistics as to the accuracy or inaccuracy of the old-fashioned boring. He knew from experience that borings had been put down, and had indicated seams which, on sinking, had either not been found to exist, or if found, were of very different thickness to what was indicated. Mr. Coulson's father, the late Mr. John Arch. Forster, and himself had, about forty-one years ago, tried two or three different kinds of boring instruments, with a view to bringing core of coal up, which were partially, but not wholly, successful.

The discussion was adjourned, and Mr. J. D. KENDALL read the following paper on "The Iron Ores of Antrim:"—

THE IRON ORES OF ANTRIM.

By J. D. KENDALL, C.E., F.G.S.

THE north-east corner of Ireland—that occupied by the county of Antrim—is almost entirely covered by a sheet of basalt, which varies in thickness from a few feet to several hundred feet. This basalt rests upon chalk, and is supposed, from the nature of the plants yielded by some inter-bedded layers of Lignite, to be of Miocene age. A generalised section of the rocks in this part of Ireland is given in Fig. 1, Plate XXIII.

Generally, the basalt may be divided into two classes, amorphous and columnar, the latter of which must be well-known to all who have visited the famous Giant's Causeway, on the north coast; and the former may also there be seen between and below the two tiers of columns which form such a conspicuous feature of the cliffs.

Although the basalt is not a sedimentary rock, but volcanic, yet, as is often the case with rocks of the latter class, it shows distinct traces of bedding, as may be seen in the cliffs at Pleaskin, near the Giant's Causeway, a sketch of which is given in Fig. 2.

MODE IN WHICH THE ORES OCCUR AND THEIR NATURE.

Parallel to the bed-planes of the basalt and inter-stratified with that rock are a number of ferruginous bands, which, of late years, have attracted considerable attention. The precise number of these bands is not known, but they occur one above another like seams of coal, as shown in Fig. 1, Plate XXIV., which is a section of the cliffs near Downhill.

In the above sketch only two seams are shown; in other places, however, there are more. Usually they consist of a ferruginous clay called bole, with an underlying layer of lithomarge; but one seam, the most important of all, and perhaps the only seam that has yet been worked to a commercial success, consists of three beds. The position of this seam, as seen at Portmoon, is immediately under the lower tier of basaltic columns. It appears to be the highest of the series of ferruginous bands, at least the writer is not aware that any have been found above it. The seam which occurs in a similar position, that is, below the lower tier of basaltic columns in the cliffs near the Giant's Causeway, is the same, and it may be found in many other parts of the county. A general section of the seam is given in Fig 2. and described below.

a.—Columnar Basalt.—Lower tier.

b.—Clay.—Slate-coloured, passing gradually into the overlying basalt. The thickness of the clay is very irregular, and it peels off the overlying basalt in laminæ, parallel to the sinuosities of the under surface thereof.

c.—Pisolitic Ore.—This bed consists of a soft brown or reddish ochre, in which are thickly embedded small irregular pieces of harder ore about the size of peas, which are strongly attracted by the magnet, being partly hematite and partly magnetite. Sometimes this bed has an amorphous character and appears as limonite when it is not magnetic. The junction between it and the overlying clay is very distinct, and they separate quite easily. A quantity of fossil wood has been found in the bed, the vegetable tissue of which was replaced by limonite. The pieces which have been seen by the writer belong to a coniferous species allied to the yew. Average thickness of bed about two feet.

d.—Bole.—A yellowish-red ochre, containing numerous concretionary nodules of basalt. It is moderately hard, and breaks into irregular cuboidal pieces. The junction between this and the overlying pisolitic ore is not very distinct. Average thickness about six feet.

e.—Lithomarge.—A variegated soft rock of a prevailing blue slate colour and greasy feel. Like the bole, it contains concretionary nodules of basalt, but they are more numerous in this bed than in the bole. The line separating it from the bole is somewhat indistinct. Average thickness about 25 feet.

f.—Concretionary Basalt.—Passes gradually into the overlying lithomarge.

The nodules of basalt included in the bole and lithomarge are very curious. Fig. 1, Plate XXV., is a sketch of three of these nodules occurring in the bole at Ballylagan.

Fig. 2 shows two similar nodules enclosed in the lithomarge, at Pleaskin. The centres of the nodules consist of compact basalt, which gradually and by concretionary layers passes into either bole or lithomarge.

The extent of the ferruginous bed containing pisolitic ore is not known ; but it must cover many thousands of acres, although it does not occur everywhere within the basaltic area. In many places it has been removed by denudation, being found in the hills but absent in the intervening valleys. The breach of continuity thus brought about is further increased by the numerous faults that traverse the county.

It is possible that there may be more than one band containing pisolitic ore, and that the seams which have been worked by the different Mining Companies operating in the county may not be portions of one original seam as is generally supposed, but so far as is at present known, they appear to be.

The quality of the pisolitic ore is good, as shown by the following analyses:—

Constituents.	Red Bay.	Red Bay.	Cargan.	Broughshane.	Knockboy.	Slievananee.
Pero. of iron ...	59·40	77·22	66·56	65·42	63·70	71·00
Protoxide of iron ...	...	...	...	...	...	18·00
Oxide of manganese	...	...	·11	trace	...	trace
Titanic acid ... Vanadic acid	...	trace	3·68	5·28	4·60	...
Alumina	2·80	...	7·92	12·54	12·75	...
Silica	10·40	20·65	5·47	7·08	6·30	9·00
Sulphur...	...	...	·03	trace	·02	...
Phosphorus	...	...	trace	·02	·06	...
Magnesia	...	...	·16	·08	·05	...
Lime	...	...	·68	·20	·10	...
Water of combintn.	8·40	2·13	14·34	8·82	12·70	...
Metallic iron ...	41·58	54·05	46·61	45·99	44·60	63·70
Analyst	Apjohn.	Cameron.	Tosh.	Tosh.	Tosh.	Cameron.

The bole yields only about half as much iron as the pisolitic ore, and contains a much larger quantity of alumina. The following are analyses of samples taken chiefly from the bole, but having a slight admixture of the pisolitic ore:—

Constituents.	Kilwaughter.	Kilwaughter.	Glenarm.	Tully.
Pero. of iron	41·00	45·00	33·34	45·50
Oxide of manganese ...	...	trace	...	trace
Titanic acid	·50	...	5·31	2·00
Alumina	51·00	36·44	41·13	35·50
Silica	1·00	...	3·78	4·00
Magnesia	trace	2·44	·97	...
Lime	·50	0·56	·21	·35
Sulphur	...	...	trace	...
Phosphorus	...	...	·04	...
Water of combination	6·00	18·00	15·55	12·65
Metallic iron	28·70	31·50	23·34	31·85
Analyst	Cameron.	Cameron.	Tosh.	Cameron.

The yield of iron by the lithomarge is too small to render it of any value for iron-making, as is shown by the following analysis:—

Pero. of iron	6·61
Magnesia	1·47
Lime	·43
Potash	6·35
Silica	49·75
Alumina	29·88
Water	5·48
	99·97
Metallic iron	4·62

ORIGIN OF THE DEPOSITS.

Lithomarge and Bole.—The manner in which these beds have been produced seems to the writer to be rendered perfectly clear, by the presence in them of the concretionary nodules already noticed. The graduation from bole to basalt and from lithomarge to basalt, as seen in the nodules of the respective beds, leaves no doubt whatever in his mind that both bole and lithomarge are the result of metamorphic action on basalt. The appearance presented by these nodules cannot possibly be explained on any other assumption, but whether the rock from which the two beds were produced was exactly alike in chemical constitution, as well as like that of the basalt now above and below them, it is impossible at present to say. The probability is, in the writer's opinion, that the beds of rock from which the bole and lithomarge were produced differed in their chemical constituents. If not, and it is assumed that they were both subjected to the same metamorphic action, then the two beds of lithomarge and bole must represent two different stages of the metamorphic process. But if bole were metamorphosed lithomarge, that is, if it had undergone a higher degree of metamorphism than lithomarge, there would be found in the concretionary nodules of the bole, a transition from basalt to lithomarge in the first place, and then from lithomarge to bole; in other words, between the bole and basalt forming the centre of the nodules, there would be found a layer of lithomarge, which is not the case. Then again, if lithomarge were altered bole, there would be found in the concretions of the lithomarge bed a layer of bole immediately round the basaltic kernels, which did not appear. These facts incline the writer to the idea that the bole has been produced from a bed of basalt chemically different from that which, by alteration, has resulted in lithomarge. Below are two analyses of basalt from Antrim.

	I.	II.
Peroxide of iron	27·87	8·95
Magnesia	4·00	...
Lime...	4·15	4·55
Silica	39·72	53·70
Alumina	14·32	25·41
Sulphuret of iron	...	tr.
Soda	9·94	...
Potash		...
Water		4·30

They show how variable that rock is, and that its composition differs quite as much in the same locality as lithomarge does from bole. A fact which may throw some light on the mode of metamorphism may be observed, in connection with the bed of clay lying between the pisolitic bed and the overlying basalt. This clay, the writer believes, is also metamorphosed basalt, for there is a most gradual laminated passage from hard basalt to soft clay, as shown in Fig. 1, Plate XXVI. Wherever this clay bed crops out to the day it appears to thicken, as shown at *a*, Fig. 2, which is a section of the pisolitic ore and accompanying beds, as seen at Ballylagan. This thickening of the clay-bed at the outcrop would seem to indicate that whatever was the metamorphic action which produced the clay, it acted most powerfully near the surface. The metamorphism cannot, however, have been recent, or the upper part (*c*) of the bed A might be expected to be also converted into clay. This may have been so at one time and have been subsequently removed by glacial or pre-glacial denudation.

PISOLITIC ORE.—This bed has been accounted for in various ways. Some have supposed it to be of igneous origin, others consider it to be metamorphosed bole, whilst not a few are of opinion that it had an aqueous origin. The fact, previously referred to, that fossil wood has been found in the bed, seems to favour the last idea. It clearly precludes the possibility of the first and second. Besides, if this ore is the result of metamorphic action on bole, why is the same sort of pisolitic ore not found accompanying the other bole beds? They were all alike, overlaid by a bed of basalt, which, according to the holders of this view, was instrumental in producing the pisolitic ore.

The precise mode of deposition usually advocated by those who believe in the aqueous origin of this bed, is the sedimentary. But that view, it seems to the writer, is scarcely reconcilable with the facts. The freedom of the ore from the mechanical admixture of other rocks, alone seems a sufficient argument against its deposition in that way. The most likely mode of origin appears to be that of precipitation from a chemical solution, possibly by organic agency, but not necessarily so. On that supposition, the absence of foreign matter, such as would almost assuredly have been present had the bed been of sedimentary origin, offers no difficulty, whilst the occurrence of wood in the ore is as easily explained by assuming the ore to be a sediment. Suppose the bed of basalt from which the bole was produced to have been in a comparatively soft and decomposed state at the time the pisolitic ore was deposited, that would also afford a probable explanation of the fact already mentioned, that the junction of the pisolitic bed and bole is somewhat indistinct. Some of the first precipitated ore would almost certainly find its way into the decomposed bed below, the effect of which would be to produce the appearance of a regular transition from iron ore to bole. The magnetic character of the ore is probably due to the influence of the overlying basalt whilst it was in the condition of molten lava.

It may be thought somewhat improbable that three beds, such as the pisolitic ore, the bole, and the lithomarge, should be found lying together in such intimate relations and yet two of them to have originated in one way, and the other in a manner entirely different. It may be asked why, if the pisolitic ore was precipitated from a chemical solution, should it be underlaid by bole and lithomarge ? It might as easily have been thrown down, it may be said, on unaltered basalt. But it should not be forgotten that one of the very conditions which is necessary to produce a chemical precipitate, that is the presence of water, is also one that is likely to afford the agent necessary to effect the metamorphic change which resulted in the formation of bole and lithomarge, so that these beds might have been formed at the same time or nearly so, and yet in very different ways. Besides, by adopting that view, the difficulty of explaining the absence of pisolitic ore from any of the underlying bands yielding only bole and lithomarge is avoided. On the precipitation hypothesis it need only be supposed that if the lower beds, like the upper one, were submerged in water, iron was present only during the deposition of the pisolitic ore accompanying the upper bed, or it may be that then only were the necessary organisms present to effect the precipitation.

AGE OF THE DEPOSITS.

Being inter-bedded with rocks of miocene age, it is certain that these ores are not older than middle Tertiary; nor can the pisolitic ore be younger, as it must have been formed contemporaneously with the rocks in which it occurs. The bole and lithomarge may be much younger if they are metamorphosed basalt, but the evidence afforded by the blended junction of the pisolitic ore and bole suggests that these two beds, at any rate, To illustrate Mr. J. D. Kendall's paper "On the Iron Ores of Antrim"

FIG. 1.

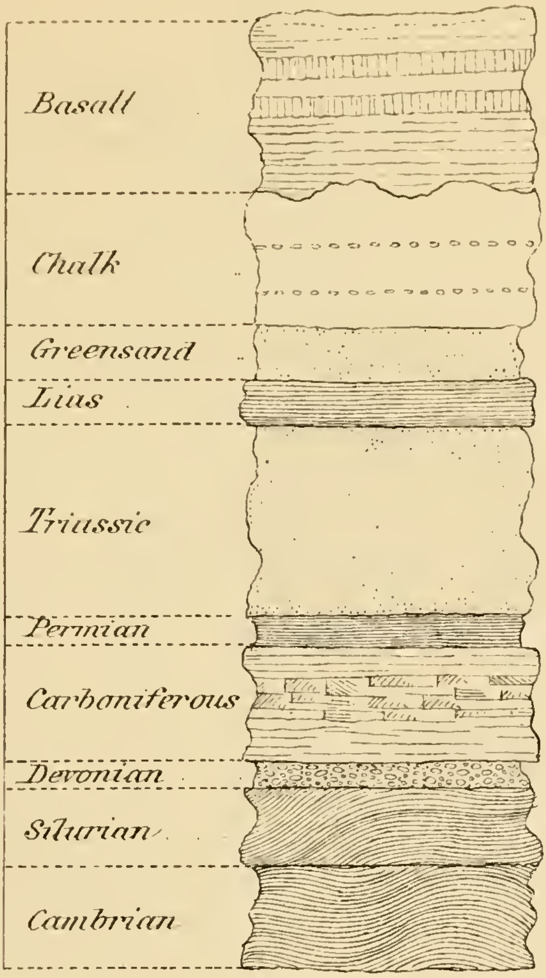
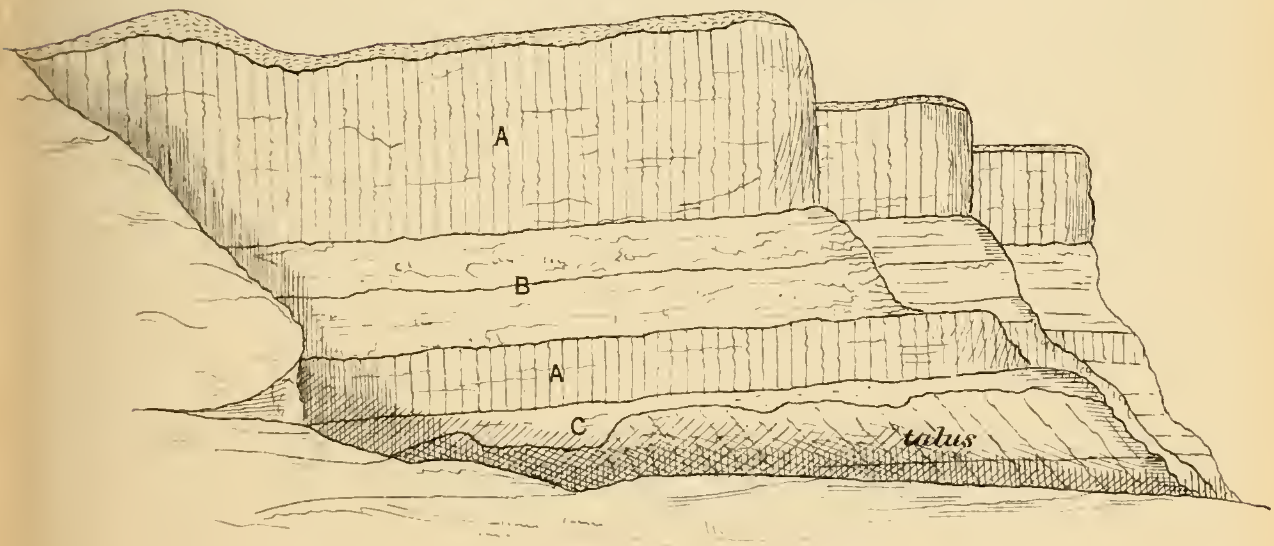


FIG. 2.



A . Columnar Basalt
B . Amorphous Basalt
C . Ferruginous Bed

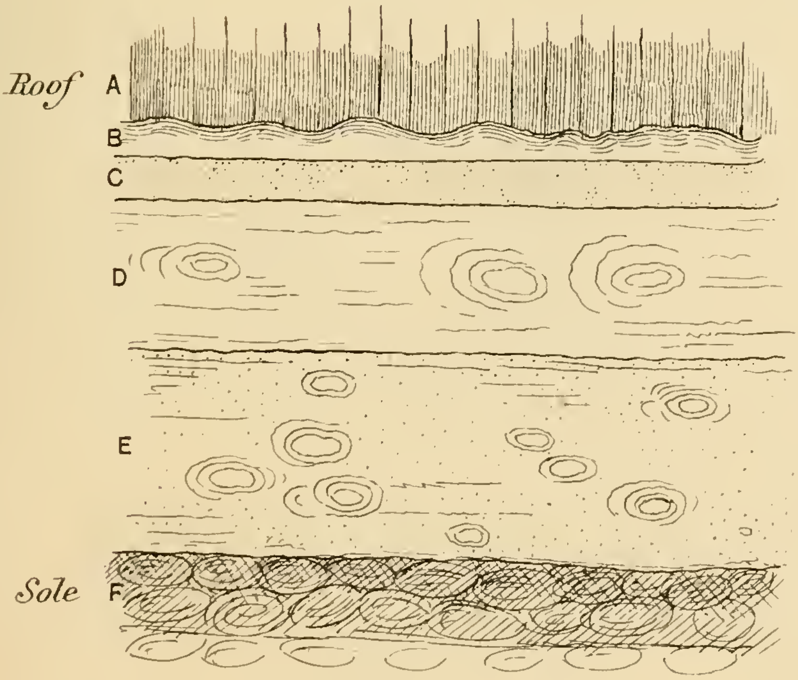
Andw Reid Newcastle

To illustrate Mr. J. D. Kendall's paper "On the Iron Ores of Antrim".

FIG. 1.

A. *Ferruginous Bands*
B. *Basalt*
C. *Chalk*

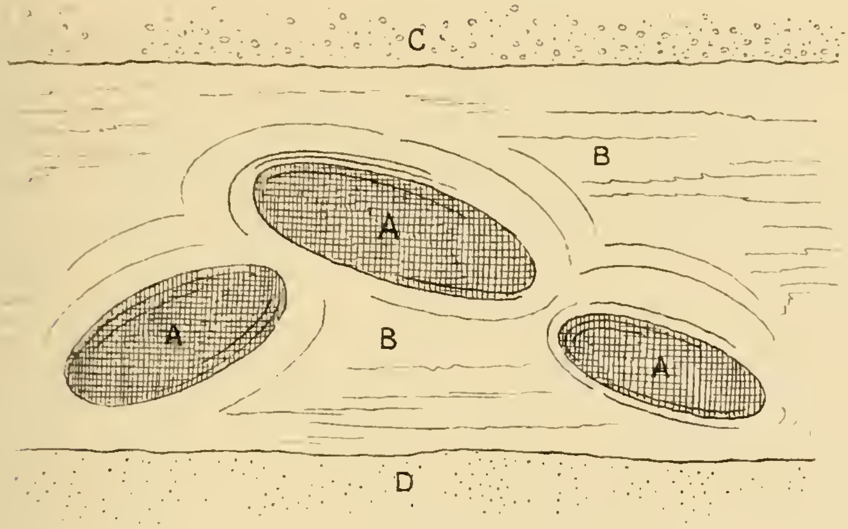
FIG. 2.



Andw Reid Newcastle

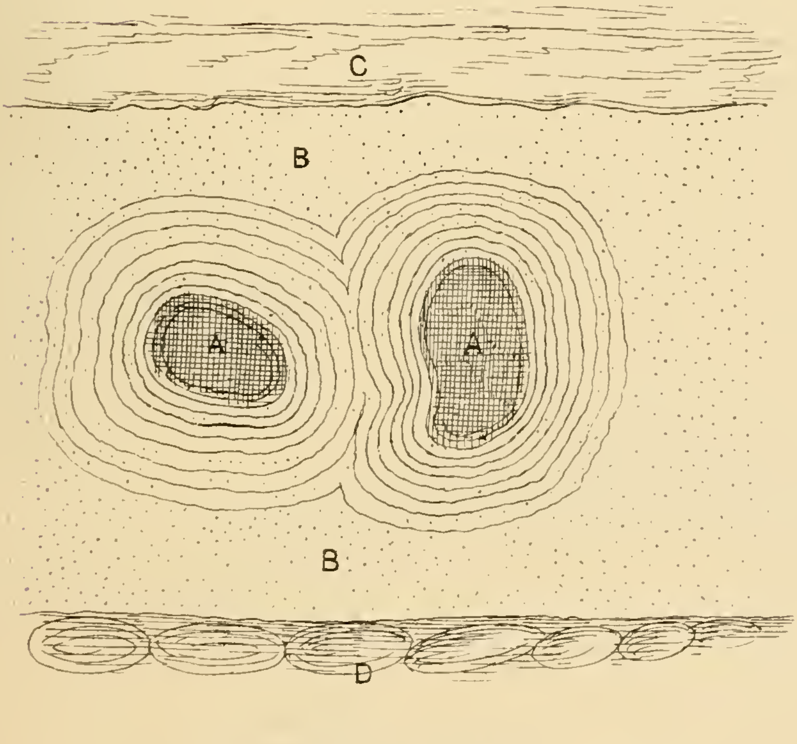
To illustrate Mr. J. D. Kendall's paper "On the Iron Ores of Antrim."

FIG. I.



A. *Nodules of Basalt*
B. *Bole*
C. *Pisolitic Ore*
D. *Lithomarge*

FIG 2.

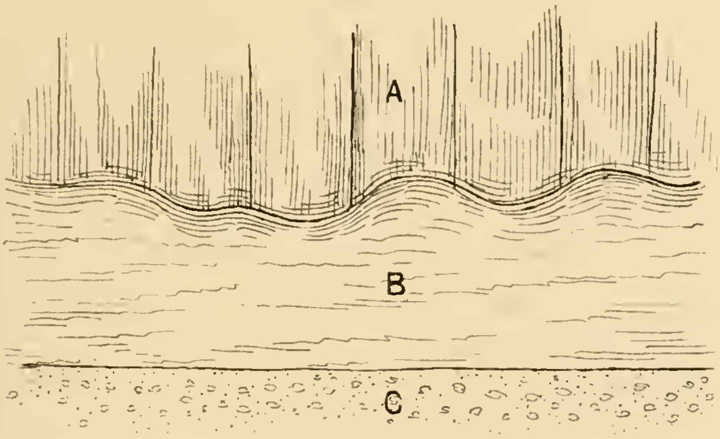


A. *Nodules of Basalt*
B. *Lithomarge*
C. *Bole*
D. *Concretionary Basalt*

Andw Reid, Newcastle

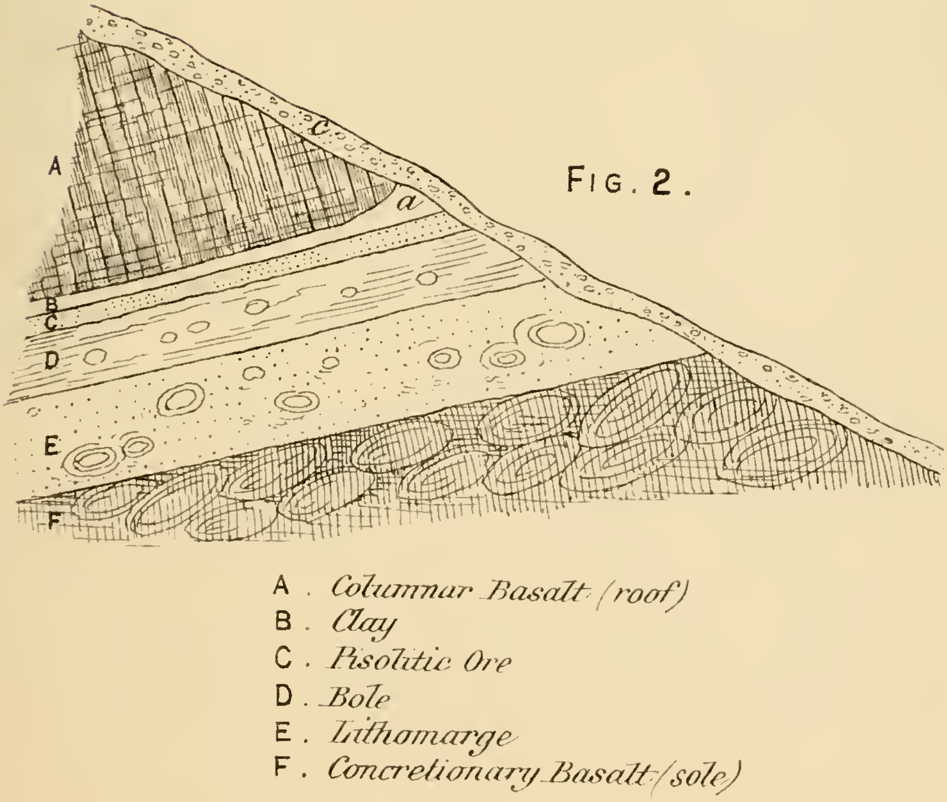
To illustrate Mr J. D. Kendall's paper "On the Iron Ores of Antrim."

FIG. I.



A . *Columnar Basalt*
B . *Clay (Laminated adjoining Basalt)*
C . *Pisolitic Ore*

FIG. 2.



A . *Columnar Basalt (roof)*
B . *Clay*
C . *Pisolitic Ore*
D . *Bole*
E . *Lithomarge*
F . *Concretionary Basalt (sole)*

Andw Reid Newcastle

originated at the same time. It is also probable that the lithomarge was produced then as well, so that the whole three beds may be dated as middle Miocene.

The CHAIRMAN said, that this paper was one of a character which deserved their best consideration. The commercial importance of the subject was evidenced by the fact that in 1860 the produce from the Antrim fields was only 20,000 tons; at the end of the next five years it had increased to nearly 100,000 tons; in 1875 it was 122,000 tons; and in 1879 it was 155,000 tons of iron ore. As there was still some other business to get through, he thought the discussion had better be postponed till the paper was printed and in the hands of the members.

Mr. J. D. Kendall's paper on the "Hematite Deposits of West Cumberland" was then discussed.

Mr. KENDALL stated that in the discussion which took place, in his absence, on his supplementary paper on this subject—which paper and discussion are together published in Vol. XXX., Part I., of the Transactions—a number of observations were made by Professor Lebour which he felt called upon to answer.

Professor Lebour asserts that his (Mr. Kendall's) explanation of these deposits is this—"That a solution of perchloride of iron coming into contact either with limestone, granite, slate, or lava, instantly alters the rock into a precipitate of red peroxide of iron."

Nowhere in the paper was the word "instantly" used in the above sense, and only in one place—Vol. XXVIII., page 148, line 30 from top—was anything said or implied at all resembling the remarks of Professor Lebour, above quoted; for nowhere but in the discussion which took place on his first paper—which discussion is published in Vol. XXVIII., page 219 of the Transactions—had he (Mr. Kendall) put forward his views as to how the replacement took place in the granite, slate, or lava. In that discussion, page 232, he stated that "he agreed with Mr. Steavenson that there is a difficulty in seeing how any solution of iron could replace granite and slate, but he had before him a specimen which came from the Boot deposit, which he thought threw very considerable light on how the replacement might have been effected. A part of this specimen was limestone, and this limestone blended off in one direction into granite, and in the other into hematite. Now, if it were supposed that the *hematite of the veins in the granite and slate were preceded by limestone,* much of Mr. Steavenson's difficulty would disappear. How the limestone got there is another question which he had not attempted to answer, but it seemed to him that it might have been produced in some such manner as the following. Suppose the rocks to be submerged in the sea, and that heated waters containing carbonate of soda were rising from below through the joints in the rocks; the silica in the walls of these joints would be slowly dissolved. Small quantities of sea water would also find their way into the rocks, and these coming into contact with the ascending alkaline waters, a reaction would ensue between the carbonate of soda and the lime salts of the sea water. The result would be a precipitate of carbonate of lime, which would take the place of the dissolved silica. The other minerals in the rocks might have been previously removed by decomposition through the influence of hydrochloric and carbonic acids."

Then, again, the supplementary paper was written for the very purpose of adducing facts in support of this double replacement, that is, to show that the veins of hematite in the slate, granite, lavas, and ashes, were originally veins of carbonate of lime and magnesia on which the perchloride of iron acted.

Again, Professor Lebour, referring to a section in the supplementary paper, speaks of it as showing a vein of " calcite and carbonate of magnesia"—that is, calcite and magnesite, two distinct minerals; but he (Mr. Kendall) found in the vein referred to only one mineral, carbonate of lime and magnesia (dolomite), which is different from either of the minerals mentioned by Professor Lebour. Would Professor Lebour be good enough to give his reasons for thus differing on a matter of fact which can be easily settled, and about which there need not be two opinions?

Speaking of the section above referred to, Professor Lebour said, that it " was a simple representation of a typical vein of any sort of ore, and those lumps of country rock in the middle of the vein were simply the 'horses' of the country rock, such as were found in almost every vein; and when these 'horses' were found they did not always occur, as Mr. Kendall seemed to assume, as boulders tumbled at hazard in the vein, but often as portions of country rock *in situ.*" Now, the pieces of country rock shown in the section—so-called boulders of Professor Lebour, but which are not boulders at all—had no connection whatever with the cheeks of the vein, as he (Mr. K.) was able to trace them from end to end along the line of the vein, that is, at right angles to the plane of the section. Some of them were only a few inches in length, whilst others were several feet.

So much by way of reply. He would now like to ask Professor Lebour for proof of the statement made by him in the discussion that "old caverns were found in the limestone filled up with hematite." What are the facts on which such an opinion is based? He (Mr. Kendall) had shown—as he thought, conclusively—by reference to an abundance of facts—and he could furnish many more if required—that *hematite was not deposited in caverns,* and he would be extremely glad to know the data which had led Professor Lebour to an opposite conclusion. The opinions of earnest workers must be formed by the facts that have come under their own observation, or by facts that are generally accepted, or by both. From which of these does Professor Lebour arrive at the opinion above stated, and how?

The point raised by the President as to the source of the perchloride of iron loses much, if not the whole, of its force when it is remembered that chloride of iron is frequently found—as already pointed out—among volcanic emanations, and that in the craters of certain volcanos peroxide of iron has been found in considerable quantities. M. Elie de Beaumont remarks ("Note sur les Emanations Volcaniques et Métallifères," page 19), that "iron as a chloride, often changing into peroxide (specular iron, *fer oligiste*), is among the most abundant of the substances derived from volcanic emanations."

Professor Lebour read the following paragraph from Mr. Kendall's original paper (Vol. XXVIII. of the Institute Transactions, p. 148):—

"For instance, if a piece of chalk is dropped into a solution of perchloride of iron, there at once sets in a reaction between them; part of the chalk is dissolved, and a red precipitate thrown down in its place. In time the chalk would disappear altogether, and nothing be left but this red precipitate. Now, that seems to be the process by which the hematite deposits were produced. The limestone, the slate, and the granite were each attacked like the chalk in the above experiment by a solution of iron, by which parts of them were removed and peroxide of iron thrown down in place thereof."

This seemed to be a sufficient justification of his (Mr. Lebour's) statement of Mr. Kendall's theory, and "at once" was fairly good English for "instantly." As to magnesite and dolomite, he thought Mr. Kendall might have given him credit for a knowledge of the difference between these minerals; the point was, however, not in any way material to the question at issue, and if he had unintentionally misquoted Mr. Kendall in this particular, he very willingly apologised for doing so. As to the "horses" of country rock shown in the diagram (page 28, Vol. XXX. of the Transactions), he had only spoken of them as they were shown in the figure, and his criticism had, he was glad to find, elicited the new and valuable facts from Mr. Kendall which were necessary for a proper comprehension of the figure.

Turning to the effect of perchloride of iron solution upon limestone, he would first note in passing that the first replacement result obtainable in that way would be a hydrated compound, the water of which would have to be got rid of in some way before hematite could be produced. In *what* way Mr. Kendall did not say. He presumed that the probable reaction contemplated by Mr. Kendall would be fairly represented by this equation:—

$$Fe_2Cl_6 + 3\ CaCO_3 = Fe_2O_3 + 3\ CaCl_2 + 3\ CO_2.$$

From this the fact was obtained that 300 parts by weight of limestone would produce only 160 parts by weight of hematite. Assuming the specific gravity of limestone to be 2·7, and that of hematite 5, a step further can be made and the relative volumes of the displaced stone and of the replacing ore found out, which would prove that 432 cubic feet of limestone could yield but 150 cubic feet of hematite. Now, was it a fact or not that many of the cavities in the carboniferous limestone, which he was not allowed to call caverns, were filled or nearly filled with hematite? If Mr. Kendall's theory were the true one, the cavities would never be even half filled with hematite. This consideration was alone sufficient to upset the theory.

Mr. Kendall asked him to prove that the cave-like cavities in limestone holding the ore were caverns. This was the general belief held by geologists, because these cavities had usually all the characters of caverns, and as the hematite was not found in them only, but filling up hollows and fissures in all manner of rocks indiscriminately, no relations of cause and effect need be suspected to exist between the ore and the containing stone. He was bound to admit that Mr. Kendall, in one at least of his beautiful drawings, had shown appearances which it was difficult to account for on the cavern theory, and possibly more evidence of the same, or even more weighty kind, might in time be brought to light. In that case the cavern theory would have to be given up, but Mr. Kendall's theory would not, he thought, be substituted for it. In conclusion, he begged to repeat what he had said at a former meeting, and to express his strong sense of the great value of Mr. Kendall's facts, and his admiration of the beautiful plates by means of which he illustrated them.

Mr. Kendall said, that Professor Lebour was still wrong in his use of the word "instantly." If they referred to the paper they would find it there stated that a *reaction at once set in*, not that a *replacement was* *at once effected*, as Professor Lebour reads it. There is no statement as to the length of time occupied by the replacement. The chemical formulæ of Professor Lebour no doubt represented the reaction that would take place under certain conditions, and the calculation based upon these formulæ was correct in *principle;* but Professor Lebour took the specific gravity of hematite too high. Instead of 5 it should only be about 3·9. Then it must not be forgotten that the hematite deposits contain a very large number of loughs, many of which are still empty, but more of which have been filled with dolomite. Besides, it is very probable that these loughs were once very much larger than they are now, and that the kidney ore which lines their walls, sometimes as much as eight inches in thickness, was formed after the amorphous ore. When to these considerations was added the effect likely to be produced by the perchloride of iron coming into contact with infiltrated sea-water containing alkaline salts, it will be seen that the mathematical test of Professor Lebour is robbed of its force and accuracy. Such a test is all very well in a laboratory, where disturbing conditions can be eliminated and quantities ascertained with precision, but it is of very little use in the question under discussion. But even supposing there were some force in it, the principle of replacement would not be affected. It was perfectly certain from the facts they knew that limestone had been replaced by hematite, no matter how the replacement had been effected. He did not, as already stated (Vol. XXVIII., page 232), bind himself to the particular kind of iron by which the replacement was effected—that is, as to whether it was perchloride of iron or carbonate of iron, or any other salt of iron; but he did say it was a replacement. That was a deduction from geological premises independent altogether of chemical considerations. He would like Professor Lebour to give them the facts upon which his opinions as to caverns were based. The general "*belief* of geologists" does not justify the positive statement that "old caverns were found in the limestone filled up with hematite," unless that belief is based on facts. If it is so based, what are the facts? The cavities in the limestone holding hematite have not usually all the characters of caverns, as Professor Lebour says, and by carefully reading the paper he will find that out. He (Mr. Kendall) had given a great number of facts to show that hematite was not deposited in caverns. If Professor Lebour could bring forward others showing that it was, he (Mr. Kendall) would try to prove that the arguments based on these facts were inconclusive; if he could not do so, he would give up his present position, and say at once that in some cases hematite had been thrown down in caverns. He was sure the members of the Institute would appreciate very highly any paper Professor Lebour might bring forward upon this matter.

Professor Lebour said that Mr. Kendall had so explained his meaning that they were now more of one mind than they were. If Mr. Kendall had been present at the last meeting, they could have had the matter settled in five minutes.

Mr. Kendall—He differed as much as ever from Professor Lebour so far as the caverns are concerned.

Professor Lebour—But the perchloride of iron is given up altogether.

Mr. Kendall—No, it is not; but it may be wrong. As stated in Vol. XXVIII., page 231, "the *pith* of the paper was in the attempt to prove that the ore had been formed by replacement," and on that point he invited Professor Lebour's criticisms.

The meeting then concluded.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, MARCH 5TH, 1881, IN THE WOOD MEMORIAL HALL.

G. C. GREENWELL, Esq., President, in the Chair.

The Secretary read the minutes of the last general meeting and reported the proceedings of the Council.

The following gentlemen were elected :—

Associate Members—

Mr. Joseph Pringle, Manager, Coxlodge Colliery, South Gosforth, Newcastle-on-Tyne.
Mr. Walter Merivale, C.E., Engineers' Office, Central Station, Newcastle-on-Tyne.

Professor G. A. Lebour read the following paper :—

THE MINERAL RESOURCES OF THE COUNTRY BETWEEN ROTHBURY AND WOOLER, NORTHUMBERLAND.

BY G. A. LEBOUR, M.A., F.G.S.,

PROFESSOR OF GEOLOGY IN THE UNIVERSITY OF DURHAM COLLEGE OF PHYSICAL SCIENCE,
NEWCASTLE-ON-TYNE.

WITHIN the last few months it has been repeatedly stated by those who are anxious that a railway should be constructed between the Tyne and the Tweed across Central Northumberland that the country to be thus traversed was interesting and valuable from an agricultural point of view only. The object of the present paper is to bring the light of geological observation to bear upon the subject, and to show that, although the region in question is undoubtedly primarily an agricultural one, there are yet not a few natural resources within it which may fairly be classed under the head of " Minerals," using the term in its ordinary or non-scientific sense.

GEOLOGY OF THE DISTRICT.

The chief features of the geology of the district will easily be understood by glancing at the accompanying sketch map and sections, Plates XXVII. and XXVIII.

The chief rocks exposed are the following, in descending order, the Drift and Alluvial Deposits being omitted as unnecessary for the purposes of this inquiry :—

5.—The Lower Bernician Rocks, or Lower Carboniferous Limestone series, consisting of thick grits and sandstones, shales (some of them with clay ironstone), numerous beds of marine limestone, under-clays, and coals.

4.—The Tuedian Beds, or Calciferous Sandstone series, consisting of grits and sandstones, shales, and beds of impure limestone.

3.—The Basement Beds, or Upper Old Red Sandstone, consisting chiefly of reddish grits and conglomerates.

2.—Silurian Clay Slates.

1.—The Cheviot Rocks, consisting of granite, syenite, porphyrite, dolerite, ashes, and breccia.

Of these five divisions No. 2, 3, 4, and 5, are sedimentary. No. 1 is igneous. The high ground is formed of the latter, the lower of the former. The useful products afforded by these rocks may be noticed under the following heads, viz.:—Building stones, ornamental stones, limestones, cement stones, clays, coal, and metalliferous ores.

BUILDING STONES.

Those at present in use are almost exclusively the grits and sandstones of the Bernician and Tuedian Groups. These occur of considerable thickness and with every variety of grain from the coarsest to the finest. Perhaps the best of these is that quarried on Biddlestone Edge, near Burradon, a stone which has furnished the material for many of the large and well-built mansions of the neighbourhood. The grits of Rothbury and Chillingham are good examples of these stones, but they are so generally present throughout the non-eruptive portion of the region that it is needless to further particularize them.

In the Cheviot hills, however, other kinds of stone occur which have seldom, if ever, been made use of for anything better than dry-wall making, but which could with advantage be employed for higher purposes were the localities in which they are found rendered more easily accessible. On the other side of the Border the igneous rocks of which these hills are formed are not allowed to remain untouched, witness the church at Yetholm, which is built of pitchstone porphyry, a kind of glassy felsite which is also found, though not in such large quantities, near Wooler. Again, the granite and syenite, with the intermediate varieties of granitic syenite and syenitic granite (so named according as mica or hornblende predominates) of Cheviot, Lousey Crag, Langleehope, Akeld, Yevering, Reaveley, Linhope, Staindrop, and many other places, although often too full of joints for remunerative quarrying, would, in well-selected spots, yield blocks of very large size and of very handsome grain. The porphyrites again might furnish, under similar conditions, building stone of great value for decorative architecture. They consist of a felsitic base in which are imbedded large and small crystals of felspar. As a rule they are much fissured, but there are many places where this is not the case, and where large supplies of good-sized blocks could easily be obtained, such, for instance, as near Biddlestone Hall, where the stone is a bright red porphyry, most beautiful after rain, and near Akeld, where it is of a rich chocolate brown speckled with white. The red porphyrite is the most widely distributed.

ORNAMENTAL STONES.

The red porphyritic felsites mentioned above might well claim a place under this head also, but they must yield precedence to what, for want of a better name, may be called the Ingram stone. This is a most beautiful quartzose breccia that occurs close to the village of Ingram, and at several places in the neighbourhood. It is formed of a number of sub-angular fragments of quartz, held together by a siliceous cement, and the whole, matrix and inclusions, are bright red. The stone is excessively hard, and is capable of receiving a perfect polish. Indeed a more handsome or less-known material for monuments of great durability is not to be met with. The only case in which, to the writer's knowledge, it has been utilized, is in the churchyard at Ingram, where a large block, a small portion of which only has been polished, was a few years ago placed as a memorial to some of the victims of the Abbots-Ripton accident. Perhaps the numerous geodic agates which are found in the amygdaloidal felsites of the Cheviots, at the Ridlees, at Akeld, and elsewhere, should be mentioned here.

LIMESTONES.

The only limestones worth burning for lime occur in the Bernician series, and they improve in quality for this purpose the higher they are in that series. Towards the base they become impure, in some cases cherty, and in others oolitic, *i.e.*, consisting of many-coated small spheroidal concretions.* The latter character does not, however, appear to impair the quality of the stone to any great extent, as, for example, at Hetchester on the Coquet above Rothbury, where beds of this nature are extensively quarried and burned. That many of the limestones are fit for burning is proved by the number of lime-kilns that are found dotting the country here and there along their outcrops throughout the Bernician area. Few of the beds, however, can compare with the Great Limestone of Greenleighton, or the Four Fathom Limestone of Elf Hills, as agricultural limestones, and it is quite possible that new railway facilities might diminish the working and burning of these lower Bernician calcareous bands.

CEMENT STONES.

The Calciferous Sandstone series of Scotland, has long been known as to its upper and more typical part, for the numerous beds of cement stone and bituminous shale which it contains. In the Tuedian of North-

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* Note.—These beds may possibly be really of the Upper Tuedian age.

umberland the oil shales are absent—or at all events have not yet been found—but the cement stones are present. These beds represent the limestones of the Bernician series above; indeed they are limestones themselves, but with such an admixture of impurities, argillaceous and ferruginous, as to be quite unfit for the ordinary purposes to which ordinary limestones may be put. But if as limestones these beds be most impure, for the purposes of cement manufacture they are excellent, and there seems to be no good reason why cement making should not become as flourishing an industry in Northumberland as it is in Scotland. Trials of some of the Tuedian cement stones have been made on a very small scale and with the best results, but the beds vary in thickness (rarely attaining fifteen feet), are anything but constant over large areas, and their composition is doubtless variable likewise, so that special processes would be required for the treatment of the stone in different cases. It is right to point out these difficulties, none of which, however, seem to be at all insurmountable.

CLAYS.

The Cheviot Rocks being all felspathic, the tendency of their disintegration and decomposition is to produce clays more or less of the nature of the Kaolin or china clay of Cornwall and Devon. Accordingly the writer has found clay of this kind, but not of the purest, occurring as the infilling of fissures at several spots within the porphyritic hills. At none of these places were the deposits of sufficient importance to suggest the possibility of their ever being worked profitably, but enough was seen to justify a search among these rocks for deposits of similar nature and of larger extent. It is even possible that in some cases where the stone is deeply weathered, it might pay to wash down the decomposed felspar after the Cornish fashion.

Of brick-earths and coarse potter's clays there are plenty in the drifts which obscure and mask the older rocks of the district, more especially in the old lake basin of Flodden, north of Wooler.

COALS.

The seams of coal are all in the Bernician series. They are thin and not of the best quality, but several of them have been and some are still worked for landsale purposes. Some of the seams are well known, such as the following, given in descending order:—

The *Fawcet* or *Caldside* coal, worked at Doddington, Biter Bit (or Biteabout), Chatton, &c., varying from 1 foot 3 inches to 3 feet.

The *Craw* or *Main* coal, worked at Eglingham and Chatton. This is the second best coal in the district. According to the late Mr. G. Tate, F.G.S., it is from 2 feet 6 inches to 5 feet thick, is a strong coal, but leaves a considerable residue after burning; some portions were formerly used at smithies, when sea-borne coal was taxed.

The *Hardy* or *Stony* coal, worked at Ford and Lemmington, with a maximum of 3 feet.

The *Main* or *Bulman* coal, worked at Doddington, Barmoor, Chatton, Eglingham, &c., a good steam coal varying from 2 feet to 6 feet 2 inches. The best coal in the district.

The *Three-Quarter, Cooper Eye,* and *Wester* coals, each with a maximum of about 3 feet, three poor seams, below which none are known to be workable.*

ORES.

These are probably the least valuable mineral products of the district, but it may be as well to enumerate those that are known to be present. Iron ores occur as clay-ironstone in the Bernician, and, to a less extent, in the Tuedian shales, but not, so far as the writer is aware, anywhere in workable quantities unless the Brinkburn ironstone shale be regarded as coming within the limit of the paper, in which case the Shilbottle coal, and some beds of "Gannister" would have to be included likewise. Mr. Tate records hematite as having been seen in a vein near to Harthope. Copper has been very frequently said to have been found in various localities in the Cheviots, as, for instance, at the Ridlees in Upper Coquetdale. The writer believes all such cases to be apocryphal; green earth, or glauconite, which is very common in the porphyrites and their associated rocks, having probably been mistaken for it. In the same way gold has more than once been recorded as a Cheviot mineral, yellow mica having given rise to the story. Lead is commonly said by miners not to occur among the Cheviot Rocks. There is, however, a very distinct lead vein, which anyone can see, at a place called Raven's Cleugh, a little to the north of Alwinton. There are also indications of veins in the neighbourhood of Ingram, and it is very unlikely indeed that these should be the only lodes in these hills.

CONCLUSION.

The list of the mineral resources known to the writer as occurring in the district under consideration is now ended. Probably the cement-

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* Much information respecting these seams is to be found in the late Mr. Tate's papers in the Berwickshire Transactions.

stones of the Tuedian, met with as they are quite near to workable seams of coal, may prove to be in the future, in conjunction with these coals, of greater importance to Northern Mid-Northumberland than any of the other products enumerated.

The PRESIDENT asked the Professor if the granite discovered in the basaltic dyke gradually changed from basalt in the same way as at Portrush?

Professor LEBOUR replied, that the points of junction between the porphyrites and granite unfortunately occurred where the flanks of the hills were covered with peat, which in that district was often of very great thickness; and the result was that these points of junction between the different kinds of rocks were very rarely seen. This was one of the great drawbacks to Cheviot geologizing, and so much so that he had never seen a junction between the granite and the porphyrites.

The PRESIDENT said, they must be very much obliged to Mr. Lebour for having taken so much pains in giving them that paper. It would perhaps give rise to discussion as to whether the resources he had described would be sufficient to add very materially to the traffic of a public railway; but a railway might give rise to certain employments and development of the district. He confessed he did not think the enumeration of the resources of the district gave much hope, but he would be very glad to hear what any gentleman had to say.

Professor LEBOUR, in answer to a question by Mr. Bewick, said the lead ore which had been found to the north of Alwinton was not on the line of dyke shown on his (the Professor's) geological map, but was north, not in connection with any basaltic dyke, and the vein was an east and west one. It had never been worked, or even attempted to be worked, although it is perfectly visible, and is one of the most beautiful veins that can be seen anywhere in the field. The seams of coal were of variable thickness from 3 feet to 6 feet, and ought to be valuable. They were worked at a number of different places, which he mentioned, but the want of railway communication had always prevented these collieries becoming anything more than landsale collieries, and supplying coal for burning lime. The coals are, however, of good quality, and used for blacksmiths' purposes.

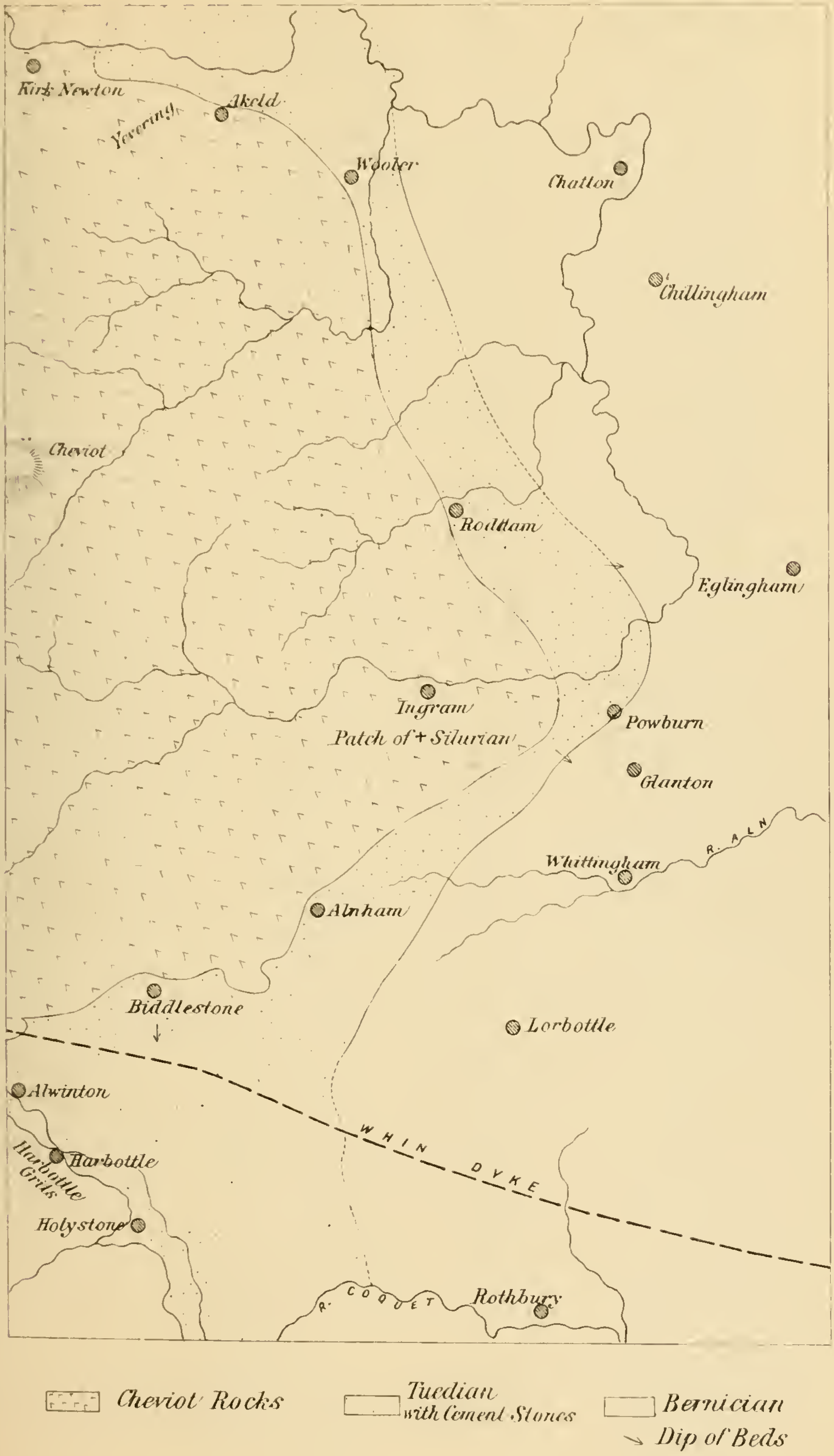
Mr. D. P. MORISON supposed that the whole of the series was limestone coal—not coal from the true coal measures.

Professor LEBOUR—Yes, all were in the Bernician series; and there was an interesting point, geologically, which he had omitted to point out in his paper. In this particular district, in a line due south-west

SKETCH MAP.

To illustrate Mr G. A. Lebour's paper "On the Mineral Resources of the Country between Rothbury and Wooler."

Scale 3 miles = 1 inch.



Andw Reid Newcastle

To illustrate Mr. G. A. Lebour's paper "On the Mineral Resources of the Country between Rothbury and Wooler."

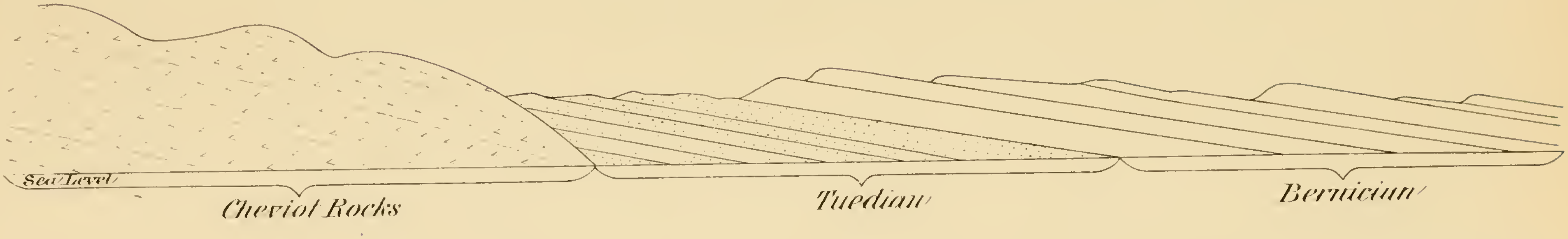


FIG. 1 _ SKETCH SECTION SHEWING GENERAL ARRANGEMENT OF THE ROCK-MASSES FROM THE CHEVIOT IN ANY DIRECTION ALONG THE DIP.

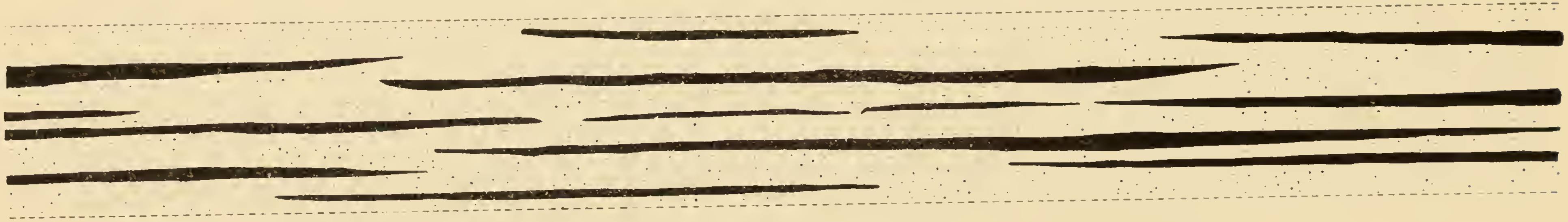


FIG. 2 _ DIAGRAM SECTION IN DIRECTION OF STRIKE SHEWING THE IRREGULAR DISTRIBUTION OF THE CEMENT STONES (BLACK) IN THE TUEDIAN SERIES _ THE DOTTED PORTION REPRESENTS THE OTHER BEDS OF THAT SERIES.

Andw Reid Newcastle

of this, there was the very greatest thickness of Carboniferous Limestone to be found anywhere in Britain, or, as far as he knew, in the world, the only approach to it being in the Kulm of Silesia. When he wrote his little book, "Outlines of the Geology of Northumberland," he thought he was going very far in saying that the series was at least 8,000 feet thick. That was against all preconceived notions; but now he was happy to say that the work of Topley, Gunn, and others of the Geological Survey, in Northumberland, had proved the statement to be under the true thickness, which was probably from 10,000 to 11,000 feet. It is not the widest part of the outcrop where there is the greatest thickness.

Mr. T. J. BEWICK said that in Yorkshire there were fewer shales and sandstones alternating with the beds of limestones; and northwards into this district the shales and sandstones increased in thickness, whilst there was probably no diminution in the aggregate depth of the limestone —which might even be thicker.

Professor LEBOUR thought that this was hardly the case, and that probably, if the beds of limestone in this district were all added together, they would not be so thick as those in Yorkshire; but they were infinitely more divided, and probably there were not fewer than twenty or thirty thin beds.

Mr. T. J. BEWICK asked Professor Lebour if he had any idea whether, if the Northumberland Central Railway was made through this district, it would lead to any development of its mineral resources?

Professor LEBOUR could not venture an opinion; it would be rather too much like a prediction. He thought he had understated the riches of the district; if he had been advocating the merits of the railway, he would probably have stated the case more strongly than he had done; but he had wished simply to give an account of the resources existing in the district which he knew, without making them appear better than they were. He thought, on the whole, that the cement beds would be the most important feature of the district at present, and there might be lead veins which would ultimately materially increase its prosperity.

The PRESIDENT proposed a vote of thanks to Professor Lebour for his very interesting paper. Perhaps it had opened the ground for a little further discussion, which he hoped it would receive.

Mr. T. J. BEWICK seconded the vote of thanks, and it was carried by acclamation.

The SECRETARY read the following "Account of a Discharge of Lightning at Kimblesworth Colliery," by Mr. John Daglish:—

ACCOUNT OF A DISCHARGE OF LIGHTNING AT KIMBLESWORTH COLLIERY, ON JULY 12TH, 1880.

BY JOHN DAGLISH.

The following evidence was taken down at the time of the occurrence:—

Mr. TATE, Manager, was in the colliery office (see Plate XXIX.), 80 yards from the shaft (3·41 p.m.) The thunder-storm was very near, the lightning very vivid, and the thunder very loud. The office was struck by the lightning at the corner *x*, where the telegraph wire enters. From the appearance of the damage done, it seems probable that the lightning passed along on the telegraph wires up to where they are attached to the office, where it divided, one portion running down the smaller wires to the telegraph instrument, melting and destroying them and sprinkling the gutta-percha over several parts of the office; the corner of the office was blackened twelve inches on each side of where these wires stood, and the small wood box surrounding them was splintered into innumerable small pieces. The larger portion of the lightning had been apparently discharged on to the office roof, carrying away many of the slates. Considerable damage was done to the interior of the office, portions of plaster being removed, and in some parts the wall scored down deeply, as if by a nail. As the damage was done in different parts of the office, apparently the discharge from the roof had been from several points. Twenty-one panes of glass were broken in different parts. The office was filled with smoke, a strong smell of burning pervading, and a detonation was heard resembling that made by the discharge of a large cannon. The lightning conductor of the large boiler chimney at the pit was struck and damaged about the same time.

GEORGE STRONG, Clerk, was in the office with Mr. Tate. Corroborates Mr. Tate's statements. Suffered from the effects for some time after.

SAMUEL BOSWELL, Onsetter, was at the bottom of the Kimblesworth Pit (100 yards deep), at A, on the north side of the downcast shaft. About 3·30 p.m. saw a bright flash, just as he was about to rap. He stood back; was stupified; heard a loud peal of thunder simultaneously with the flash.

John Ord, Onsetter, was on the north side of the shaft at A; saw a flash of light, and thought he saw it go in-bye.

Frederick Hodgin, coupling up wagons at bottom of shaft, was about 15 yards off the shaft on the north side at B, with his back to the shaft; saw a bright light which apparently passed off the drum of the underground engine (situated 20 yards north of the shaft), thought it was lightning, but heard no thunder, as the engine was running.

John Tate, Back-overman, was at the shaft bottom on the north side at B, facing towards the shaft. Saw a flash; heard R. Thirlwell say at once, "There is something gone off the drum of the engine," and he said, "I think it is lightning."

Robert Thirlwell, Engine Drum Boy, was in the engine-house on the north side of the shaft at C (9 feet above the wagonway), was looking in-bye; saw a flash, which lighted up the place; shouted to his father, "There is a flash of lightning gone in-bye;" then he heard the onsetter speaking about it. The impression on everyone was that a flash of lightning had come down the pit and gone into the workings.

John Robinson (17), attending the underground pumping-engine, had just come through the doors from the "return" where the pump is placed, into the "intake" close to the hauling-engine at D, saw a number of sparks at the joint of the compressed air pipes, and also heard a crackling noise; thought a bolt of the joint had broken; went and told the onsetter, who said lightning had come down the pit.

William Atkinson (18), wagonwayman, was at the south way ends at E (100 yards south from the shaft); the shaft cannot be seen from this point, as there is a bend in the road, saw a light, like sparks, fly out of the rope where it is socketed, with a crackling noise; had no idea of what it was; then a boy came from the shaft and said that lightning had come down the pit.

Luke Thew (17), attending to the rope off-take, was near Atkinson at south way end (100 yards from shaft), saw a bright light at the socket, heard no noise.

Mr. Tate, in answer to a question from Mr. Bewick, stated that no effects were produced in the pit beyond what was stated in the paper. There was no note of the lightning having been seen further in-bye than was there described.

Mr. Bunning then read the following letter from Mr. John Brown, the President-Elect of the North Staffordshire Institute of Mining and Mechanical Engineers:—

The Hawthorns,
3, Lozells Road, Birmingham,
18*th January*, 1881.

Dear Sir,—I have been reading the interesting account of the Lightning at Tanfield Moor Colliery in the last number of your Transactions.

About ten years ago it was reported to me at the Cannock Chase Collieries that the lightning had struck the pulleys at the No. 8 North Pit, and had gone down the round wire rope and alarmed the man at the pit bottom by a flash or report, or both (I forget which).

I remember that there was not anything said as to it traversing the workings, which were then only exploring headways in very faulty ground, and the roads wet and dirty.

I believe the effect was not observed beyond the plates or "flat sheets" at the pit bottom.

The pit was a little more than 300 yards deep; the surface works in an elevated and exposed situation, so I determined to have a lightning conductor fixed to the pit frame and above the pulleys, and this was done by Messrs. Bailey and Son, of Salford, Manchester.

The lightning could only have passed down the shaft by the rope, as there was no other metallic conductor excepting a signal wire; but I do not recollect anything having been said of there being any discharge into the engine-house.

Yours faithfully,
JOHN BROWN,
President-Elect of the North Staffordshire Institute
of Engineers.

Theo. Wood Bunning, Esq.,
Newcastle-on-Tyne.

Mr. Tate, continuing his remarks, stated that the ropes go within a few inches of the iron guides, and that two of the boys and men at B, who were mentioned, had their backs to the shaft and saw the light; but the two onsetters were facing the shaft at A.

The President said, that the lightning went down the Tanfield Moor and Kimblesworth pits at nearly the same time on the 12th of July, so that apparently it was in the same storm.

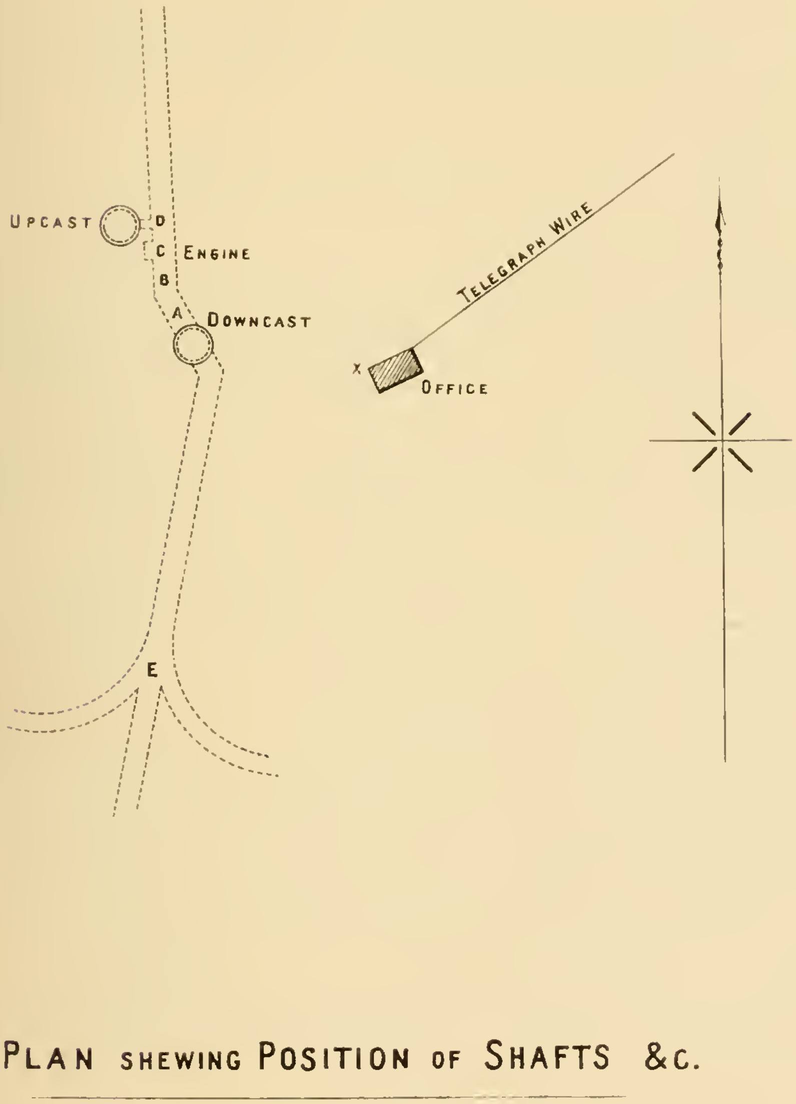
Mr. Tate, in answer to Professor Herschel, said that there was a small lightning conductor over the telegraph office on the top of the telegraph pole, but the conductor was destroyed; in fact all the wires were destroyed within 110 yards of the office, and had to be renewed.

The President said, it seemed to him strange that in the whole of the years which had passed bye, accidents of this kind had not been recorded; but he thought that what they had now heard would probably induce managers to take more notice of similar phenomena in future.

It had been thought very likely by some people that the explosion which took place at Risca was owing to lightning going down the pit; as there was a very severe thunderstorm at the time the accident happened. If they found that lightning went down pit shafts, they should try to prevent it from doing so. He thought the members would agree that they were very much obliged to Mr. Daglish for having brought these facts forward. They had heard of one particular case, and when that became corroborated by almost a similar one happening elsewhere about the same time, it very much strengthened the first account they heard, and probably they might obtain much more information now that their attention had been directed to the subject. In conclusion, he proposed a vote of thanks to Mr. Daglish. The proposal was seconded by Mr. Bewick, and having been carried by acclamation, the meeting separated.

To illustrate Mr. John Daglish's notes

"On a Discharge of Lightning at Kimblesworth Colliery."



PLAN SHEWING POSITION OF SHAFTS &C.

KIMBLESWORTH COLLIERY.

SCALE $\frac{1}{2500}$

FULL LINES, SURFACE. DOTTED, UNDERGROUND WAYS.

eedings N. E I of M&M.E 1880-81

Andw Reid Newcastle

PROCEEDINGS.

GENERAL MEETING, SATURDAY, APRIL 2nd, 1881, IN THE WOOD MEMORIAL HALL, NEWCASTLE-ON-TYNE.

G. C. GREENWELL, Esq., President, in the Chair.

The Secretary read the minutes of the last meeting and reported the proceedings of the Council.

The following gentlemen were nominated for election :—

Ordinary Member—

Mr. David Morgan Llewellin, F.G.S., Civil and Mining Engineer, Glanwern Offices, Pontypool.

Associate Member—

Mr. James Tait, Estate Agent, Garmondsway Moor, Coxhoe.

The Secretary said that Mr. Charles Parkin, who was absent, had requested him to read his paper "On the Treatment of Ores."

Mr. Bewick said there was a small attendance; the paper was a long one, and contained many statistics which they could not very well carry in their heads, and he moved that the paper be printed and issued before being discussed.

Professor Lebour seconded the motion, which was agreed to.

THE STEPHENSON CENTENARY.

The Secretary stated that he had spoken to the Mayor a few days ago as to the desirability of the authorities of the town taking some steps to celebrate the Centenary of the birth of George Stephenson in a manner worthy of the town that might be said to represent the district in which he was born, and that the proposal had been most enthusiastically received.

The President observed that he had that day attended a large and influential meeting that had been called by the Mayor to consider the subject, and had proposed that the most suitable way of identifying the name of Stephenson with the town would be to erect a spacious and handsome building for the College of Physical Science which had for the last eight years been established in the town under the auspices of the University of Durham; and this proposition had been so well received that it was carried unanimously.

Mr. Simpson proposed "That this meeting hears with satisfaction the proposal that has been adopted at the meeting held at the Town Hall to-day with respect to the George Stephenson Centenary, and the members present pledge themselves, both individually and collectively, to do all they can to ensure its success."

Mr. Bewick seconded the motion, which was agreed to, and this concluded the business of the meeting.

ON THE TREATMENT OF ORES.

By CHARLES PARKIN.

It is intended in this paper to give some description of the machinery and appliances used in dressing tin, copper, lead, and other ores in Cornwall, based upon the writer's observations made in the country during the last six years.

Although vast improvement has been made in the underground branch of mining operations in this country, the dressing department has been greatly neglected, and Cornishmen have been slow in taking up the scientific advantages which have been at their command; there is, however, in many cases, every excuse for their reluctance in adopting so-called improved machinery, when it is considered that much of what they have adopted has had to be abandoned as utterly useless, and that in many cases the working expenses and cost of the improved appliance place it beyond the means of the mine owners.

The old adage that "necessity is the mother of invention" has been peculiarly applicable in this instance, for the deplorable state of Cornish mining during the late period of depression, coupled with the strong competition with the colonies, more especially in the tin trade, made it absolutely imperative to invent, and to adopt, every mechanical means possible to reduce the cost of rendering the ores fit for market, and the consequence is that great progress has been made during the past few years by the introduction of new and improved machinery, to supersede, as far as practicable, the expensive treatment which had been carried on hitherto by manual labour alone, the result of which shows a considerable saving in each department.

CRUSHING.

The following remarks will apply more especially to tin, but to some extent, the same treatment is observed in dressing lead, copper, and other ores. The first process through which the ore passes on its arrival at surface, is that of breaking it down to a suitable size for the stamps; until recently this operation has been solely performed by hand labour under the style of "spalling" and "ragging," but Blake's stone-crusher is now being used for this work at many of the mines with satisfactory results. As most of the members of this Institute will no doubt be fully acquainted with the construction of this machine, the patent of Mr. H. R. Marsden, Soho Foundry, Leeds, it will not be necessary to give any detailed description of it here more than bears on its use in the present instance.

The action of the machine consists of subjecting the rock dropped between the two jaws to a succession of bites, until it is sufficiently crushed to pass out at the bottom, the size can be regulated at pleasure by changing the cast iron plates, and putting in narrower or broader ones. It seems to be a mistake to try to reduce the stuff too small at one operation (the best distance to leave the jaw open at the bottom is from 2 to 2½ inches), should it be necessary to reduce the ore to a smaller size, it would be better either to pass it through a second time with the jaw set closer, or to allow the stuff to fall into another machine. The patent combined arrangement of working two machines together, the larger one being a 15 inch or 20 inch × 9 inch and the smaller one a 12 inch × 5 inch seems advantageous, as it crushes the whole of the rock down to a given size with once handling, the larger stone being dropped from the larger machine into the hopper of the smaller machine. This latter plan is most desirable, also, because, when large stones are put into the large crusher and reduced at one operation into small, a good deal of power is lost; and, again, by having two machines an opportunity is offered of throwing away between the two operations any part of the stone which may contain no mineral, for often stones are met with, especially in the case of copper, of perhaps 12 inches cube, one half of which is clear spar. Another advantage in this machine is that in crushing the ore, in addition to its being broken into small pieces, it is partly disintegrated irrespective of joints or faces, and the strength of the rock is so destroyed that the stamps do nearly twice the duty upon ore crushed by this machine as upon ore "spalled" by hand labour. Where the stuff is not stamped after leaving the stone-crusher, as in some cases in lead and copper mines, and where it must in consequence be brought down to a much finer degree than in the case of tin, two machines would be undoubtedly best.

An important consideration is the position in which the machine is placed. At one mine where this crusher is used and worked by two men and a boy, 100 tons per day is passed through and carried direct to the stamps below without hand labour. In another case two boys, paid 9d. per day each, attended a small hand machine, and the amount of work done was equal to that which had previously cost 9s. per day.

Mr. Campbell in his paper read before the Cornwall Mining Institute says that—

Even allowing that in some cases considerable alteration would have to be made to place the stone-breaker as it should be placed to become a labour-saving machine, a very great economy would still be effected by the use of such a machine or machines, especially where the rock is hard, and where large quantities of ore have to be dealt with. The following figures were kindly supplied me by Captain Tregay, of Pedu-an-drea Mines, and although the stuff in different mines varies greatly in hardness, toughness, quantity to be dealt with, etc., they will, I hope, give some idea of the economy effected by the substitution of these machines over hand labour. Before reading out the figures I would remind you that in many cases the advantages in favour of the machine would be greater than here shown, as for instance where the cost of hand breaking is greater, etc. The cost of alteration would also be in some cases much less.

HAND LABOUR.

		Per 10 Tons. s.	d.
Cost of breaking		6	4
Deduct for dividing		1	3
	10	5	1
Or per ton			$6\frac{1}{10}$

BY STONE-BREAKER.

First cost of 20 inch × 9 inch machine	£400
Alterations in floors	300
	£700

	s.	d.		s.	d.
Interest on this sum @ 5 % assuming 50 tons to be put through the breaker per day					$5\frac{1}{4}$
Wear and tear					4
Coal and grease					4
Labour costs	3	3			
Deduct for dividing	1	3	=	2	$0\frac{1}{2}$
			10	3	$1\frac{3}{4}$
Or per ton					$3\frac{3}{4}$

Hand labour	$6\frac{1}{10}$d.
Machine	$3\frac{3}{4}$d.
	$2\frac{7}{20}$d. per ton in favour of machine.

In this case, where the cost of hand "spalling" is calculated at rather below the average at many mines, and a very heavy charge is assumed for the alterations of the floors, there is yet a balance of more than $2\frac{1}{4}$d. per ton in favour of the machine. It is easy to conceive that under different circumstances this saving might amount to 4d., and even more per ton.

The introduction of this machine into the Cornish mines has lessened the labour cost in a wonderful manner, and there is no doubt that the stamps will do considerably more work if the ore is first broken by it. Fully 25 per cent. more has been done in one or two experiments, where instead of stamping 34 cwts. 3 qrs. of tin ore per day on a consumption of 61·3 lbs. of coal per ton of tin ore, 44 cwts. have been stamped on a consumption of 48 lbs. of coal per ton.

STAMPING

Is the next process through which the ore is put after leaving the stone-crusher, and is about the same in principle now as it was in the earliest historic days, only improved and adopted on a larger scale.

There are many points to be taken into consideration to obtain good duty from the stamping machinery, and to economise fuel; and foremost amongst the conditions which should have particular attention are the following, viz.:—

1.—An engine and buildings sufficiently strong and powerful to allow of a high expansion of steam, with boilers of the best construction, to work high pressure steam, and of sufficient heating surface without forcing the fires.
2.—The proper loading of the fly-wheel.
3.—Stamp heads and lifters of increased weight.
4.—To lay the bed of the stamps firmly on a floor, which should be set two and a half inches below the grate.
5.—The choice of a suitable site, so that the ores can be put through the different processes, by their own gravitation, without being lifted by hand labour.

The ordinary cam stamps, Plate XXX., require little or no further explanation than is given in the plate. They are arranged in boxes in sets of four, Fig. 1, and are moved by cams *a*, Fig. 2. The height of the lift is 10½ inches, and each stamp head weighs 6½ cwts., making sixty falls a minute, and stamping a ton of stuff in every twenty-four hours. This is a very slow process, but the speed cannot be usefully increased, and much loss is incurred in the quality as well as the quantity of the work accomplished for this reason.

Besides the ordinary common stamps in use, there are the pneumatic stamps, one of which is the patent of Husband, of Hazle, by which the heads are driven by belts worked by an independent engine; and one patented by Sholl, of Manchester, which is direct-acting, having a steam cylinder for each head.

Since "cam stamps" were introduced 300 years ago they seem, until recently, to have kept their place in the public esteem, but latterly the pneumatic stamps have been adopted at some mines with very good results. They are represented in Plates XXXI. and XXXII., and in this arrangement it will be seen that the stamp is attached to a piston *a* working in an air cylinder *b*, which has an up and down motion imparted to it by a crank shaft *c*. By raising the cylinder the air is compressed below the piston, and the stamp is jerked up; and when the stroke is reversed the air which is compressed above the piston drives the stamp down with a force and a velocity much greater than would be given by the force of gravity alone. Thus, a stamp weighing three hundredweights can be made to have a velocity of 150 blows per minute and a stroke of 15 inches, while the crank only has a stroke of 10 inches. Small holes, *d d*, are placed round the centre of the cylinder, so that the ends of the cylinder may be filled at each stroke with air at the ordinary pressure. Water from the pipes, *e e*, is made to flow continuously through the piston rod, which is hollow, to prevent the heating of the cylinder by the compression of the air. This water escapes through small holes, *f f*, at the bottom, above the stamp head, and forms a portion of the supply of water required for stamping. The remainder of the water supply passes in a circular jet, *g g*, under several feet of pressure, upon the outside of the piston rod, as shown in Fig. 4, Plate XXXII. A lever, *h*, Fig. 3, Plate XXXII., attached to the stamp head by means of a screw, is guided by two vertical bars, *i i*, which permits the attendant to turn the stamp end round in any way that may be required to equalize the wear. These stamps are placed together in pairs, and stamp about 10 tons per head per day, or about ten times as much as the old cam stamps, with a diminished expenditure of fuel per ton. The slime passes away from the stamps in much the same manner as in the old process, Fig. 2, Plate XXX, over a floor, placed at an inclination of about 1 in 12, into wooden troughs about 25 feet long, 12 inches deep, and 18 inches wide, at right angles to the row of stamps, where it is deposited according to its specific gravity into pits. The very lightest particles pass, and are collected for further treatment.

At Wheal Vor they have stamped 15 cwts. per hour of the hardest rock in the county, with a consumption of about 60 lbs. of coal per ton, and with three heads have stamped 20 tons per diem of 10 hours, on an average consumption of 56 lbs. of coal per ton. At Park Mines there are six heads of those stamps at work, which have stamped 9 tons per head per diem, with a consumption of only 40 lbs., as against the ordinary stamp average of about 1 ton of coals per ton stamped, while less water is required. One of the principal objections to these stamps was, that being driven with a crank there was difficulty in obtaining a regular feed and blow; but this has been overcome, and it is said that these stamps now feed as regularly as any other. Experience has shown that the increased quantity stamped is in proportion to the increased size of the head, which is an important fact, because the wear and tear is almost in proportion to the number of cylinders.

The pneumatic stamps, to do the work of about 70 ordinary cam stamps can be erected with engine, but without boiler, for about £1,500; whereas 64 heads, on the old ordinary principle, with all modern improvements and advantages, cost about £4,000. This shows a heavy margin in the first cost in favour of the pneumatic plan.

The common stamps, however, are by no means discarded, and are still largely used, and if constructed with due regard to modern principles and situation, will accomplish their work in a most efficient manner.

In considering the erection of the plant the supply of water should not be overlooked, for it is very seldom that sufficient water is to be obtained at the surface for dressing the ores, and consequently provision has to be made for storing and using it several times over. The quantity of water required for stamping is about 800 gallons per minute for 80 heads, doing an average of about 70 tons per diem. It has been stated that from 50 to 60 tons of tin escapes from the dressing floors of about seven mines into the "red" river per month, where every pound of tin is washed in about 500 gallons of water before it is rendered fit for the smelter; and this assertion is more than probable when it is considered how many people get their living by selling the tin which they obtain from the river. Their occupation is called "tin streaming," and they are generally known as "squatters."

One horse-power is required to drive an ordinary stamp head, but the heavier lifter and head require about 1·3 horse-power per head.

The cost of stamping with ordinary stamps favourably situated and erected on the improved principle is as follows:—

	s.	d.
Wear and tear		4
Coals (at 17s. per ton)		5½
		9½
First cost, with 5 per cent. interest ...		2½
	1	0 per ton of ore.

This is exclusive of grate plates and smiths' charges.

Mr. J. Hocking, in his paper read at Camborne in 1878, gives the following comparative statement of results obtained from stamps of the ordinary description, on the old system and on the new principle, at West Bassett Mine:—

> The old stamps, which may be taken as a fair sample of a great many in this district, were erected about six years ago. Laid out without any original plan, these stamps were erected at different times. To the engine, which is one of 30-inch cylinder, 9-foot stroke, double-acting, were attached five axles of sixteen heads each, making a total of eighty heads; a 15-inch plunge lift, 9-foot stroke, for lifting the waste water to be used over again, pumping about 800 gallons per minute ten fathoms high; a large dipper wheel for lifting the stamped ore from the pit in which the stamps are placed to the level of the dressing floors; and an incline for drawing the tin stuff to supply the stamps.
>
> The new stamps were planned and designed from the outset so as to reduce the cost of both stamping and dressing to the lowest minimum point; to the engine, which is a double-acting one of 40-inch cylinder, 9-foot stroke, are attached four axles of sixteen heads each—total, sixty-four heads; and during the time that the results I am about to speak of were obtained constituted the sole load of the engine. There was a full supply of surface water, both for condensing and dressing purposes.

Comparative Results of West Bassett Stamping Engines for Week ending 26th February, 1877.

	Old 30-inch Engine.	New 40-inch Engine.
Average number of revolutions per minute, including stoppages	11·5	10·7
Load per square inch on piston in lbs.	20·6	9·31
Consumption of coal, including pumping water, etc. ...	Tons. Cwts. 32 2	......
Do. stamping only	......	17 tons
Duty	44 millions	66·3 millions
Quantity of tinstone stamped	457 tons	621 tons
Coal per ton of tinstone stamped	109 lbs.	61·3 lbs.
Quantity stamped per head per day (after allowing for stoppages)	Cwts. qrs. lbs. 19 3 13	Cwts. qrs. lbs. 34 3 0
Average weight of head and lifter	680 lbs.	877 lbs.
Total load in foot lbs.	262,530	210,480

The value of a good site for dressing purposes cannot be better illustrated than by reference to the following figures, which will show the saving that can be effected by first-class machinery. I should mention that the old stamps are on a comparatively flat piece of ground, while the new are on the side of a hill.

Cost of Stamping Tinstone and bringing it into Whits.

Old Stamps.	£	s.	d.
No. of tons stamped 1,600			
Labour cost	126	11	8
Enginemen	9	7	6
Coals, 108 tons	91	16	0
Oil, 6 gallons per week ...	4	4	0
Grease	1	10	0
Smiths' work	10	0	0
Sundries—Hemp, etc. ...	2	0	0
Engineers, etc.	1	10	0
Carpenter, and Timber for repairs	3	0	0
Wear and tear, per month ...	25	0	0
Grates	1	10	0
	£276	9	2
3s. 5·47d. per ton.			

New Stamps.				£	s.	d.
No. of tons stamped 2,380						
Labour cost at present ...	£48	4	10			
When complete ...	12	0	0			
				60	4	10
Engineman				9	0	0
Coal, 66 tons at 17s. ...				56	2	0
Oil				2	16	0
Grease				1	10	0
Wear and tear				25	0	0
Grates				1	10	0
Smith's Work				5	0	0
Sundries—Hemp, etc. ...				1	0	0
Engineers, etc.				1	10	0
Carpenters				2	0	0
Traming and filling 2,400 tons at 4¾d.				47	10	0
Wear and tear of waggon ...				6	0	0
Extra repeating water ...				10	0	0
				£229	2	10
1s. 11·1d. per ton.						

The boilers for the new stamps are built on the principle very common in the North; they are the usual Cornish tubular construction, with what are known as "Galloway's" cone tubes introduced into the tubes. These not only give greatly increased strength but give increased heating surface, and I am perfectly satisfied that they tend to economy of fuel in the generation of steam. Three years since we applied these cone tubes to one of two boilers attached to an engine with a fixed load, at a cost of £15, resulting in a saving of 1¾ cwt. of coal per day, about 8 per cent. on the total consumption. We are enabled to work steam at a pressure of 60 lbs. to the square inch.

PULVERIZING.

Where the ore is required to be reduced to a finer degree after leaving the stamps, it is taken to the pulverizer, of which there are different varieties; many mines use one which is a modification of "Stephens' patent," while others again use "Dingey's patent," and as this pulverizer has given such general satisfaction, a description of it is given.

Plate XXXIII. is an illustration of "Dingey's Patent Pulverizer" for grinding tin "roughs," lead "skimpings," and other ores requiring to be ground to a very fine degree, such ores having been previously stamped or crushed sufficiently fine to pass through a sieve six holes to the inch. It consists of a shallow basin *a*, of 6 feet internal diameter, having vertical slides fitted with a series of grates *b*, through which the pulverised material is delivered. Four annular grinding discs or runners (*c c*) 2½ feet diameter, and geared together, revolve upon the bottom of the pan at a high speed of 200 revolutions per minute; and the pan itself is made to revolve slowly, at about four or five revolutions per minute by the wheel *d*, so as to avoid any tendency to wearing in grooves. The wearing surface of the bottom of the pan is a separate cast iron plate *e*, with a number of holes in it *f*, forming shallow recesses in which the stuff to be pulverised is retained whilst the grinding runners act upon it. The stuff mixed with a stream of water is supplied by a launder *g*, into a central annular trough *h*, from which it is delivered by spouts *i i*, into the centre of each of the grinding runners; and having been ground by passing under the runners, it escapes with the water through the grates in the sides of the pan into the external trough *k*, whence it is conveyed direct to the buddles.

The shoes of the grinding runners, as well as the bottom of the pan, are made separate, of castings 1½ inch thick, so as to be readily replaced when required. The space between the grinding faces of the shoes and bottom of the pan is adjusted by hand-regulating screws and levers, supporting the runner-spindles. The total weight of the machine is about four-and-a-half tons, and can be made in lighter parts for exportation. The cost of wear and tear in destroying the grinding plates is about £2 per month per machine, and the quantity of tin leavings or "roughs," etc., which it will grind in this time is about 270 tons, but this varies according to the class of ore treated. This is less than a quarter-part of the wear and tear in stamps doing a similar portion of work; and stuff containing ever so small a percentage of ore can be treated by this machine at a profit, which by the ordinary process would not pay.

The reverse motion of the pan keeps the grinding surfaces perfectly true and free from grooves, which is a great advantage, and the stuff treated is brought to such a fine and uniform size that every particle of mineral is easily extracted; with a consumption of 9 cwts. of coal per day it has done the work of at least thirty-two head of stamps.

At Wheal Jane Mine the machine pulverized in twelve hours 82 tons of tin "roughs" sufficiently to pass through a grate of 230 holes to the square inch, and in comparing the duty of the machine with the stamps at this mine it was found to do the work of thirty head of stamps satisfactorily; in another instance it was found by experiment to do 75 per cent. more duty than stamps would do for the same amount of power expended on it. Three of these machines are at work at Frank Mills Mine, in Devon, treating the lead leavings ("Halvans"), and answer well. The cost of this machine is £140.

JIGGING.

This process has been tried for tin dressing lately and with very gratifying results, although in many of the mines the tin is found so closely amalgamated with other minerals of nearly the same specific gravity that the operation is attended with difficulties; when tin ore is in this condition buddling, and not jigging, is the next process through which it is put, consequently the following remarks under this head will apply more especially to lead and copper.

There can be no doubt of the success of jigging when applied to lead and copper ores. Jigging is a process by which the separation of the mineral from the waste is effected by causing each particle of stuff to be suspended in water for a time, and in falling allowing them to arrange themselves according to their specific gravity. The stuff resting on a sieve is forced upwards by the motion of a plunger acting on the water underneath.

A thorough classification of the stuff is necessary before it goes into the jigger, as without this no complete separation of the metal can be obtained, and it is therefore necessary that the particles to be jigged should be as nearly as possible of the same size.

The proportion between the maximum and minimum size of the stuff to be operated on should be according to the specific gravity of the minerals contained in it.

It is also very desirable to have clean water for jigging, and where very fine stuff has to be dealt with it becomes absolutely necessary, because water containing slime will tend to clog the particles together.

There are numerous kinds of machines in use, but the writer will confine himself to a couple of those, which he has seen at work, viz., the "West Chiverton," and "Collom's patent." It would be as well to state here that the old break sieve or hand jigger is still in extensive use at many of the copper mines in the county, but it must eventually give place to the continuous working jiggers. The "West Chiverton" is a capital machine, and at West Chiverton mine there are a great many of them erected ; the arrangement of the machines at this mine is both efficient and simple ; after leaving the crusher, the lead stuff passes through three revolving sieves of ten, fourteen, and twenty holes to the square inch respectively, dividing it into four different sizes, each of which is carried through launders to a separate jigger. In this case, from the time the stuff is put into the crusher until leaving the jigger it is not touched by hand, but is all prepared automatically; the mixture of lead and blend is separated here with the greatest of ease. The machine works with 140 strokes per minute, varying in length from 1 to 1½ inches. The sieves are set in with a fleet of 1 inch. The price of this machine is about £35, and at this mine 1,600 tons of lead stuff have been crushed, sized, jigged, and washed for £50 per month. Plates XXXIV. and XXXV. represent Collom's Patent Jigger, or rather a pair of them, which have been in use in Cornwall now for many years. The motion is produced by two pistons *a a*, which work up and down in square tanks, with a stroke varying from ½ an inch to 1 inch, the coarsest ore requiring the longest stroke. A lever *b* strikes the pistons alternately, spiral springs bringing them back to their first position against the stops *c c*, which can be adjusted to vary the stroke. A crank running at about 120 revolutions a minute actuates the striking lever. A pair of conical reservoirs *d d*, are placed under and at each side of the pistons, each with a fine sieve of brass wire on the top, on which is spread a bedding of ¾ of an inch of coarse ore. The material to be operated on is mixed with water and supplied to the machine by means of the launder *e*. The pipe *f* constantly supplies water to the reservoirs; this water escapes at *g*, carrying with it the light particles. The motion of the pistons drives the water up through the sieves, the lighter particles of slime resting on them are therefore raised up and carried away by the flowing water, whilst the richer stuff falls down into the reservoirs below, whence it passes off through a hole at the bottom. To carry away any stuff that may be too light to fall through the sieve, and yet be too heavy to be carried away by the water, a so-called "ragging gear" *h* is provided, which consists of a row of holes, the opening through which is regulated by plugs. The particles of ore that pass through this gear go into a distinct compartment of the reservoir *i*. A second machine *k*, in all respects like the one described, receives the water from the first, and works it over again.

Twenty-two tons of ore can be turned over by this machine per day of ten hours, which is equal to eleven ordinary hand jiggers. A fleet is generally given to the sieve of ¼ inch in the 3 feet. The cost of the machine is £80.

The cost of jigging copper with the old hand machine is about 8½d. per ton, including wear and tear ; the cost with Collom's machine is 1d. per ton. Another advantage in favour of the use of this machine is that whilst the average produce from the hutches of Collom's gives 9 per cent., the ore from the hand jigger only averages 5 per cent. There is also a smaller amount of waste, by use of the former. The spiral springs for making the return stroke of the plunger form rather a weak part in this machine, as they have to be renewed three or four times a month.

The idea that jigging is only applicable to rough stuff is not correct, as there are machines now made purposely adapted for very fine work, and where the stuff has only contained 3 per cent. of lead or blend it has been worked at a profit.

The average quantity of copper jigged per day of ten hours with the hand sieve machine is two tons. There are many conditions to be observed in order to make jigging successful. The bedding material which is left on the sieve should be about three times the size of the sieve meshes, and the richer the stuff which is to be passed through the less bedding will be requisite, and the finer the stuff the greater number and less length of plunger stroke is required. It is desirable to give the plunger a greater velocity in the down stroke than in the up stroke.

As to whether jigging will be more economical for tin dressing than buddling is a question yet to be solved, but it seems clear that much of the tin which escapes to the "red" river might be saved if jigging direct from the stamps could supersede the oft-repeated operation of buddling. Jigging by mechanical means has certainly been successful wherever it has been tried, and consequently ought to have the serious attention of all interested in tin and lead mines.

BUDDLING.

After leaving the classifiers, or, in other cases, the jigger, the stuff is treated and washed in a variety of ways. Sometimes it is deposited into long strips but generally into buddles, the two kinds usually adopted are Borlase's patent and the Convex, but the former has still the preference, although there has been great improvement in the Convex buddle since its introduction. For instance, it has been much enlarged, especially at the head, which was at first a mere cone, now it is from two feet ten inches to twelve feet diameter; six feet has been found to be the best distance to allow from the head to the tail of the buddle. It is usual for the slime tin to be lodged in larger pits after leaving the stamps previous to framing or buddling.

The convex or centre-head, Plate XXXVI., Fig. 2, is usually the first one used. It consists of a circular pit about 24 feet diameter and 18 inches deep at the edge: the centre portion is raised as at *a*, and the floor falls from it outwards towards the circumference at a fleet of about 1 in 30 for a length of 7 feet. The slime, well mixed with water, is delivered on to the centre of the buddle by a launder *b*, and is distributed upon the raised part by means of a number of spouts *c c*, which spread the liquid stream uniformly. The slime and water in their passage down the slope gradually deposit the pure ore, which is the heaviest, and falls nearest the centre. In order that the slime may spread itself uniformly over the floor, and not form little channels or gutters, revolving arms *d d*, provided with brushes *e e*, continually sweep over it, and keep it to an even surface throughout. These brushes make about six revolutions per minute. As the deposit accumulates in the buddle, the sweeps are successively raised to a corresponding extent; and the water is made to flow away at a higher level by stopping up the lower holes in the conduit, which takes the waste water from the pit, and the process is continued until the space between the centre and the circumference is filled up, or for about ten hours. The contents are then divided into head, middle, and tail; the head, being nearest the centre, contains about 70 per cent. of ore, the middle 20, and the rest only a trace.

The heads of the buddles are then passed together with water to the concave buddle (Plate XXXVI., Fig 1.) Here the stuff is conveyed direct to the circumference by the spouts, and gradually flows towards the centre, where the overflow of the water is regulated by the holes *a*. The ore is here deposited in the greatest abundance round the outside.

Plate XXXVII., Figs. 1, 2, and 3, show an improved concave buddle called Borlase's buddle. The difference between this and the ordinary concave buddle consists chiefly in the addition of an agitator *a*, which mixes the slime before it runs down the launder *b*, and the application of a ring *c*, which is made to rise and fall as the lead is deposited by means of the rod *d*, the lever *e*, and the screw *f*, and the overflow of the water is thus regulated, without the trouble of having to stop the machine to close the holes, as in the ordinary buddle.

Clean water is a great advantage again in this operation, and it is equally important that the man in charge should keep up a regular flow, otherwise much mineral will be washed away.

The mineral sticks wherever it touches in the large head buddles, while in the small ones, with a large flow of water, the mineral has no chance of adhering to the bottom. In the Borlase buddle it is distributed so thinly that it sticks just in the same way as may be noticed in a vanning shovel.

In the St. Austell district the writer has seen tin treated in small buddles which had no head at all, generally known as spout buddles, they are inexpensive and very simple, and a floor might be laid out with them for about one-third of the cost of other buddles. For some class of work no doubt the spout buddles are equally as good as the others for the same reason that long strips are preferable to the buddle. It is therefore important in laying out works to well understand the class of work to be dealt with.

The average yield of tin stuff in this district is about twenty-eight pounds of tin to the ton, and in the dressing of stuff yielding this percentage there is a loss of about one-eighth.

The tailings of the buddles generally produce from two to three pounds per ton on average work.

The Fnu Vanner was tried at West Seaton mine and did its work very well, but was too expensive in its working for Cornish ores. It might do very well for silver and gold.

TOSSING AND PACKING MACHINE.

Figs. 3 and 4, Plate XXXVI., show a very efficient and simple arrangement, combined both for tossing and packing. The machinery for this is often much more complicated. After the slime has been buddled three or four times it undergoes the further process of "tossing:" mixed with about equal parts of water it is put into a tub *a*, and agitated violently by means of a rotating shovel or disc *b*, which is raised as the tub becomes full of lead. This keeps the lighter particles freely suspended, and whilst thus in suspension the stuff is "packed" by the repeated blows of an iron bar *c*, which strikes the side of the tub about 100 times a minute. The heavy particles are then caused to deposit on the bottom, and become closely "packed" together.

To illustrate Mr Charles Parkin's paper on the "Treatment of Ores.

THE ORDINARY CAM STAMP.

FIG. 1

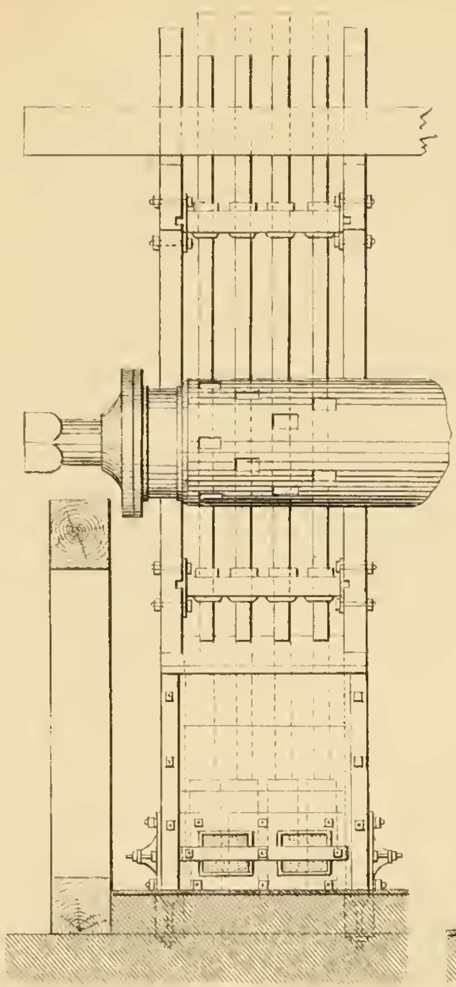
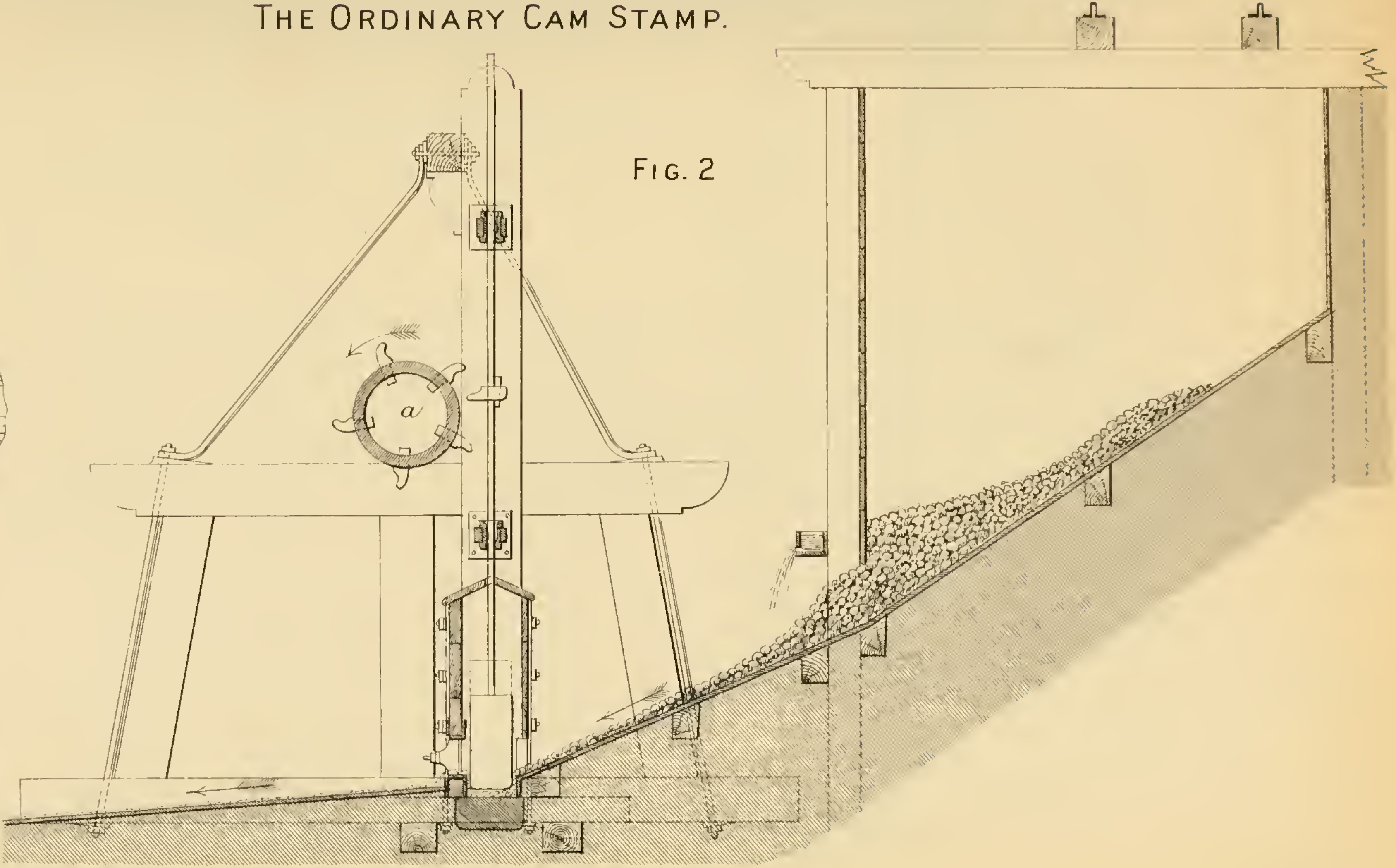


FIG. 2

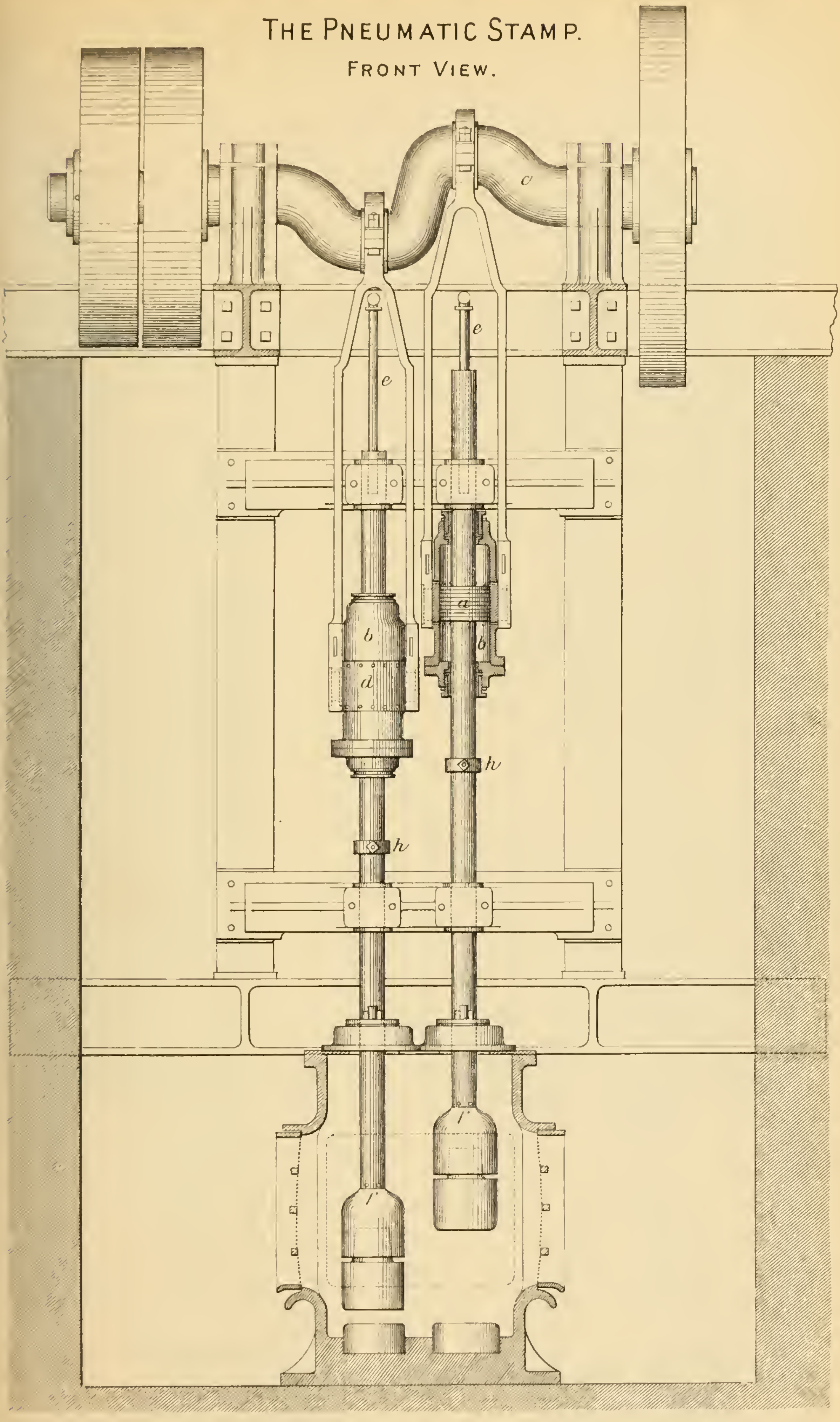


Andw Reid Newcastle

To illustrate Mr. Charles Parkin's paper on the "Treatment of Ores"

THE PNEUMATIC STAMP.

FRONT VIEW.



Andw. Reid Newcastle

To illustrate Mr Charles Parkin's paper on the "Treatment of Ores"

THE PNEUMATIC STAMP.

FIG. 1.

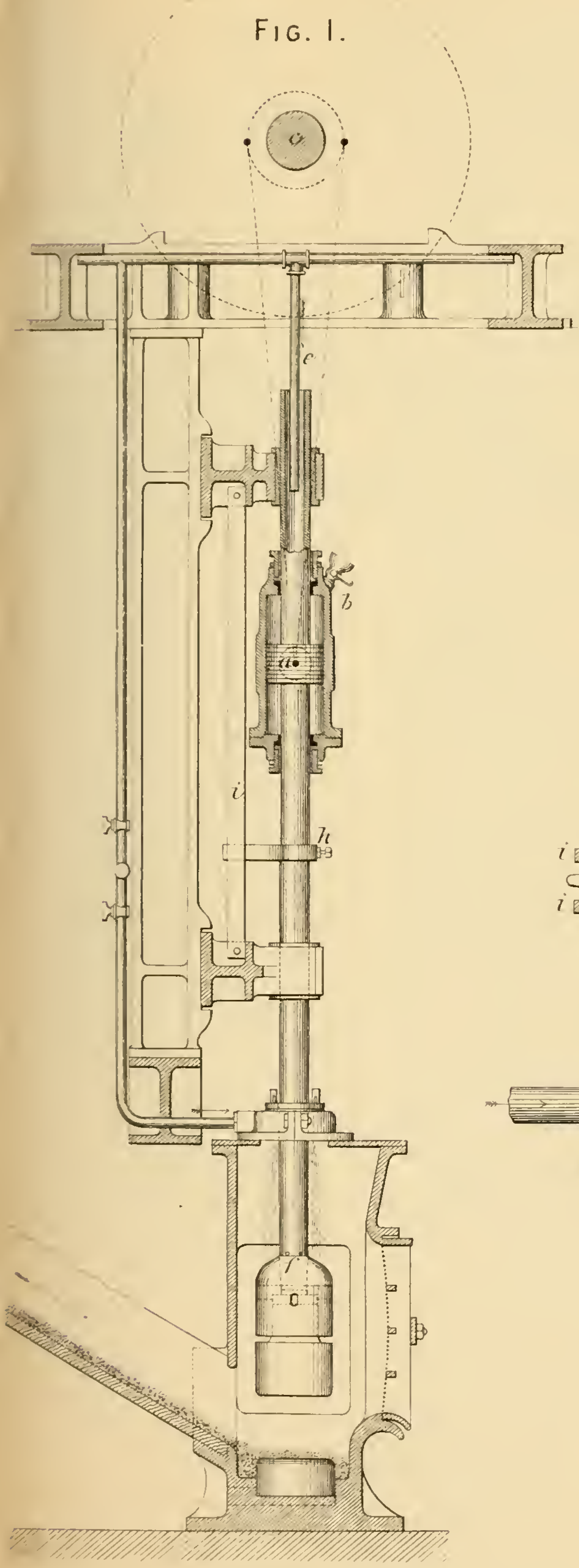


FIG. 2.

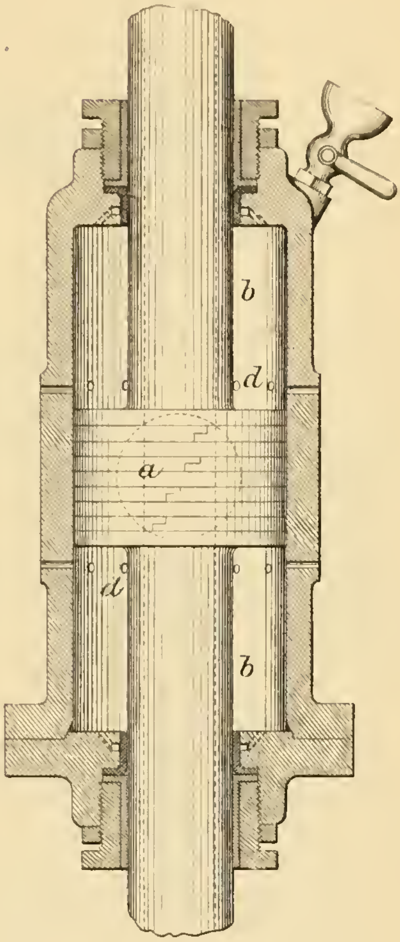


FIG. 3.

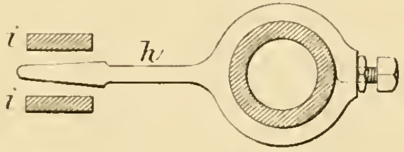


FIG. 4.

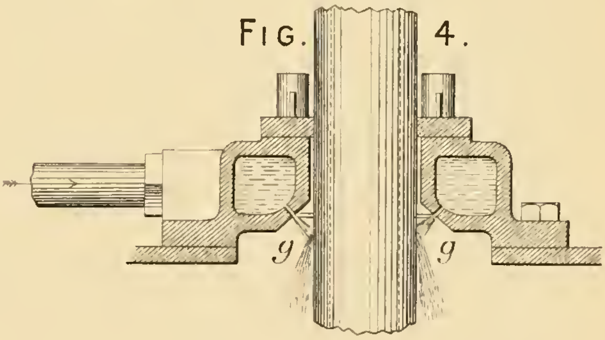
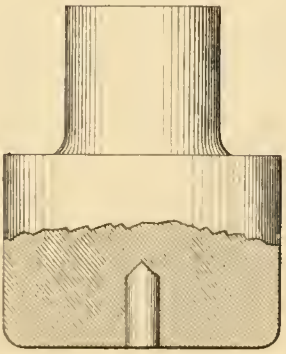


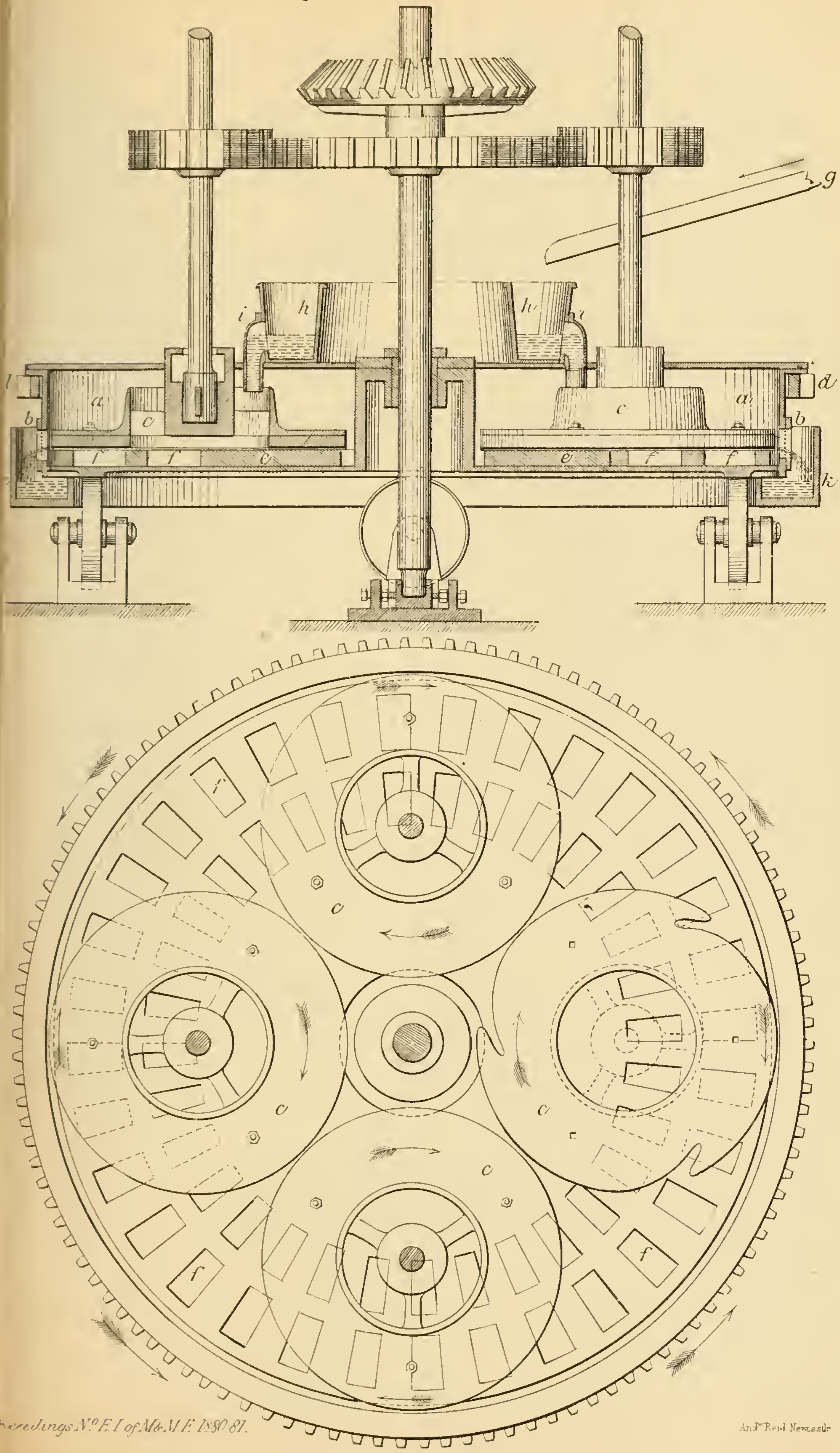
FIG. 5.



Andw Reid, Newcastle

o illustrate Mr Charles Parkin's paper on the "Treatment of Ores."

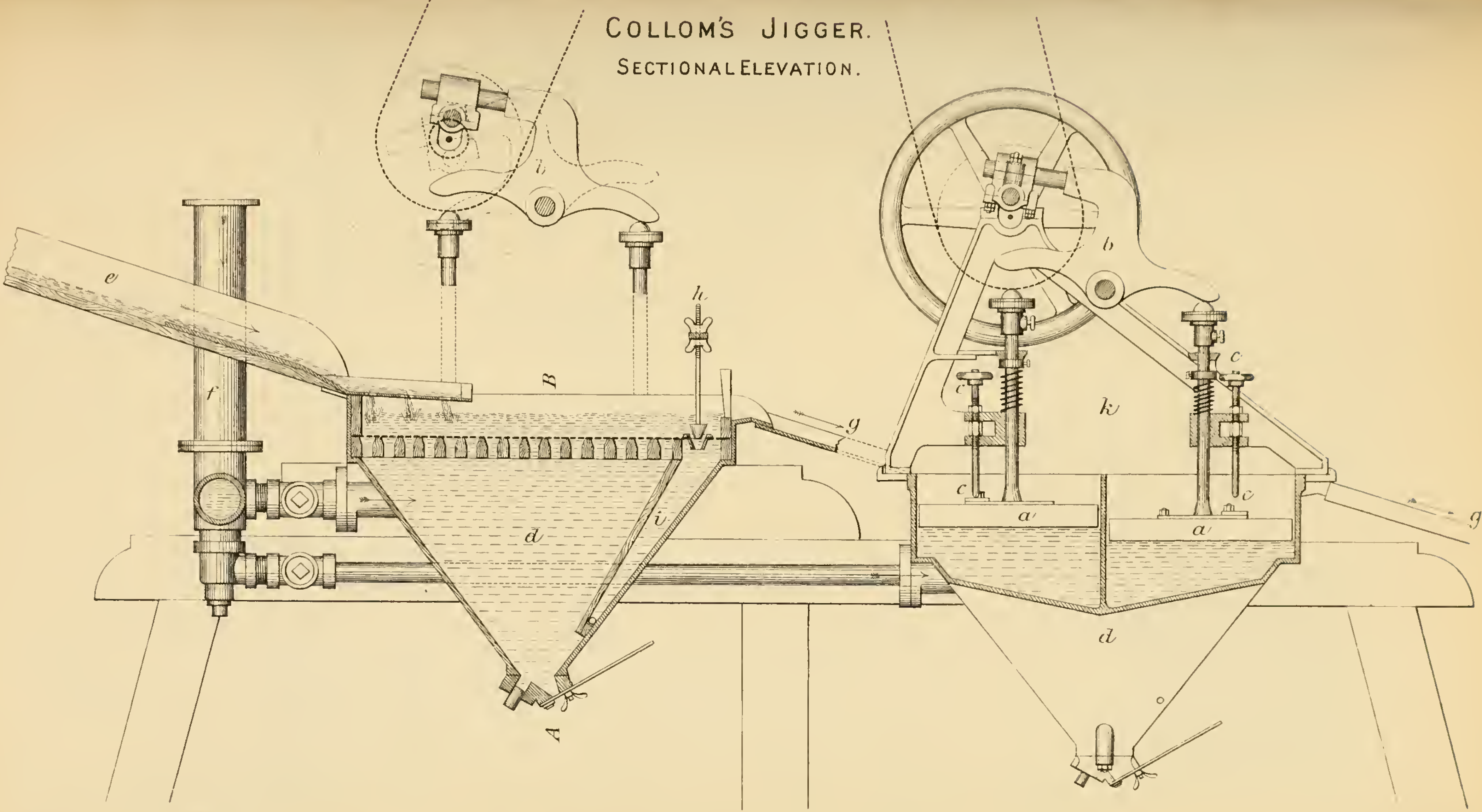
DINGEY'S PULVERIZER.



Andw Reid Newcastle

COLLOM'S JIGGER.

SECTIONAL ELEVATION.

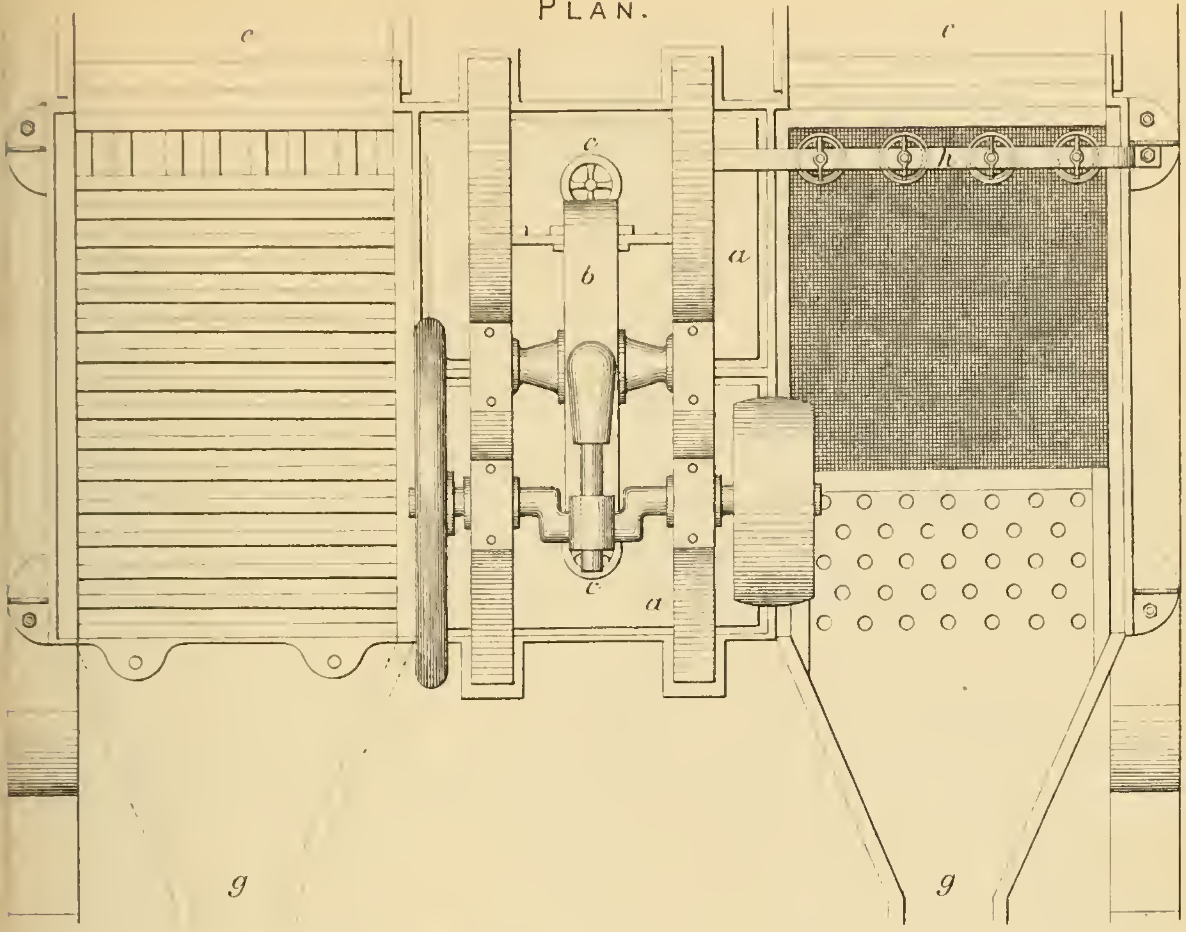


Andw Reid Newcastle

To illustrate Mr. Charles Parkin's paper on the "Treatment of Ores."

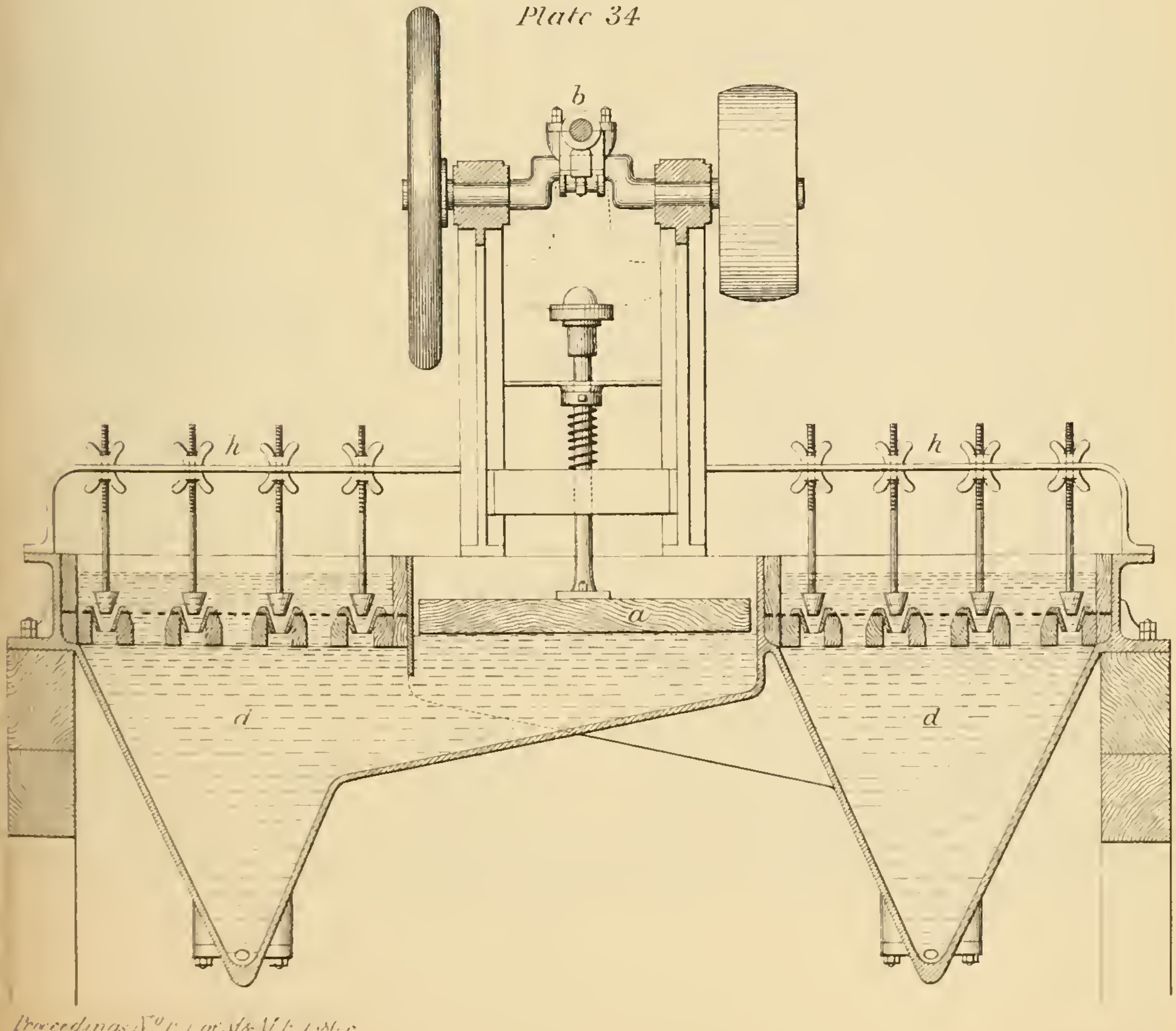
COLLOM'S JIGGER.

PLAN.



CROSS SECTION THRO' THE LINE A.B.

Plate 34



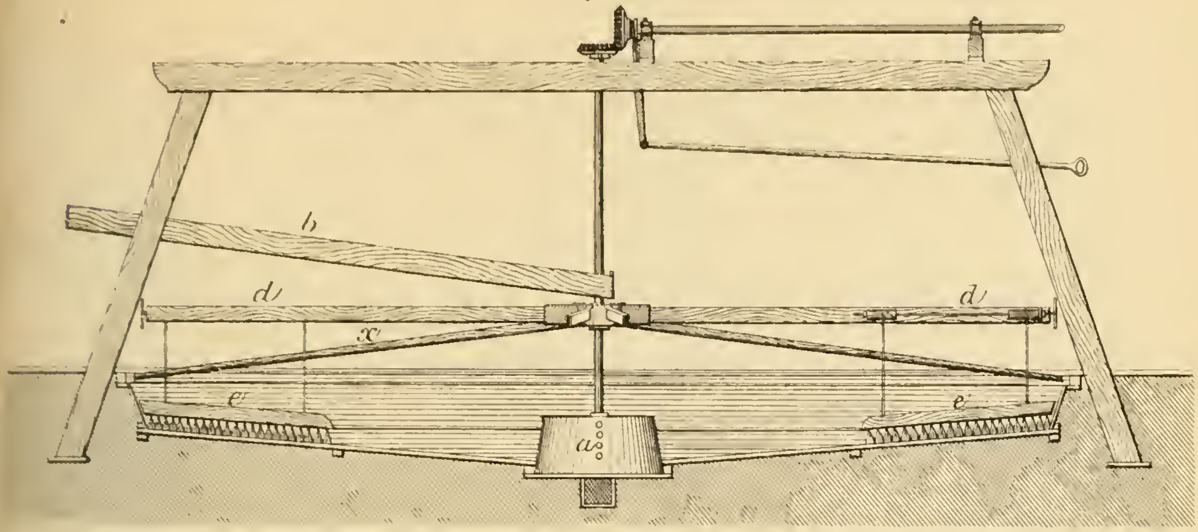
Proceedings N.º E. I. of M. & M. E. 1876.

Andrew Reid, Newcastle

To illustrate Mr Charles Parkin's paper on the "Treatment of Ores

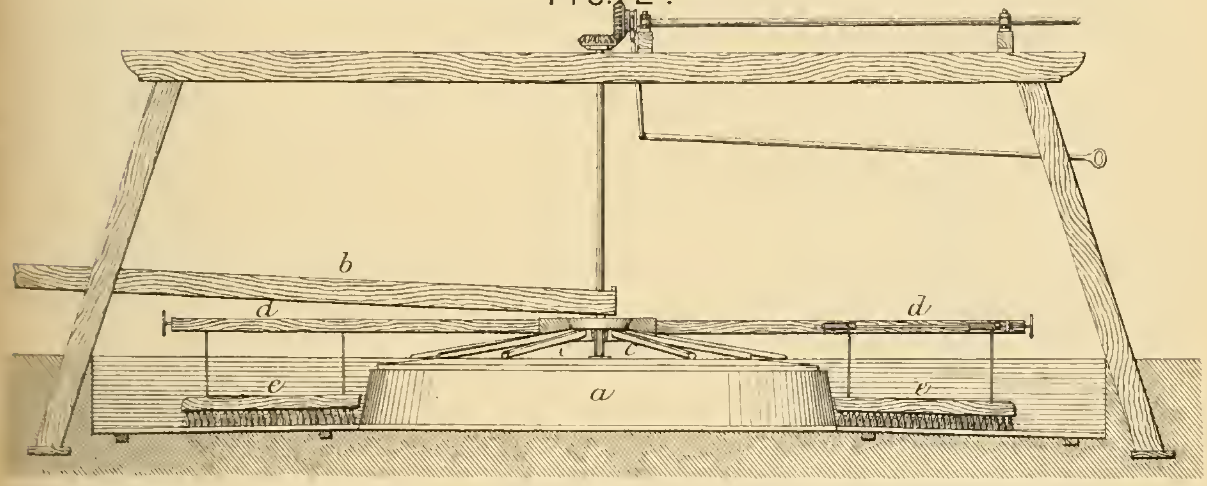
THE CONCAVE BUDDLE.

FIG. 1.



THE CONVEX BUDDLE.

FIG. 2.



TOSSING AND PACKING MACHINE.

FIG. 3.

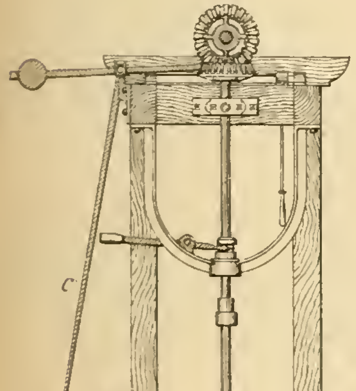
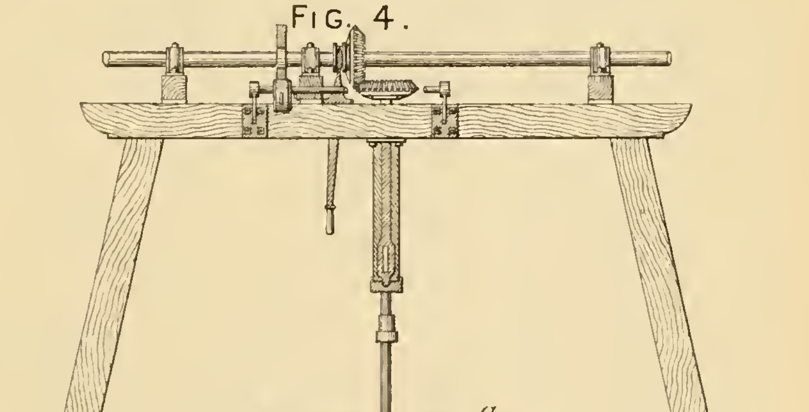


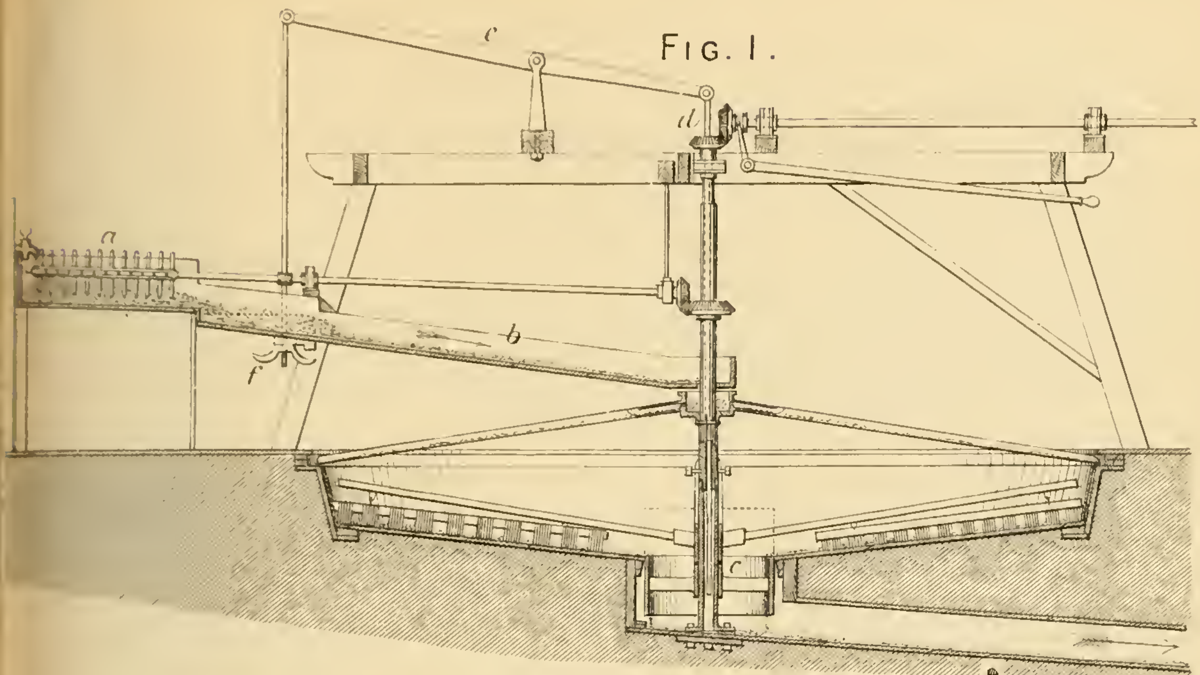
FIG. 4.



Andrew Reid, Newcastle

To illustrate Mr. Charles Parkin's paper on the "Treatment of Ores."

FIG. 1.



THE BORLASE BUDDLE.

FIG. 3.

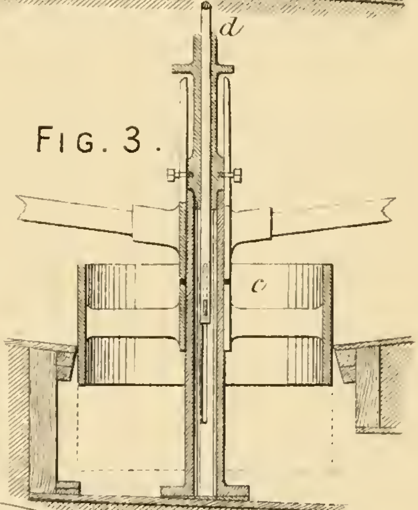
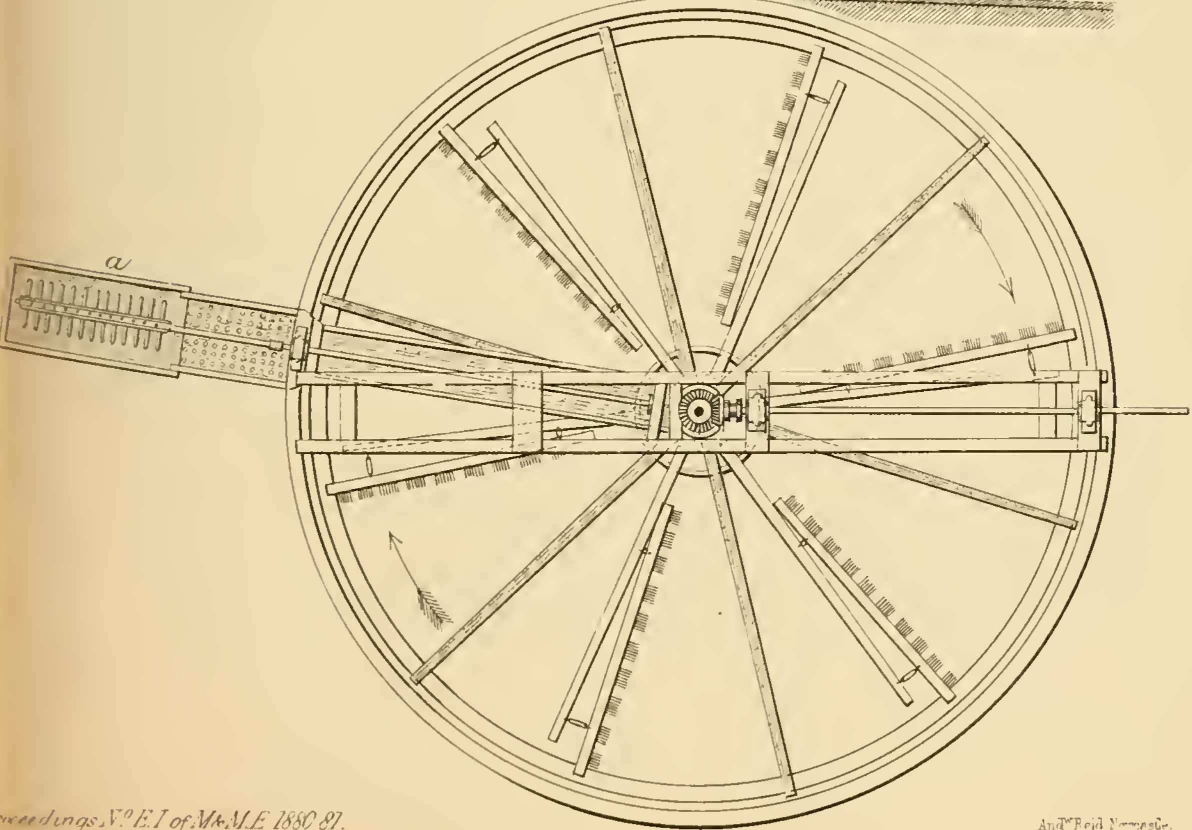


FIG. 2.



Andw Reid Newcastle.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, MAY 14TH, 1881, IN THE LECTURE ROOM OF THE LITERARY AND PHILOSOPHICAL SOCIETY, NEWCASTLE-UPON-TYNE.

G. C. GREENWELL, ESQ., PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last meeting, and reported the proceedings of the Council.

The following gentlemen were elected :—

ORDINARY MEMBER—

Mr. DAVID MORGAN LLEWELLIN, F.G.S., Civil and Mining Engineer, Glanwern Offices, Pontypool.

ASSOCIATE MEMBER—

Mr. JAMES TAIT, Estate Agent, Garmondsway Moor, Coxhoe.

The following were nominated for election at the next meeting :—

ASSOCIATE MEMBER—

Mr. HARGRAVE WALTERS, M.E., Coton Park and Linton Colliery, Burton-on-Trent.

STUDENT—

Mr. EDWARD HOOPER, Haydon Bridge, Northumberland.

The PRESIDENT said the first business was to hear Mr. Swan's description of his electric lamp, and to that end he had great pleasure in introducing Mr. Swan to the meeting.

Mr. SWAN said, from time to time during the last twenty years the question had been propounded of the feasibility of lighting mines by electricity, and various proposals had been made with reference to it. The first idea was to employ a Giessler tube for the purpose. An apparatus on this principle was devised by Messrs. Dumas and Benoît, and was exhibited in Newcastle about eighteen years ago. In the apparatus of Messrs. Dumas and Benoît an induction coil and battery were arranged very neatly in a little knapsack, which could be strapped on the back of a workman, and transplanted to the place where it was to be used. When that place was reached the intention was that the workman should detach it from his back, and hang up the lamp in a convenient position. This earliest form of electrical lamp had the advantage of being self-contained, so to speak, and of carrying its own light-producing power along with it; but it had the great drawback of giving a very faint light. and of being somewhat costly and cumbrous, since each lamp required as an accompaniment both a battery and an induction coil. At all events the fact of its never having been adopted as a practical lamp in mines was evidence of its not having commended itself to the good opinion of mining engineers (the electric light produced—in a vacuum tube—was the faintest form of electrical light). Then it was proposed to employ the arc light in mines—not in the dangerous parts of mines, but as a means of lighting portions of mines which might be lighted by means of naked lights. They knew the kind of light to which he made reference when he spoke of the arc light produced between carbon points. That extremely brilliant light, if it could be placed in a perfectly close vessel, and maintained without much trouble and without much cost, would evidently be a very good form of light for a mine; but unfortunately it could not be maintained as a steady light without some mechanical arrangement more or less cumbersome in the nature of a regulator lamp, and it could not be enclosed perfectly without incurring the disadvantage of having a deposit formed upon the glass which contained it; practically, therefore. this form of electrical lighting had never gone further than a proposal—a proposal which he believed had been condemned by some of the best physicists who had looked into the question, and whose opinion had been asked as to its applicability. Between these two extremes of a very faint light and very brilliant light there was a middle path along which occurred a possibility of producing electrical light in another way and of intermediate power—by passing an electrical current through a very thin conductor made of some comparatively resisting and comparatively infusible material. This last-mentioned method is illustrated by Fig. 5, Plate 38, where *a* is a thin wire of platinum, and *b b* are copper wire conductors of much stouter material. The thick conductors, *b b*, offered comparatively little resistance, but the contrary was the case with the thin conductor, not only because of its thinness, but because of its being composed of platinum, which was a bad conductor; if a current was passed through it, it would become white hot, while the rest of the conductor, *b b*, was cold. Now, if it were possible to keep a piece of platinum wire like that at a white heat without too great an expenditure of the electric current, nothing would be better as a means of producing light; but unfortunately a wire even of that thinness required a very strong electrical current to make it white hot, so that it would become too expensive to produce electrical light by means of a white hot wire of that kind; it could not be made sufficiently hot for the production of an economical light without melting it. Many had so attempted to use it, but had not been successful. But the principle remained good all the same. It was only necessary to find another material analogous to platinum in respect of its lower conductivity, but different from it in its fusibility; such a substance was found in carbon. By making carbon in the form of a very fine filament it was possible to send through it an electric current which would heat it to a very high degree, and cause it to emit a brilliant light without excessive cost. It was also possible to carry it to a higher temperature than could be accomplished with platinum; and because a very slight increase of temperature had the effect of increasing the light very considerably, the substitution of carbon for platinum was attended with great economy. His improvements in electric lighting had been directed to the utilization of carbon on the principle of producing light by incandescence; by that means getting rid of all the machinery inseparable from the ordinary type of electric lamp, and with the further advantage, that the light so produced *could be divided indefinitely*. It hardly needed elaboration or remark to show that any given length of wire, which could be made of a white heat in the manner described, would also become of a white heat if divided into several pieces, and interposed in the thick conductor in different places, perhaps widely apart. It was almost a self-evident thing that the same power which was required to heat that length of wire in one continuous piece would also suffice to produce the same result if it were divided into several pieces. Self-evident or not, it was a fact, that however many pieces the platinum wire was divided into, it would require the same electrical force to make it white hot that it took to make it white hot when in one piece; so that this method of producing the electric light involved the principle of *divisibility*, and that was the most important point in connection with the subject he was going to bring under their consideration to-day. He did not at first think of applying his lamp to mining purposes. His intention was simply to produce an electric lamp which was generally applicable; but several persons, whose opinions he could not but pay great respect to, represented to him that it was not an unsuitable form of lamp for lighting coal-mines; and their strongly expressed wish had led him to put the lamp in the shape in which it would have to be used if it received such an application; and the ultimate result was the form of safety-lamp now exhibited. The construction of the lamp is shown in Plate XXXVIII.:—a is a glass tube from which the air has been almost totally exhausted; b is a slender filament of carbon bent with a loop, with its ends secured in two steel sockets c, c', with two little rings d, d', these two steel sockets are continued in the shape of steel strips e, e', till they meet the wires f, f'; these wires terminate in two loops g, g'; h is a glass rod swelled at i, where it contains the two wires g, g', which are fixed therein when the rod is blown, the other end of the glass rod h terminates in a projection j, where two small pieces of wire k, k', are fixed while the glass is hot; these two pieces pass through small holes in the strips e, e', and keep them steady. The upper part of the lamp is enclosed in a brass cylinder p, which screws into a brass ring q, formed so as to receive a glass cylinder r, secured to the ring q by means of four strong wire supports t, t', and the brass button u. The top part of the cylinder p is closed by means of a wooden plug s. The glass $a\,a$ is encompassed by a socket of some non-conducting material l; secured on each side of this are two brass slips m, m', one of which, m', is prolonged to y, so that it can be pressed by the finger when the cylinder p is removed from the ring q and the lower portion of the lamp. The inside of the wooden top is also provided with two brass strips n, n', which are in connection with the conducting wires o, o', at the bottom these strips n, m, and n', m', are so bent as to act as springs, and one of them m', has a small catch x, which can be released at will by pressure applied to y; this arrangement allows the lighting portion of the lamp to be readily detached from its case and as readily replaced. In the position in which the apparatus is shown in the Plate the current is completed, passing from o to n, then to m through the loop g to f, and onwards through the steel strip e to the socket c, passing through the carbon filament b which it makes white hot, it returns through c', e', f', g', m', till it reaches n', which is in connection with the return wire o'. No doubt the details of this lamp could be very considerably improved in the direction of simplicity; perhaps the form of the glass could also be improved. It had been represented to him that it would be an advantage if the glass were carried higher up, and a little bevelled at q, so as to allow the rays of light to pass upwards. Improvements of that kind they could easily frame in their own minds; all he asked them to do now was to consider the principle, and whether in any case it might be applicable to the wants of coal-miners. They would observe it was absolutely secluded from air, and therefore would be quite safe in a dangerous atmosphere, on condition, of course, that the glass did not break: but he believed that in the ordinary safety-lamp they were exposed to that danger. There were safety-lamps in common use—the Clanny lamp, for instance—which had glass about them, and the Clanny lamp became unsafe when the glass was broken; but he thought this danger almost imaginary, because a blow which would break the glass would inevitably break the carbon, and consequently extinguish the light. He thought a lamp of that kind would be much less liable to be broken by water falling upon it, which was a source of danger in connection with safety-lamps of the ordinary kind surrounded by glass; but that danger must be much less in a lamp of this kind, because the amount of heat was so small that the outer glass would scarcely be warm; therefore, the danger of fracture of the glass from water falling upon it would, he thought, be very small indeed. He ought, however, to mention another danger, namely, that which would result from the accidental rupture of the wires. It always happened that when wires which carried a current such as would be required for the lamp were severed, a spark occurred at the moment and place of severance. Now, if the wires which were in communication between the electric generator and the lamp were accidentally broken, a spark would occur which, in an explosive atmosphere, would be dangerous; but the wires might be made of such a nature that the chances of their being broken were extremely remote, but still it would not do to shut out of sight the danger that might arise from that source. Great care would have to be taken in making and unmaking the connection between the lamp and the main wires: the current would have to be previously cut off the wire through which the attachment or detachment was being made, or special contact devices would have to be provided which would cut off by a covering of liquid all communication between the spark and outer atmosphere, or seclude it in a close box, in order to guard against the possibility of a spark occurring where it might be dangerous. He thought it would not be right to show them the good points of the lamp without at the same time mentioning whatever objection he himself could see to it. One of the main questions with them would be, how far a lamp of that kind would be practicable, supposing it to give a good light and to be comparatively safe? A further question would be, what kind of apparatus would be necessary in order to work the lamp, and what would be the expense of it? He need hardly tell them, because there was probably no one present who did not know, that in order to produce the electric current for lighting purposes they were now using some kind of motive power—generally that of a steam engine—so that, if these lamps were used in mines, they would have to draw upon their fan or other engines for the supply of the power to be applied to the working of what was called a dynamo-electrical machine. A dynamo-electrical machine was very simple, and by means of it electricity was produced simply and cheaply. It consisted of two parts—an electro-magnet which was fixed, and an electro-magnet which was moveable. In order to develop an electric current it was necessary to give a rotary motion to the moveable electro-magnet. This apparatus was a somewhat heavy one, and he did not know how it could be arranged so as to assume a portable form and be connected with the lamp in the same way as was proposed in the case of Dumas and Benoît's first electric lamp, where, as the light was feeble, only a comparatively small electric current was required. This would have to be very much increased to give the light contemplated now, and would require a much larger apparatus, one altogether too cumbersome to be portable, so that they would have to realize the necessity of having the lamp tethered by means of wires—he was afraid thick ones—to the main wires coming from the dynamo-electric machine. The wires might be flexible, but they must be very strong, so that to a certain extent the lamp was a fixed lamp. But supposing these difficulties were not thought sufficient to debar the lamp from use—he meant supposing the tethering of the lamp were not thought an insuperable objection to it—and supposing the production of a current at the pit head by means of a dynamo-electrical machine was thought not to involve too much trouble and cost, then he believed they would have there a lamp which might be considered as one means of producing that very indispensable thing in coal-mining, a reasonably safe artificial light. An experiment would be made almost immediately with a number of these lamps; he had fifty of them being made now, and as soon as made they would be placed at the disposal of the Accidents in Mines Commission. They would be first used in a colliery in Nottinghamshire; some also were to be tried at Garnock Colliery, near Glasgow, and their practicability for coal-mining thoroughly tested; but he did not think their use as safety-lamps would be tested in either of those mines; that point, he believed, would be thoroughly tested in the laboratory by Professor Abel and his assistants, so that the question of the adaptability of this lamp for use in mines was to this extent receiving an answer. With regard to the amount of power necessary to work such lamps, about one horse power would be consumed for every ten or twenty lamps. Professor Herschel had (with his usual kindness) lent him a small hand dynamo-electrical machine, which enabled him to demonstrate to them how exactly proportional was the motive power required to drive it to the amount of electricity produced. He fancied that one of the questions they would have to ask him, would be whether instead of keeping the current always supplied directly from the electro-dynamical machine, there could not be a store of electricity carried about with the lamp. He was sorry to say there was not much to be hoped for at present in that direction. The operation of a Daniell's battery was accompanied by a chemical change, which ended in the deposition of copper on one side of a porous diaphragm, and the dissolution of zinc on the other. It is quite conceivable that this process might be reversed by means of the dynamo-electrical machine, and the zinc deposited, while the copper was dissolved by a reverse action of the current; so that the using of the current of a Daniell's battery, and charging it again from a dynamo-electrical machine, would constitute something like a store of electricity; and he thought it quite likely that great progress would be made in the perfecting of apparatus of this kind, and that electricity might in this way be to some extent stored. He had had lamps going an hour, or perhaps even longer by means of stored electricity; but at present for the lighting of coal mines electrically he thought the use of a dynamo-electrical machine direct, would be found to be necessary. Having now stated his proposition with regard to the electrical illumination of mines, he left it to their consideration as to how far it was practicable to adopt the idea. It was a question for them much more than for himself. He had shown them how far the electrician could help them in the matter, and he thought it worthy of their consideration how far they could make it fit in with their other arrangements. He thought it would perhaps more fully answer the end the Institute had in view if he reserved anything further he had to say till the subject was discussed. He would be very glad to answer any question which might be asked of him.

Mr. Swan in answer to the President, stated that the light of the lamp exhibited was equal to that given by two or three candles, although it might very readily be increased to 10 or 12. With reference to the beautiful woolly material found in coke ovens, he did not think it could be made use of in a lamp of that kind; he had not tried it, but he had looked at it very carefully, and the difficulty with it was that the filaments were so extremely thin and tender, that it would not be possible to secure them in such a way as to make a perfect contact with the conductor which conveyed the current to and from the filament.

In answer to Mr. T. J. Bewick—the increase of cost by increasing the light would depend upon the way in which it was done. If the light were increased by lengthening the carbon, then the increase of cost to the increase of light would be absolutely in the proportion of the increase of light; but if the light were increased by sending a greater current through carbon of a given size and length, then a very slight increase of current would give a very great increase of luminosity. When his lamp was shown to Professor Tyndall, he said he thought it might be made applicable to the illumination of mines, and suggested that perhaps its safety might be increased by having a double casing of glass, with water between the casings.

In reply to Mr. Cuthbert Berkley—he did not think that at present it was possible to produce the requisite amount of electricity to work a lamp for any useful length of time by clock-work, for it required a man to exert himself very considerably to illuminate one lamp; and even if the machinery producing the electricity were to be considerably improved, he did not think the power could be reduced so far as to give any hope of a clock-work motion becoming possible, and on the other hand there was absolutely no loss of power in conveying electricity twenty or thirty miles to the lamps. There was always a certain amount of what was quite analogous to leakage by lengthening the conducting wires; but, under proper conditions, leakage was not so considerable as to prevent electricity being conveyed a great deal more than a mile; even as much as ten or twenty miles might be thought of as not impracticable. Should the glass become broken the lamp would go out instantly; immediately air got admission to a lamp of this sort it would go out. The carbon would burn away just as a piece of coal burnt on a fire, and as the filament in a lamp was very thin, it would burn away in a moment. The time it would take to replace the lamp with another would evidently depend upon the construction of the lamp. He had some being constructed so that by the undoing of a single screw the lamp could be replaced in two minutes, even when the change was effected in the dark.

Mr. A. L. Steavenson hoped that anything he or any one else might say would not be considered by Mr. Swan in the light of criticism, but merely in the light of remarks offered by the members of the Institute for the purpose of affording assistance to Mr. Swan in the very valuable experiments he was now making. Of course, the first difficulty with the members was these long wires. Everyone acquainted with pit work must be aware that to have a lot of such long cords as these moving about was very serious. At the present moment he could not see how to get over it; but for the purpose of lighting the main roads and the shaft bottoms, such lamps as had been shown could undoubtedly be used with great ease. When they got into the workings they would have to light up the hewers, which, he thought, it was barely possible to do; but beyond this again they had the wastes and returns, and various parts of the mine, where there might be more or less fallen material, and where a man had enough to do to get through himself without carrying wires after him. He had known men compelled to travel with a Davy lamp in their mouths. Under such circumstances it would be very difficult to introduce a lamp such as Mr. Swan had put before them. The question of cost would not enter into the calculation; if a lamp could be found, the use of which would be a guarantee for perfect safety, he was certain the question of cost would not enter into the consideration of the manager of a mine. He would like to ask Mr. Swan how far he considered the lamp would fairly compare with the ordinary Davy lamp now in use in intensity or amount of light? One use which he thought the lamp might be applied to was to light a place known to contain dangerous gases. Men were sometimes known to be where it was almost impossible to reach them with the present appliances, and where a lamp like this could be employed. In the ordinary working of a coal pit there were often as many as 300 or 400 safety-lamps used by the miners, and in order to supply their places by the electric light it would be necessary to regulate the intensity of the current, so as not to destroy the lamp from any sudden increase of current caused, say, by a certain number of lights becoming extinguished, or from numbers of men leaving the pit. That would have, of course, to be carefully considered, so as not to extinguish all the lamps of a mine at one moment. It would be a serious matter to have several hundred men in a mine left suddenly in the dark by the severance of the wire.

Mr. SWAN said, he had but little practical knowledge of coal-mining, and would not enter into any disputation, or anything approaching to it, with Mr. Steavenson as to the applicability of a lamp of this kind under all the conditions in which it had to be used. He could very well imagine conditions under which it would be totally impracticable; but perhaps there were mines, not so common in this part of the country as in others, where a lamp of the kind shown might not be impracticable. From what he gleaned in conversation with members of the Mines Commission the other day, he thought that it might be feasible to employ it in working the long-wall system, and in certain mines where the method of working was very regular and where there was ample space. The main wires might be laid in some cases under the roadway, in other cases overhead, up to the face of the coal, whence branch wires might be taken, entanglement might be prevented by the wires being rolled up on reels. With such help it might be possible for men to place their lamps in a convenient position without their being very much encumbered by the wires. The opinion seemed to be entertained by some mining engineers with whom he had discussed the matter that it was not entirely unfeasible to use the wires in certain mines, but that there are other mines, and perhaps they are the majority, in which it would not be feasible. Still he submitted there would be cases where the space was ample and the method of working very regular and systematic, where it might be useful to employ a lamp of this kind. The regulation of the current might be made at the place where the electric current was generated; it might be part and parcel of the generating machine. There were several ways in which the regulation might be effected. The danger from the rupture of the wires would still have to be encountered; but he thought the wires might be made so secure as to present no serious danger from accident. Telegraph wires laid under ground very seldom go wrong. Probably electric wires in mines should be laid similarly in iron tubes and under ground.

The President said, they were all very much indebted to Mr. Swan for his most interesting communication. He must confess that seeing what changes had taken place in electric lighting, especially in the direction initiated by Mr. Swan, he did not entirely lose hope of seeing the time when a self-contained and portable electric safety lamp would be invented, which would be able to be brought within the power of the person who used the lamp, to carry to his work, and be driven probably by some little reservoir of compressed air or other power; and he was more especially sanguine when he saw the matter taken up by such men as Mr. Swan. He had great pleasure in proposing a vote of thanks to that gentleman.

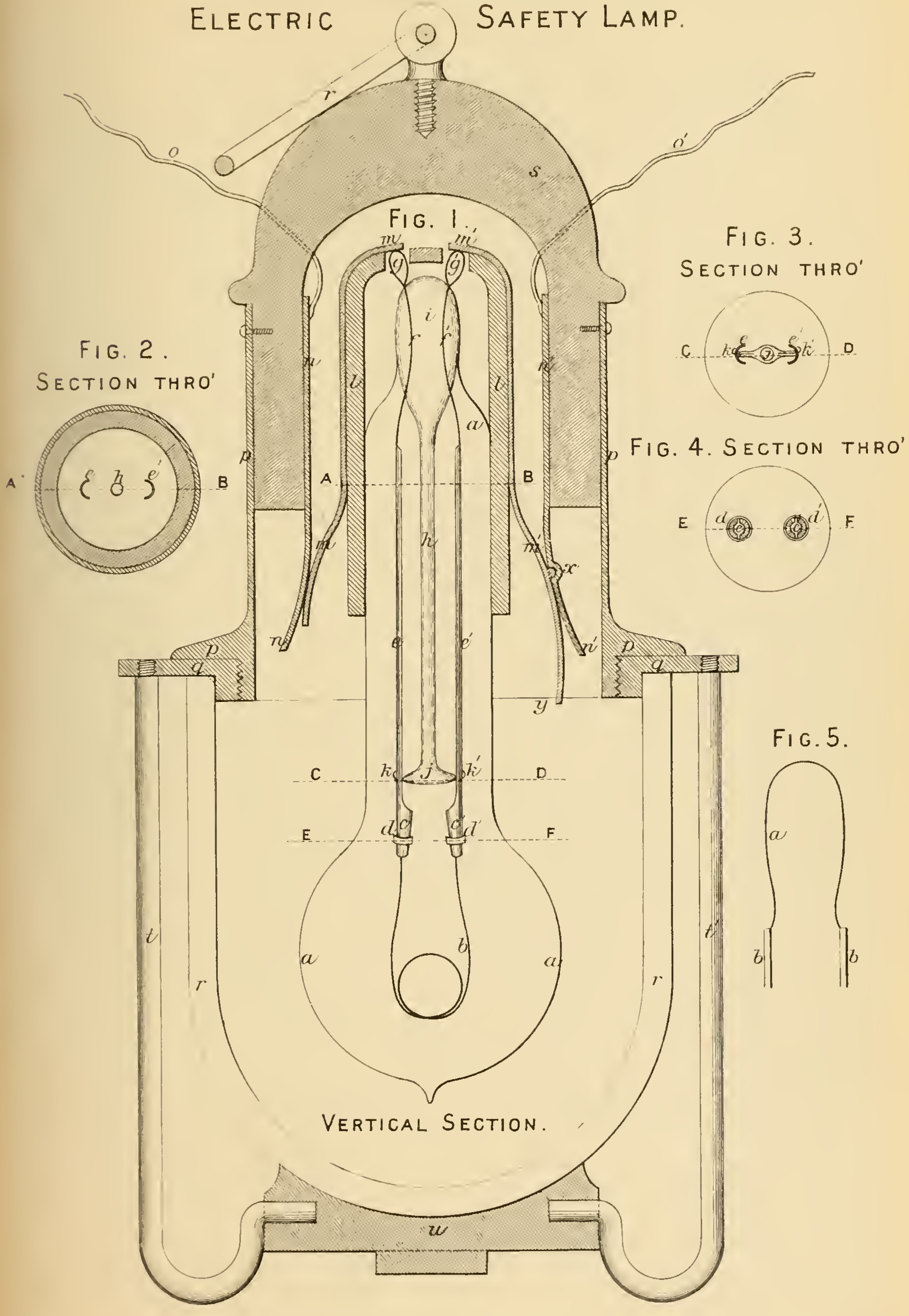
Mr. A. L. Steavenson said he had great pleasure in seconding the vote of thanks.

The motion was carried by acclamation.

Mr. Swan said he joined most earnestly in the hope which Mr. Greenwell had expressed. Seeing the rapid changes in the direction of advancement which had been made in so short a time, one was ready almost to hope anything and everything. He would like to say, in conclusion, how very much obliged he was to Professor Herschel for his

To illustrate Mr. J. W. Swan's paper on his Electric Lamp as adapted for Mining purposes.

ELECTRIC SAFETY LAMP.



Scale 5/6 of Full Size.

A. Reid Newcastle

kindness in providing him with apparatus and assistance. The Professor had helped him with such hearty goodwill as made him doubly indebted.

On the motion of the President, seconded by Mr. J. B. Simpson, a vote of thanks was given to the members of the Literary and Philosophical Society for having so very kindly granted them the use of their lecture room.

The meeting then terminated.

PROCEEDINGS.

GENERAL MEETING, SATURDAY, JUNE 4TH, 1881, IN THE WOOD MEMORIAL HALL.

J. B. SIMPSON, Esq., Vice-President, in the Chair.

The Secretary read the minutes of the last general meeting, and reported the proceedings of the Council.

The following gentlemen were elected :—

Associate Member—

Mr. Hargrave Walters, M.E., Coton Park and Linton Colliery, Burton-on-Trent.

Student—

Mr. Edward Hooper, Haydon Bridge, Northumberland.

The following were nominated for election at the next meeting :—

Ordinary Member—

Mr. John Grey Cranston, Consulting Mining and Mechanical Engineer, 29, Grey Street, Newcastle-upon-Tyne.

The balloting list for the annual election of officers in August was submitted in pursuance of Bye-law 21; after which, as there was but a limited attendance of members, the meeting was adjourned.

EXPERIMENTS SHOWING THE PRESSURE OF GAS IN THE SOLID COAL.*

By LINDSAY WOOD.

The writer having had his attention drawn to the frequency of blowers of gas escaping from coal workings at high pressures, was led to try a series of experiments to ascertain if gas existed at any pressure in the solid coal itself.

He was also anxious to ascertain what quantity of gas was given off from a given area of a face of working coal, and at what rate this exudation of gas diminished per hour of exposure, so as, if possible, to ascertain the effect, from this cause, of rapidly exposing new surfaces of coal by quick working, with a view of having some data by which to compare pits working 12 hours a day with those working 24 hours.

To this end five distinct experiments were made, and holes were bored at different depths into the coal in various seams at Elemore, Hetton, Eppleton, Boldon, and Harton Collieries; these holes were plugged and gauges applied, and it was soon found that very great pressures were shown to exist.

Arrangements were also made, which are hereafter described, by which the quantity of gas given off from the boreholes of a known surface area was accurately measured.

One of these experiments was made in the Low Main Seam at Elemore Colliery, at a depth of 750 feet from the surface; one in the Hutton Seam at Hetton Colliery, at a depth of 1,228 feet; and eight in the Hutton Seam at Eppleton Colliery, at a depth of 1,261 feet. Five were made in the Bensham Seam at Boldon Colliery, at a depth of 1,268 feet from the surface; and three were made in the Bensham Seam at Harton Colliery, at a depth of 1,215 feet.

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* Read at the General Meeting held on the 19th June, 1880, but publication delayed to permit of further experiments being recorded.

It will be noticed from this that all the experiments except the first were tried at a depth within 2 per cent. of 1,243 feet, the mean of the whole.

THE EXPERIMENT MADE AT ELEMORE COLLIERY.

The Elemore Colliery was opened out about the year 1826—54 years before the experiment was made, the following being the account of the strata sunk through in the Lady Isabella Pit:—

TOWNSHIP OF PITTINGTON, DURHAM.

Sheet 20 of Ordnance Map. Lat. 54° 48′ 14½″, Long. 1° 26′ 45″.

Approximate surface level 400 feet above sea (Ordnance datum).

	Fs.	Ft.	In.	Fs.	Ft.	In.
Outset	2	4	0			
Strong brown clay ...	8	0	0			
Limestone	16	0	0			
Blue limestone ...	0	1	0			
Brown clay, seared with blue	0	0	7			
Sand bed.—Soft sand, in which the water increased to 1,000 gallons per hour ...	10	3	0			
White post, in which a crib was set ...	0	2	10			
Grey metal	0	1	10			
COAL	0	1	10			
				38	3	1
Grey metal	0	1	10			
White post	0	5	0			
Grey metal	0	0	10			
White post	0	0	10			
Grey metal	0	1	10			
White post	0	0	7			
Strong blue metal ...	2	3	4			
COAL	0	0	9			
				4	3	0
Brown thill	1	1	4			
White post	0	4	1			
Blue metal	0	0	5			
White post	2	1	0			
Blue metal stone ...	0	0	2			
White post	3	0	9			
Brown whin	0	2	6			
White post	0	5	3			
Grey metal	1	4	2			
Black stone	0	0	3			
Grey metal	0	1	4			
Carried forward	10	3	3	42	6	1

	Fs.	Ft.	In.	Fs.	Ft.	In
Brought forward	10	3	3	42	6	1
Black stone	0	2	3			
Brown thill	0	2				
COAL	0	1	0			
				11	3	0
Brown thill	0	0	9			
COAL	0	3	9			
Thill	0	4	0			
Blue metal	1	5	0			
Grey metal, with post girdles	2	0	0			
Strong white post ...	1	4	0			
Grey metal	2	0	10			
Strong white post, mixed with iron-stone balls ...	3 0	0 2	7 0			*
Grey metal	0	0	10			
Strong grey metal, with post girdles ...	7	4	6			
Grey post	2	2	4			
COAL—*High Main Seam*	0	5	10			
				23	4	5
White thill	0	4	0			
Strong white post ...	1	0	8½			
Black stone	0	1	0			
Blue metal	2	1	7			
Grey metal	2	5	3			
Strong white post ...	2	0	6			
Strong brown post, mixed with whin ...	4	0	6½			
COAL (*supposed Maudlin Seam*) ...	0	0	9			
				13	2	4
Carried forward				91	3	10

* Approximate sea level (Ordnance datum).

	Ft.	In.	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward						91	3	10
Brown thill			0	0	10½			
White post			0	2	7			
Grey metal			0	5	3			
COAL			0	0	2			
Soft brown thill ...			0	2	5			
Soft white thill ...			0	0	9			
Soft brown post girdles			0	1	0			
Grey metal			0	2	0			
COAL			0	0	4			
						2	3	4½
Brown thill			0	0	8			
Soft white post ...			0	4	0			
Grey metal			0	4	0			
Soft blue metal and post girdles ...			2	5	0			
COAL—LOW MAIN SEAM			0	3	9			
						4	5	5
Grey metal			1	0	1			
White post			4	4	2			
COAL			0	0	5			
Grey metal			2	3	4			
White post			1	0	6			
Whin girdles ...			2	0	3			
Black stone			0	3	3			
Carried forward			12	0	0	99	0	7½
Brought forward			12	0	0	99	0	7½
Grey metal			1	3	7			
COAL			0	0	9			
						13	4	4
Band			0	0	3			
Brown thill			0	0	8			
Grey metal			3	3	4			
Strong white post ...			3	3	0			
Strong brown whin ...			0	4	0			
Strong white post ...			6	0	0			
Hutton Seam—	Ft.	In.						
COAL ...	4	5						
Band ...	0	1						
COAL, bottom ...	0	9						
Strong splint	0	4						
			0	5	7			
						14	4	10
Black stone						0	0	6
Total						127	4	3½

NOTE.—The George and Lady Isabella Pits are about 45 yards apart, and there is a dip dyke to the East of 7 fathoms between the two shafts.

The experiment was made in the Low Main Seam at a point about 319 yards south-east from the shaft, and fully 60 yards from any whole workings or goaf; the dip of the strata being towards the east.

The roof is composed of grey metal and post girdle, is rather tender, and the thill is of strong seggar clay.

The coal is clear, hard, bituminous, and moderately bright, with the cleavage well defined, and is used for household purposes.

The Main Coal Seam 114 feet above is partially worked, and the Hutton Seam 78 feet below is partially worked.

The specific gravity is 1·24.

On August 28th, 1879, a hole was bored in the solid coal at the face of a narrow board. See Section No. 1.

SECTION NO. 1.

CONDITIONS.

	Ft	In.
The length of the borehole was	7	0
The diameter of ,, ...		2¼
The diameter of pipe fixed in the hole		½
Gas space	2	6
Hole at right angles to the cleat.		
Cover—depth of hole from surface	750 feet.	
Distance of hole from shaft	319 yards.	
Description of gauge used...	Bourdon's.	

The hole was plugged up in the following way:—The pipe for conveying the gas from the gas space to the pressure gauge was screwed at its inside end and provided with a nut and washer, the other end was provided with a collar. Between this collar and the nut were placed, first a metal socket, and then a number of India-rubber washers which were a little smaller in diameter than the hole. When these were placed in the hole they were all screwed tightly up together, and the space round the socket at the outer end of the borehole filled with good Portland cement.

RESULTS.—See Table, Page 225.

Pressure of Gas.

	Lbs. per sq. inch
In the first 5 minutes after the hole was made tight the pressure rose to	13
In 2 hours and 20 minutes the pressure was	25½
In 11 hours and 35 minutes the maximum was attained, namely	28
This maximum pressure was maintained for 4 hours, when a steady decrease ensued; the gauge was attentively observed, and the varying pressures noted every hour.	
In the first 12 hours after the maximum, the pressure was	27
In 36 hours after this	25½
A steady decrease still going on, the hourly observance of the pressure was continued.	
At the end of 26 days 3 hours and 25 minutes the last pressure was read off and noted, which was ...	8¼

THE EXPERIMENT MADE AT HETTON COLLIERY.

The Hetton Colliery was opened out about the year 1822—58 years before the experiment was made, the following being the account of the strata sunk through in the Minor Pit:—

TOWNSHIP OF HETTON-LE-HOLE, DURHAM.

Sheet 21 of Ordnance Map. Lat. 54° 48′ 59″, Long. 1° 26′ 26″.

Begun Dec. 20th, 1820.

Approximate surface level 319 feet above sea (Ordnance datum).

	Fs.	Ft.	In.	Fs.	Ft.	In.
Outset	1	0	0			
Soil	0	2	0			
Sand	1	3	0			
Gravel	0	4	0			
Limestone, marl, and soft limestone ...	3	0	0			
Yellow limestone in different beds ...	15	5	6			
Blue limestone, flaggy at bottom (called "Blue Rag") ...	7	2	2			
Blue metal	0	5	2			
Soft sandstone ...	0	4	4			
Very soft white metal stone	0	1	2			
Grey metal stone ...	0	0	9			
Strong brown limestone, mixed with whin	1	2	8			
Soft bluish grey metal stone	5	2	3			
COAL	0	1	4			
				38	4	4
Soft grey metal ...	0	4	8			
Blue metal stone ...	1	3	0			
COAL, mixed with black metal ...	0	1	9			
				2	3	5
Grey metal stone ...	2	5	10			
COAL	0	1	0			
				3	0	10
Grey metal stone ...	0	0	4			
Black metal, mixed with *coal*	0	0	7			
COAL	0	1	10			
				0	2	9
Grey metal stone or thill	0	1	4			
Grey metal stone, with partings	4	0	10			
Strong white post and water, very spongy	3	1	8			
COAL	0	2	4			
				8	0	2
Carried forward				52	5	6

	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward				52	5	6
Grey metal stone or thill	0	1	6			
						*
White post	0	2	3			
Grey metal stone ...	1	2	5			
White post, with partings and water ...	6	3	3			
Grey metal stone ...	0	2	8			
COAL, mixed with black metal ...	0	1	6			
				9	1	7
Thill	0	0	8			
White post	0	2	5			
Grey metal	0	2	2			
Grey metal stone, with post girdles ...	0	1	4			
Grey metal	0	0	6			
COAL	0	0	10			
				1	1	11
Thill	0	0	3			
Grey metal stone ...	0	0	10			
White post	1	4	2			
Grey metal, mixed with post	0	2	9			
				2	2	0
Black and blue metal	1	5	10			
COAL	0	0	3			
				2	0	1
Grey metal	0	1	3			
White post	1	1	9			
Grey and white post, mixed with grey metal stone ...	1	5	2			
Whin	0	3	7			
White post, with blue metal and partings	0	2	10			
Strong white post ...	1	4	6			
Strong white spongy post, with partings	4	5	11			
Grey and white post and water	3	1	3			
Grey metal stone ...	0	4	6			
Carried forward	15	0	9	67	5	1

---

* Approximate sea level (Ordnance datum).

	Ft.	In.	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward			15	0	9	67	5	1
Three-Quarter Seam (High Main on Tyne)—								
COAL ...	0	4						
Grey metal...	1	0						
COAL ...	1	3						
Band ...	0	5						
COAL ...	3	2						
Band ...	0	4						
COAL, mixed with black metal ...	0	11						
			1	1	5			
						16	2	2
Thill			0	1	8			
Grey metal stone, with large ironstone balls			1	2	4			
Strong grey metal post, with girdles ...			3	3	9			
Black metal, with scares of *coal* ...			0	0	9			
COAL			0	1	2			
						5	3	8
Dark grey metal, with scares of *coal* ...			0	2	8			
Grey metal, with ironstone balls			0	2	6			
Grey metal, with dunnish post girdles ...			3	1	10			
Grey metal stone ...			1	0	8			
COAL *(5/4 Seam on Wear)*			0	1	7			
						5	3	3
Black metal, with scares of *coal* ...			0	0	6			
Dark grey metal ...			0	4	4			
COAL			0	0	5			
						0	5	3
Grey metal stone, with post girdles ...			5	4	6			
Grey post			0	4	10			
Blue and grey metal stones			3	5	9			
						10	3	1
Blue and grey metal, with post girdles ...			1	5	3			
High Main (Yard Coal on Tyne)—								
COAL, top	1	8						
Band ...	0	1						
COAL ...	4	9						
			1	0	6			
						2	5	9
Thill			0	0	8			
Grey and white post...			1	5	0			
Black metal stone ...			0	1	4			
Blue metal, with ironstone girdles ...			1	2	4			
Black metal stone ...			0	1	4			
						3	4	8
Carried forward						113	2	11

	Ft.	In.	Fs.	Ft.	In.	Fs	Ft	In.
Brought forward						113	2	11
Blue metal, with ironstone girdles ...			0	2	10			
COAL			0	0	5			
						0	3	3
Strong grey metal stone			0	2	0			
Grey and white post...			4	3	9			
Grey metal			1	3	2			
Maudlin or Bensham Seam—								
COAL ...	1	2						
Grey metal...	3	9						
COAL ...	0	4						
			0	5	3			
						7	2	2
Grey metal			0	4	2			
Blue metal			0	4	0			
Grey metal			1	5	6			
Blue metal, with *coal pipes*			0	3	8			
Strong grey post ...			0	5	8			
Strong grey post, with girdles			0	5	2			
Whin			0	3	0			
Soft grey metal ...			2	5	8			
COAL—*Low Main Seam (5/4 on Tyne)*			0	4	1			
						9	4	11
White post			2	0	6			
Whin			0	2	2			
Grey metal, with post girdles			2	0	10			
Black and blue metal			1	0	0			
COAL, splint ...			0	1	0			
						5	4	6
Grey metal and post girdles			0	5	11			
COAL			0	0	4			
Band			0	0	1¾			
COAL			0	0	7			
						1	0	11¾
Thill			0	4	0			
Strong grey metal ...			1	2	0			
Grey post			1	2	11			
						3	2	11
Black metal			0	3	0			
Blue metal, with girdles			0	1	4			
Strong white post ...			4	0	0			
Grey metal and post girdles			1	1	0			
HUTTON SEAM—								
COAL ...	4	7½						
Band ...	0	3½						
COAL, bottom	1	3						
			1	0	2			
						6	5	6
Total						148	3	1¾

The experiment was made in the Hutton Seam at a point about 3,530 yards due east from the shaft and about 100 yards from some old goaf, the dip of the strata being towards the east.

The roof is composed of grey metal with post girdles, and is moderately good. The thill is of rather soft seggar clay.

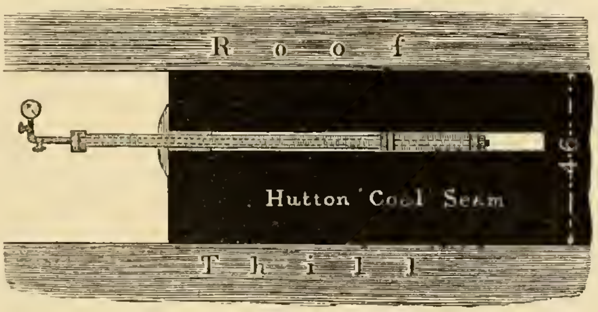
The coal is clear, hard, and bituminous, with the cleavage well defined, and is used for household purposes.

None of the coal seams, either above or below, have been worked.

The specific gravity is 1·17.

On September 1st a hole was bored in the solid coal at the face of a winning headways, on the dip side of a 7-feet trouble. See Section No. 2.

SECTION NO. 2.



CONDITIONS.

	Ft.	In.
The length of the borehole was	9	0
The diameter of „		2½
The diameter of pipe fixed in the hole		½
Gas space	2	0
The hole parallel with the cleat.		
Cover—depth of hole from surface	1,228 feet.	
Distance of hole from shaft	3,530 yards.	
Description of gauge used...	Bourdon's.	

The hole was made tight in the same way as in Experiment No. 1, except that only one foot of India-rubber washers was used; these washers were screwed up and expanded so as to completely fill the hole, the outer end being filled up with Portland cement. See Section No. 2.

RESULTS.—See Table, Page 226.

Pressure of Gas.

		Lbs. per sq. inch.
Sept. 1.	—At 10 P.M. the gauge was screwed on, and the readings were noted every hour. In five minutes the pressure was	8½
,,	At 11 P.M. ,,	29
Sept. 2.	—At 5 A.M., the pressure was	40
	Up to this time a steady increase went on, which was followed by an equally steady decrease.	
,,	At 6 A.M. the pressure was	39½
	Readings continued to be taken every hour; and decreasing pressure was noted until 8 P.M., when it fell to	35
	This last noted pressure was at once succeeded by increasing pressures.	
,,	At 9 P.M. the pressure noted was	37
	During the next 33½ hours various fluctuations occurred; sometimes the gauge showed increasing and sometimes decreasing pressures.	
Sept. 4.	—At the end of this time, namely, at 6·30 A.M., being 2 days and 8½ hours from the commencement, the highest pressure was noted, namely	45
	Half an hour later the pressure fell to	40
	And remained so for several hours, when the experiment was discontinued.	

THE EXPERIMENTS MADE AT EPPLETON COLLIERY.

The Eppleton Colliery was opened out about the year 1837, 43 years before the experiments were made, the following being the account of the strata sunk through in the Jane Pit :—

TOWNSHIP OF GREAT EPPLETON, DURHAM.

Sheet 21 of Ordnance Map. Lat. 54° 49′ 40″, Long. 1° 26′ 1″.

Begun May 23rd, 1825.

Approximate surface level 435 feet above sea (Ordnance datum).

	Fs.	Ft.	In.	Fs.	Ft.	In.
Soil	0	1	7			
Sand and gravel ...	4	3	0			
Limestone	9	3	0			
Yellow sand (water got near the bottom, which increased to 6 tubs of 60 gallons an hour)	18	2	9			
Confused post ...	0	2	0			
Grey metal stone (first wedging crib laid at top of grey metal)	0	5	0			
Red metal, with water	1	1	0			
Black band, with water	0	0	4			
Soft red metal and water	3	1	11			
Soft blue metal, with water (second wedging cribs laid about 3½ fathoms into this blue metal) ...	11	0	6			
Whinstone, with water (had 70 tubs of 60 gallons per hour)	0	0	6			
Black metal, with water	0	1	4			
COAL	0	1	8	50	0	7
Grey thill (third wedging crib laid at this thill, and stopped the whole of the water—had in all 36 tubs of 80 gallons per hour)	0	0	5			
White post (got a little water in this post)	0	3	0			
Soft red metal ...	0	5	0			
Grey and red post (on entering this post the large feeder was got, and was drawn out of bottom with						
Carried forward	1	2	5	50	0	7
Brought forward	1	2	5	50	0	7
gin; pumps were then put in, and at 9 fathoms into post laid fourth crib; the water was only partially stopped) ...	10	0	0			
Soft blue metal ...	0	0	6			
Soft black metal ...	0	0	6			
Blue metal, with bands of *coal*	0	3	4	12	0	9
Grey metal stone, with post girdles and water (laid two more cribs in this metal, and stopped all the water)	1	5	1			
Black metal	1	1	0			
Grey thill	0	1	6			
COAL, and a drift driven through to *Carolina Pit* ...	0	2	0	3	3	7
Grey thill	0	1	0			
Grey post, with water (last wedging crib laid on the bottom, and tubbing all got in, but not wedged, owing to the breaking of malleable iron shaft; this crib afterwards cut out, and metal substituted)	0	3	7	0	4	7
Total depth to where left off in 1827, when the water overpowered the engines, and as measured when resumed on Nov. 15th, 1831...				66	3	6
Carried forward				66	3	6

	Ft.	In.	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward						66	3	6
Strong white post ...	3	5						
Dark post ...	2	0						
Strong white post ...	1	8						
			1	1	1			
Strong grey metal to where was laid a wedging crib, which carried the whole of the water			0	3	11			
Grey metal			0	3	10			
Blue metal			3	2	1			
COAL ...	0	2						
Band	0	1						
COAL ...	0	3						
			0	0	6			
						5	5	5 *
White thill			0	1	5			
Post			0	3	0			
Very strong grey metal, mixed with whin and ironstone girdles, upon which a crib (wood) was laid, but afterwards cut out			1	1	3			
Blue stone			1	0	3½			
Black stone			0	0	5			
COAL			0	0	10			
						3	1	2½
Thill stone			0	1	10¼			
Post, to where two metal wedging cribs were laid, the water had been accumulating for the last 5 fathoms, which was all borne up by this crib, and the pit kept quite dry—engine, 1 stroke in about 6 minutes			0	0	11¼			
Post (continuation of the above)			1	1	10¼			
Grey metal, mixed with whin			0	2	2			
Post			0	4	8½			
Blue metal			1	4	0			
COAL ...	1	9						
Band	0	11						
COAL ...	2	1½						
			0	4	9½			
						5	2	3¾
(A drift driven through to *Carolina Pit,* and got water).								
Carried forward						81	0	5¼

	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward				81	0	5¼
Thill stone, in which were laid two metal wedging cribs that carried all the feeders	0	2	4			
Grey and white post	0	1	10			
Grey metal	0	1	10			
White post, with water (about 300 gallons per minute) ...	0	1	10			
White post, with blue metal partings, very thin	5	3	5½			
Blue metal	0	0	6			
White post, with two thin blue metal partings (one at the bottom)	0	2	11½			
COAL	0	1	11			
				7	4	8
Black stone	0	1	0			
White thill	0	5	6½			
Grey thill, in which two wedging cribs were laid to carry and tub off the water	0	4	11			
Grey metal (continued)	3	1	0			
Post, with threads and water	0	2	9			
Blue stone	0	0	8			
Strong post	1	3	4			
Post, with partings and water (about 90 gallons a minute)...	6	2	9½			
COAL	0	0	4			
				13	4	4
Thill	0	3	8			
Grey metal, with threads, to where a wedging crib was laid for the purpose of securing the pit	0	0	3			
Grey metal (continued below the crib) ...	0	3	0			
Black metal, mixed with post girdles...	2	0	8			
Black stone	2	4	0			
COAL	0	1	0			
Thill	1	0	10			
Post, mixed with grey metal	1	2	7			
Strong post to two metal wedging cribs	0	2	5			
Carried forward	9	0	5	102	3	5¼

* Approximate sea level (Ordnance datum).

	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward	9	0	5	102	3	5¼
Post, very close and strong, without any water (drew the pumps after finishing the last tub) ...	7	2	7			
Grey metal, with post girdles, in which there were three leaders of dykes, apparently dipping to West, and very soft	3	0	0			
Blue metal	0	1	6			
COAL—*Three-Quarter Seam,* with about 20 inches of coarse *top coal,* and *coarse coal* at the bottom	1	0	6			
				20	5	0
Black thill	0	1	10			
Very strong grey metal	1	1	9			
Ironstone girdle ...	0	0	4			
White thill stone and seggar clay, mixed with grey metal ...	2	2	7			
Grey metal	......					
Black metal	0	0	8			
COAL, mixed with stone	0	1	10			
				4	3	0
Thill	0	2	6			
Blue and grey metal...	0	4	10			
COAL	0	0	1¼			
				1	1	5¼
Strong grey metal, inclining to post ...	2	4	0			
White post, at bottom of which a leader of a dyke was discovered	1	1	8			
Grey metal	0	4	9			
COAL—*Five-Quarter Seam,* in which is a trouble rising to east 4 feet ...	0	1	9			
				5	0	2
Thill	1	1	4			
Black stone	0	1	6			
Grey metal, with post girdles	1	1	2			
Post	1	3	10			
Black stone	0	0	6			
Grey metal	2	2	10			
Post	0	1	0			
Grey metal	0	1	2			
Whin	0	1	5			
Carried forward	7	2	9	134	1	0½

	Ft.	In.	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward			7	2	9	134	1	0½
Blue stone (much disturbed and broken, and at about 3 fathoms into it got the leader of a trouble rising to the East)			5	2	1			
COAL (*supposed Main Coal,* but only found on the west side of the leader got in the blue stone above) ...			1	0	6			
						13	5	4
Very mild blue metal			5	5	6			
Low Main Seam—								
COAL, good	5	6						
Black swad	0	3						
COAL, bottom ...	1	10						
			1	1	7			
						7	1	1
Black stone			0	0	3			
Grey metal			3	2	5			
Post			0	1	1			
Black stone			0	1	3			
COAL, splinty ...			0	2	2			
						4	1	2
Black stone, mixed with *coal*			0	3	10			
Grey metal			0	1	0			
Strong post, with grey metal partings ...			2	3	6			
Blue metal, mixed with grey metal girdle			1	1	0			
Very soft black metal			0	5	4			
COAL			0	0	10			
						5	3	6
Black thill			0	2	10			
White post			0	0	6			
Grey metal			0	1	6			
White post (walled off)			0	4	8			
Grey metal, mixed with post girdles...			1	3	4			
Black stone			0	0	9			
COAL ...	0	7						
Band	0	2						
COAL ...	0	11						
			0	1	8			
						3	3	3
Black stone			0	1	10			
Grey metal, mixed with post girdles...			0	2	6			
Grey metal			0	5	6			
Whin, mixed with post			0	2	4			
Carried forward			2	0	2	168	3	4½

	Ft.	In.	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward			2	0	2	168	3	4½
Grey metal			0	1	6			
Black stone			0	5	2			
Grey metal			0	1	6			
Whin, mixed with pest			0	0	6			
Grey metal, mixed with post girdles...			1	0	6			
Blue stone			0	0	9			
Black stone			0	0	2			
HUTTON SEAM—								
COAL, good	3	11½						
COAL, coarse	0	6						
			0	4	5½			
						5	2	8½
Thill			0	1	8			
COAL, coarse and brassy...	0	6						
COAL, coarse	0	7						
			0	1	1			
						0	2	9
Carried forward						174	2	10

	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward				174	2	10
Sunk below seam as sump:—						
Black stone	0	0	6			
Thill	0	2	0			
Grey metal	2	4	9			
Black stone	0	0	8			
	0	0	5			
Thill	0	3	0			
				3	5	4
Total				178	2	2

The whole of the experiments were made in the Hutton Seam at a point about 4,000 yards north-east from the shaft and 396 yards from any whole working or goaf, the dip of the strata being towards the east.

The roof is composed of blue and grey metal mixed with post girdles, and is moderately good. The thill is of soft seggar clay.

The coal is clear, very bright, bituminous, and moderately hard, with the cleavage fairly defined.

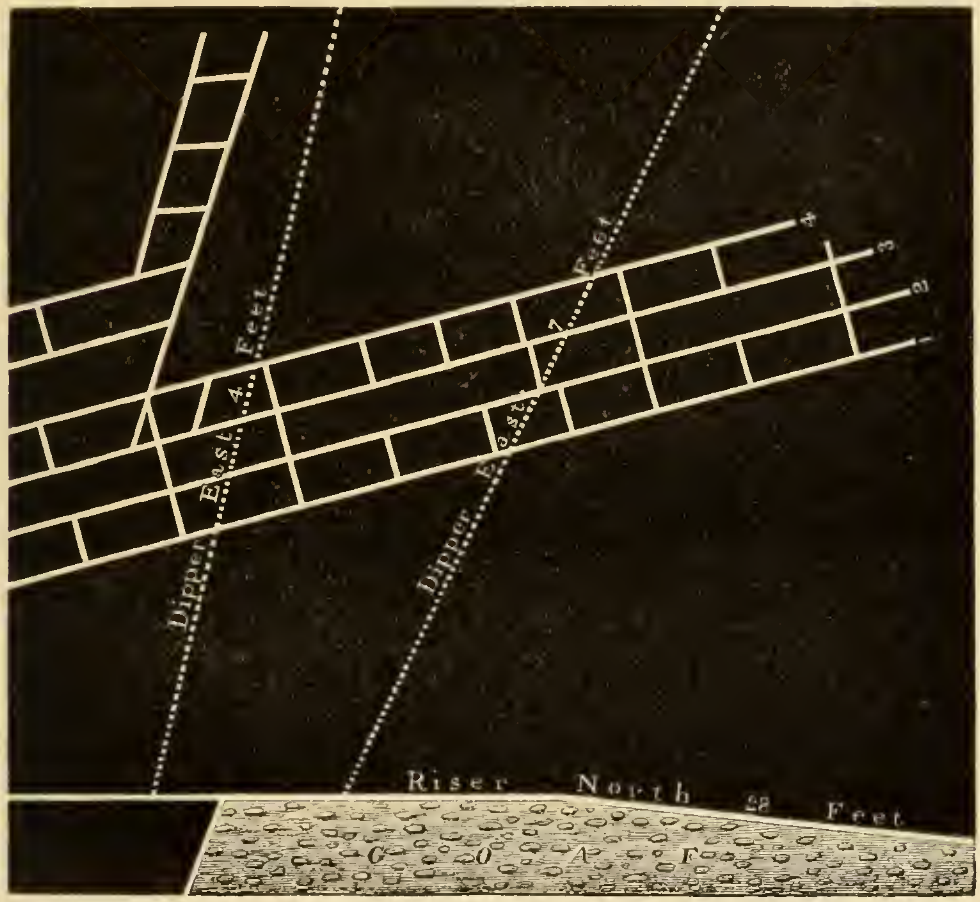
The coal is not worked in any seam either above or below.

The following is an analysis of the coal:—

Fixed carbon	60·34
Matters volatile at a red heat, other than sulphur and moisture	33·31
Sulphur	1·47
Ash	3·48
Moisture	1·40
	100·00

The specific gravity is 1·24.

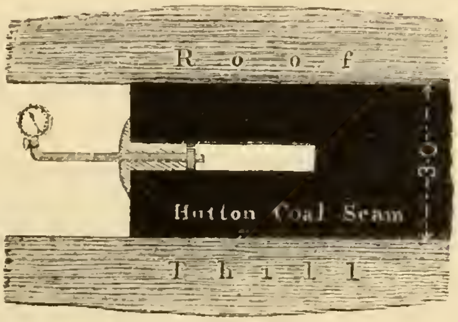
Plan No. 1 showing the position of the workings in which the experiments were made.



EXPERIMENT I.

On August 29th, 1879, a hole was bored in the solid coal at the face of No. 4 Winning Cross Cut. See Plan No. 1 and Section No. 3.

SECTION No. 3.



CONDITIONS.

	Ft	In
The length of the borehole was	3	6
The diameter of ,, ...		1½
The diameter of pipe fixed in the hole		½
Gas space	2	0

Hole bored about 65 deg. to the cleat.

Cover—depth of hole from surface	1,261 feet.
Distance of hole from shaft	4,000 yards.
Description of gauge used...	Bourdon's.

To make the borehole secure and gas tight, a wooden plug, previously bored to receive the half-inch iron pipe, was driven into the hole, and firmly wedged in, the outer end being covered with Portland cement. See Section No. 2.

RESULTS.—See Table, Page 227.

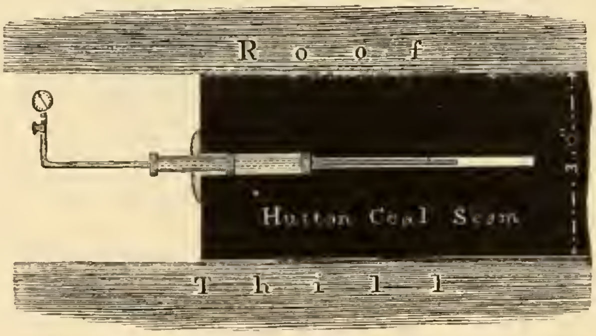
Pressure of Gas.

	Lbs. per sq. inch.
Aug. 29.—At 8·46 A.M. the pressure gauge was screwed on to the pipe, and the pressure was observed and noted at intervals varying from three to five minutes.	
At 8·58½ A.M. the pressure was	30
A steady increase followed.	
At 9·36 A.M. the gauge registered	54
At 10 A.M. the maximum was reached and noted, namely	54¾
Aug. 30.—At 1·30 A.M., the gauge was taken off a short time and then screwed on again. In thirty minutes the pressure rose to	45
The experiment was then discontinued.	

EXPERIMENT II.

On September 1st, 1879, a hole was bored in the solid coal at the face of No. 3 Crosscut. See Plan No. 1, page 175, and Section No. 4.

Section No. 4.



CONDITIONS.

	Ft.	In.
The length of the borehole was	7	6
The diameter of „		1¼
Afterwards enlarged to 2 inches for 2 feet in length at outer end.		
The diameter of pipe fixed in the hole		½
Gas space	2	0
Hole bored about 65 deg. to the cleat.		
Cover—depth of hole from surface	1,261 feet.	
Distance of hole from shaft	3,970 yards.	
Description of gauge used	Bourdon's.	

The pipe in the hole was made tight by 16 inches of India-rubber washers being screwed up and expanded, the outer end of the pipe being filled up and plastered over with Portland cement. See Section No. 4.

RESULTS.—SEE TABLE, PAGE 227.

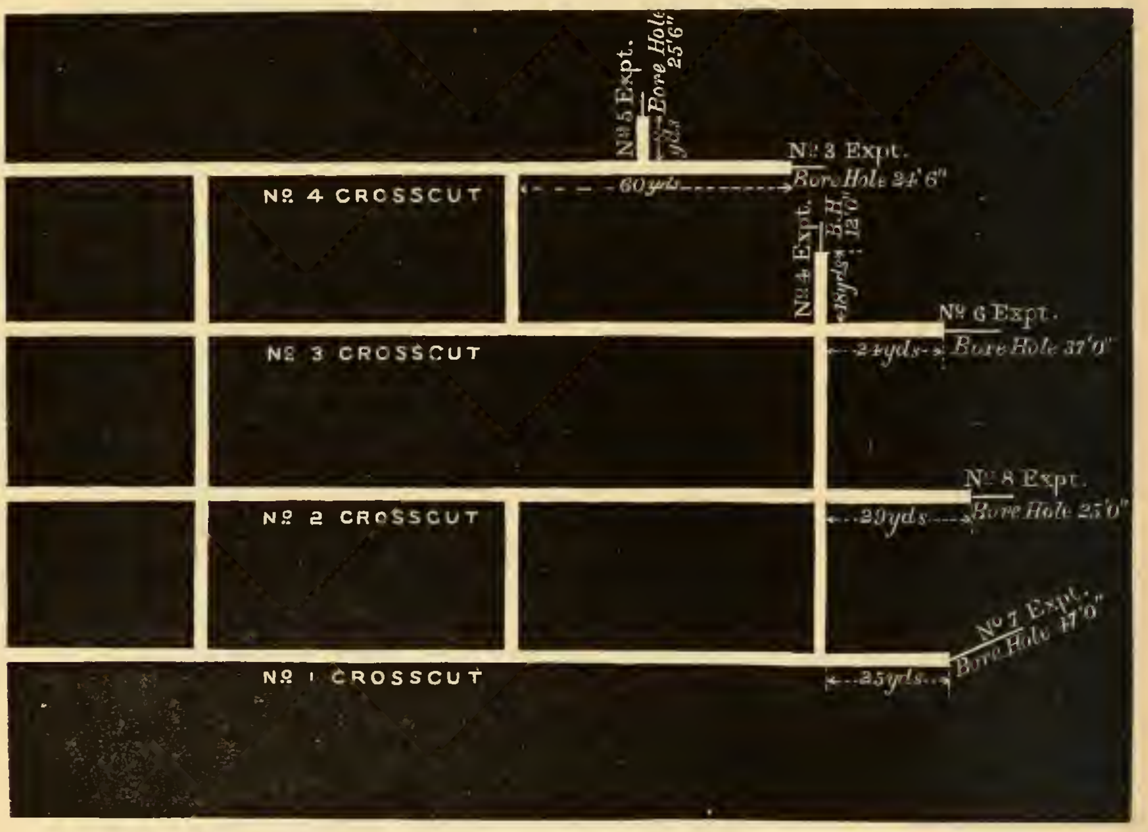
		Pressure of Gas. Lbs. per sq. inch.
Sept.	1.—At 9·50 A.M. the gauge was screwed on.	
„	At 10·5 A.M. the pressure was	10
„	At 10·12 A.M. „	25
	Some leakage was observed, and the India-rubber was screwed tighter, and more cement put on.	
„	At 10·14 A.M. the pressure was	30
„	At 10·40 A.M. „	50
	The pressures were read off and noted at times varying from three to twelve minutes.	
„	At 4 P.M. the pressure noted was	93½
	Then ensued a decrease, readings being taken every hour.	
„	At 10 P.M. the pressure read off was	80
	This was followed by an increase.	
Sept.	2.—At 8·22 P.M. (being 34 hours 22 minutes from the commencement of the experiment) the maximum pressure was reached, namely ...	104½
	Various fluctuations then ensued, the pressures increasing and decreasing, and never giving the same readings for more than three consecutive hours.	

Pressure of Gas.

			Lbs. per sq. inch.
Sept. 3.—At 12 P.M. the pressure was	...	... ...	93
Sept. 4.—At 1 A.M.	„	... ...	98
„ At 8 A.M.	„	... ...	90

This pressure was maintained up to September 5th, at 4 A.M., being 3 days 18 hours and 10 minutes from the commencement, when the experiment was discontinued.

Plan No. 2, being an enlargement of a portion of Plan No. 1, showing the winning crosscuts in which the experiments were made.



EXPERIMENT III.

On September 5th, 1879, a hole was bored in the solid coal at the face of No. 4 Winning Crosscut. See Plans Nos. 1 and 2, and Section No. 5.

SECTION NO. 5.

CONDITIONS.

	Ft.	In.
The length of the borehole was	24	6
The diameter of „		2½
The diameter of pipe fixed in the hole		½
Gas space	4	0

Hole bored about 65 deg. to the cleat.

Cover—depth of hole from surface	1,261 feet.
Distance of hole from shaft	3,970 yards.
Description of gauge used	Bourdon's.

To make this hole perfectly tight, 2 feet 6 inches of India-rubber washers were put on the inner end of pipe, then a 12-inch wooden washer, then 3 inches of India-rubber, and then 12 inches of wood, and so on nearly to the outer end of the pipe. The whole of this was screwed up, and the India-rubber expanded, the outer end of the hole being filled with cement. The whole face of the coal was then cemented over. See Section No. 5.

RESULTS.

Pressure of Gas.

The readings will be found *in extenso* on page 228; but such of them as are necessary to illustrate the remarks which follow are given in the following table :—

DATE.	HOUR.	Lbs. Pressure.	Barometer in inches.	Thermo. in degrees.	DATE.	HOUR.	Lbs. Pressure.	Barometer in inches.	Thermo. in degrees.
Sept. 5 ...	11·0 a.m.	[1]...	...	...	Sept. 11 ...	3·0 p.m.	201	30·63	71
„ „ ...	11·2 „	21	...	...	„ „ ...	6·0 p.m.	201	30·62	71
„ „ ...	12·54 p.m.	121	...	...	„ 12 ...	8·0 a.m.	198	30·30	72
„ 6 ...	5·0 a.m.	181	...	...	„ „ ...	3·0 p.m.	199	30·32	71
„ „ ...	6·0 „	179	...	...	„ „ ...	4·0 „	198	30·31	71
„ „ ...	7·0 „	179	...	...	„ 13 ...	4·0 a.m.	198	30·41	71
„ „ ...	8·0 „	181	...	...	„ „ ...	6·0 „	196	30·41	71
„ „ ...	2·0 p.m.	184	...	...	„ „ ...	7·0 „	197	30·42	71
„ „ ...	3·0 „	183	...	...	„ „ ...	4·0 p.m.	195	30·54	71
„ 8 ...	6·0 „	195	...	...	„ „ ...	6·0 „	193	30·55	71
„ 9 ...	6·0 a.m.	184	30·12	72	„ „ ...	7·0 „	194	30·58	70
„ „ ...	12·0 noon	190	30·10	72	„ 15 ...	11·0 p.m.	185	30·85	70
„ „ ...	2·0 p.m.	190	30·20	72	„ „ ...	12·0 „	186	30·85	70
„ „ ...	5·0 „	197	30·30	72	„ 16 ...	5·0 a.m.	186	30·88	70
„ „ ...	6·0 „	201	30·30	72	„ 17 ...	12·0 noon.	180	30·86	71
„ „ ...	9·0 „	204	30·45	72	„ „ ...	1·0 p.m.	177	30·88	71
„ „ ...	11·0 „[2]	204	30·50	72	„ „ ...	4·0 „	180	30·85	70
„ 10 ...	6·0 „	201	30·70	73	„ „ ...	5·0 „	181	30·85	70
„ „ ...	8·0 a.m.	201	30·72	72	„ „ ...	6·0 „	180	30·85	70
„ „ ...	1·0 p.m.	203½	30·73	72	„ 18 ...	10·30 „	170	30·88	70
„ „ ...	4·0 „	202½	30·74	71	„ 19 ...	10·0 „	168	31·00	71
„ „ ...	6·0 „	203	30·74	71	„ 22 ...	9·0 „	156½	30·60	73
„ „ ...	8 0 „	202	30·77	71	„ „ ...	10·0 „	158	30·58	72
„ 11 ...	3·0 a.m.	202	30·78	71	„ „ ...	11·0 „	161	30·54	71
„ „ ...	10·0 a.m.	200	30·60	71	„ 24 ...	9·0 a.m.	160	30·29	71
„ „ ...	11·0 a.m.	200	30·65	71	„ 26 ...	10·0 „	155	30·91	70

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[1] Gauge put on. [2] Maximum pressure.

Pressure of Gas.

Sept. 5.—At 11 A.M. the gauge was screwed on.

Lbs per sq. inch.

In two minutes the pressure rose to 21

The gauge was very attentively observed, and readings noted at times varying from half a minute to three minutes.

The pressure rose rapidly, as much as 5 lbs. in three minutes at the commencement of the experiment, and in 1 hour and 54 minutes 120 lbs. pressure was reached, the ratio of rise being 1 lb. in three minutes.

The gauge continued to register increasing pressures until

Sept. 6.—At 5 A.M., 18 hours from the commencement, when it was 181

„ In the next two hours (6 and 7 A.M.) it was ... 179

„ At 8 A.M. 181

„ At 2 P.M. 184

„ At 3 P.M. 183

Increasing pressures again ensued. The readings were now recorded regularly every hour, and showed that the gauge remained stationary for several consecutive hours, with an occasional rise or fall of 1 lb.

Sept. 8.—At 6 P.M., 3 days 7 hours from the commencement, the pressure was 195

This was followed by decreasing pressures until

Sept. 9.—At 6 A.M., when the pressure was 184

In order to ascertain whether the various fluctuations indicated by the gauge were caused by atmospheric changes, a barometer and thermometer were obtained, and their readings noted with those of the pressure gauge.

It will be observed that the pressure fell to 201 lbs. in seven hours, at which time the barometer was 30·70, and the thermometer 73 deg. The pressure then rose to 203½ lbs., and the barometer to 30·73 inches; the thermometer falling to 72 deg. After which, the pressure decreased and went down to 202½ lbs.; then rose to 203 lbs.; and again went down to 202 lbs., at which it stood several hours. The barometer continued steadily rising through all the above fluctuations of pressure.

On September 11th, at 3 A.M., 5 days 16 hours from the commencement of the experiment, the readings were :—Gauge, 202 lbs.; barometer, 30·78 inches; thermometer, 71 degrees.

Pressure of Gas.

After that a regular and steady decrease of pressure, with falling barometrical readings, ensued, which continued several hours; then the barometer began to rise, but the gas pressure continued to fall. The barometer rose at 11·0 A.M., $\frac{5}{100}$, and stood steady three hours, at 30·65 inches, the gas pressure remaining the same, namely, 200 lbs. In the next two hours the gas pressure rose to 201 lbs., and the barometer dropped to 30·63 inches: the several readings being at this time, September 11th, 3 P.M., 6 days 4 hours from commencement:—Gauge, 201 lbs.; barometer, 30·63 inches; thermometer, 71 degrees.

A steady decrease in the gas pressure now followed, and continued seventeen hours, the barometer slowly falling the whole time: readings at this time, September 12th, 8 A.M.:—The gauge, 198 lbs.; barometer, 30·30 inches; thermometer, 72 degrees.

In the next seven hours the gas pressure stood at 199 lbs., the barometer slightly varying every hour—sometimes rising and sometimes falling. The readings noted one hour after this time were as follows:—September 12th, 4 P.M.; Gauge, 198 lbs.; barometer, 30·31 inches; thermometer, 71 deg. The pressure remained at 198 lbs. for twelve hours; during seven of these hours the barometer stood at 30·31 inches; then began to rise a little, and at the end of the thirteen hours the readings were:—Gauge, 198 lbs.; barometer, 30·41 inches; thermometer, 71 degrees.

The next two hours, the gas pressure fell to 196 lbs.; then rose to 197 lbs., at which it stood for nine hours, the barometer steadily rising all the time. One hour afterwards, the gas pressure fell 2 lbs.; the readings at this time, September 13th, 4 P.M., were:—Gauge, 195 lbs.; barometer, 30·54 inches; thermometer, 71 degrees.

The gas pressure fell 2 lbs. in the next two hours, then rose 1 lb. in the next hour; the barometer continuing to rise slowly. These fluctuations were followed by a steady decrease of pressure, which continued for fifty-three hours, the barometer rising slowly the whole of the time.

On September 15th, at 11 P.M., the several readings were:—Gauge, 185 lbs.; barometer, 30·85 inches; thermometer, 70 deg. In the next hour the pressure rose to 186 lbs.; the barometer and thermometer remaining the same.

The pressure was now steady for five hours, the barometer still rising, then succeeded (with only one interruption of two hours, when the pressure rose from 185 lbs. to 186 lbs.) a steady decrease, continuing for thirty-one hours, the barometer rising a great part of the time. The readings at this time, viz., on the 17th September, at 12 noon, were:—Gauge, 180 lbs.; barometer, 30·86 inches; and thermometer, 71 degrees.

Pressure of Gas.

During the whole of this experiment the readings were taken every hour.

	Gauge. Lbs.	Barometer. Inches.	Thermometer. Degrees.
One hour after the above readings, that is on			
Sept. 17.—At 1 P.M., a fall of 3 lbs. occurred	177	30·88	71
The pressure then stood 3 hrs.			
„ Then at 4 P.M. it rose to ...	180	30·85	70
„ „ 5 „ „ ...	181	30·85	70
„ „ 6 „ „ ...	180	30·85	70

At this point the gauge was screwed off and the pipe allowed to remain open. After the gauge was again attached, the pressure rose in nineteen hours to 170 lbs.; the barometer standing at 30·88 inches; and the thermometer, at 70 deg. With the barometer steadily rising, the gas pressure (with one or two exceptions, when there was an increase) steadily decreased; so that on September 19th, at 10 P.M., the readings were:—Gauge, 168 lbs.; barometer, 31·00 inches; thermometer, 71 degrees.

From this date to September 22nd, nothing occurred requiring special notice; a steady decrease invariably went on. On September 22nd, a somewhat sudden rise took place, which will be seen from the following readings:—

	Gauge. Lbs.	Barometer. Inches.	Thermometer. Degrees.
Sept. 22.—At 9 P.M. the readings were...	156½	30·60	73
„ At 10 P.M. „ ...	158	30·58	72
„ At 11 P.M. „ ...	161	30·54	71

The barometer, previous to 9 P.M., was steady for six hours.

When the pressure reached 160 lbs. it remained stationary thirty-one hours, the barometer slowly rising nearly the whole of the time.

On September 24th, at 9 A.M., the readings were :—Gauge, 160 lbs.; barometer, 30·29 inches; thermometer, 71 deg.

Nothing requiring notice occurred from this time up to September 26th, at 10 A.M., when the readings were :—Gauge, 155 lbs.; barometer, 30·91 inches; thermometer, 70 deg. The barometer had steadily risen, with one exception, during the whole of the observations between September 24th and 26th.

On September 26th no regular readings were noted after 10 A.M.

On October 1st, twenty-six days from the commencement of the experiment, the pressure was 152 lbs.

MEASUREMENT OF GAS.

Quantity of Gas.

A series of experiments were now made to ascertain the quantity of gas given off from a known area of coal face during the time that the gas was maintained at pressures varying from 105 lbs. to that of the atmosphere.

Quantity of Gas.

This was done by allowing only such a quantity of gas to escape from the borehole as would keep the desired pressure uniform during the time of measurement.

The following results were obtained by allowing the gas to escape through a pneumatic trough into a glass jar, with the gas pressure at zero.

The capacity of the jar was five pints, or 173·295 cubic inches.

Average time in filling	23 seconds.
Being equal to	1 cubic foot in 3 minutes 49 seconds.
Or	15·72 cubic feet in 1 hour.
Superficial area of bore-hole equal to ...	2·65 square feet.
Discharge of gas per hour per square foot	5·927 cubic feet.

Arrangements were made to continue this part of the experiment more accurately, and on October 3rd, recourse was had to a "Grall's Dry Gas Meter," through which the gas was passed as it issued from the hole; a small gasometer was also used, having an exact capacity of 2 cubic feet. See Plate XLV., which shows also the arrangement of taps by which the pressure was regulated. The meter and gasometer were carefully tested together by filling the gasometer with exactly 2 cubic feet of gas, which was then passed through the dry meter, and the result proved the accuracy of both. The results obtained with the gasometer will be seen from the following table :—

1.	At maximum pressure of	105	lbs. per sq. in.	got	1	cub. ft.	in 9	mins.	5	secs.
2.	At pressure of	90	,,	,,	1	,,	9	,,	53	,,
3.	,,	75	,,	,,	1	,,	11	,,	21	,,
4.	,,	60	,,	,,	1	,,	9	,,	3	,,
5.	,,	45	,,	,,	1	,,	7	,,	32	,,
6.	,,	30	,,	,,	1	,,	5	,,	6	,,
7.	,,	20	,,	,,	1	,,	4	,,	32	,,
8.	,,	10	,,	,,	1	,,	4	,,	18	,,
9.	,,	5	,,	,,	1	,,	3	,,	38	,,
10.	At	zero		,,	1	,,	3	,,	44	,,

The gas was allowed to pass through the meter without intermission, the quantity passing being read off and noted about every twelve hours. These readings give an average of 1 cubic foot in eight minutes three seconds.

On October 18th readings of the barometer and thermometer were again noted, and the quantities indicated by the meter read off every three hours.

The following table shows *in extenso* the results obtained by the dry meter—

TABLE SHOWING THE QUANTITY OF GAS COMING FROM THE HOLE, THE TIME OCCUPIED IN PASSING THROUGH THE METER, THE TIME PER CUBIC FOOT, AND THE CUBIC FEET PER HOUR, WITH THE PRESSURE RUN OFF.

DATE.	Cubic Feet passed through Meter.	Time Occupied.	Time per Cubic Foot.	Cubic Feet per Hour.	Barometer.	Thermometer.
	Cubic Feet.	H. M.	M. S.	Cubic Feet.	Inches.	Degrees.
October 3 and 4	163·07	14·3	5·10	11·40	...	...
„ 4	117·94	12·0	6·6	9·82	...	...
„ 5	109·03	13·0	7·9	8·38[1]	...	...
„ 5	97·02	11·0	6·48	8·82	...	...
„ 6	98·91	11·30	6·58	8·75	...	...
„ 6	112·06	12·30	6·42	9·11	...	...
„ 7	107·64	12·0	6·41	8·97	...	...
„ 7	131·38	13·0	5·56	10·10	...	...
„ 8	122·62	11·0	5·22	11·14	...	...
„ 8	64·60	8·0	7·26	8·07[2]	...	...
„ 9	75·50	12·0	9·32	6·29	...	...
„ 9	84·50	12·0	8·31	7·04	...	...
„ 10	85·50	12·0	8·25	7·12	...	...
„ 10	83·10	12·0	8·40	6·92	...	...
„ 11	83·50	12·0	8·37	6·95	...	...
„ 11	74·70	10·0	8·2	7·47[3]	...	...
„ 12	76·50	12·0	9·25	6·37	...	...
„ 12	92·90	12·0	7·45	7·74	...	...
„ 13	82·10	12·0	8·46	6·84	...	...
„ 13	83·10	12·0	8·40	6·92	...	...
„ 14	85·20	12·0	8·27	7·10	...	...
„ 14	83·70	12·0	8·36	6·97	...	...
„ 15	89·20	12·0	8·4	7·43	...	...
„ 15	78·30	12·0	9·12	6·52	...	...
„ 16	74·50	12·0	9·39	6·20	...	...
„ 16	96·10	12·0	7·30	8·00	...	...
„ 17	85·20	12·0	8·27	7·10	...	...
„ 17	86·60	12·0	8·19	7·21	...	...
„ 17 and 18	49·60	7·0	8·29	7·08[4]	...	...
„ 18	24·0	3·0	7·30	8·00	...	...
„ 18	20·50	3·0	8·47	6·83	...	...
„ 18	19·50	3·0	9·14	6·50	...	...
„ 18	21·35	3·0	8·26	7·11	30·77	70
„ 18	22·10	3·0	8·8	7·36	30·73	70
„ 18	20·90	3·0	8·37	6·96	30·73	70
„ 18	20·15	3·0	8·56	6·72	30·60	69
„ 18	22·70	3·0	7·56	7·56	30·50	69
„ 19	24·40	3·0	7·22	8·13	30·29	70
„ 19	20·10	3·0	8·57	6·70	30·27	70
„ 19	20·40	3·0	8·49	6·80	30·16	70
„ 19	22·60	3·0	7·57	7·53	30·14	70
„ 19	20·50	3·0	8·47	6·83	30·13	70
„ 19	20·70	3·0	8·41	6·90	30·09	70
„ 19	26·30	3·0	6·50	8·76	30·05	70
„ 19	20·70	3·0	8·41	6·90	29·98	70
„ 20	23·50	3·0	7·40	7·83	29·90	70
„ 20	22·30	3·0	8·4	7·43	29·88	70
„ 20	21·80	3·0	8·15	7·26	29·88	70
„ 20	20·40	3·0	8·49	6·80	29·98	69
„ 20	21·80	3·0	8·15	7·26	30·08	69
„ 20	20·20	3·0	8·55	6·73	30·18	69
„ 20	25·50	3·0	7·4	8·59	30·37	70
„ 20	21·50	3·0	8·22	7·16	30·44	70
„ 21	20·80	3·0	8·39	6·93	30·50	70
„ 21	21·50	3·0	8·22	7·16	30·52	69
„ 21	21·60	3·0	8·20	7·20	30·56	70
„ 21	19·80	3·0	9·5	6·60	30·60	69
„ 21	21·50	3·0	8·22	7·16	30·64	70
„ 21	21·0	3·0	8·34	7·00	30·67	70
„ 21	23·60	3·0	7·37	7·86	30·71	70
„ 21	21·80	3·0	8·15	7·26	30·71	70
„ 22	21·30	3·0	8·27	7·10	30·72	70
„ 22	20·60	3·0	8·44	6·86	30·68	69
„ 22	22·60	3·0	7·58	7·53	30·61	70

[1] Meter filled with water. [2] Water taken out and syphon put on pipe. [3] Two hours spent in comparing meter and gasometer. [4] 12 p.m., taken now every three hours, counting from this.

Quantity of Gas.

On October 25th the measuring of gas with the dry meter was resumed, when—

1. One cubic foot passed in 3 hours 55 minutes.
2. ,, ,, 4 ,, 15 ,,
3. ,, ,, 4 ,, 27 ,,

These results were compared with others taken at the pneumatic trough to test their accuracy, with the following results :—

1. One cubic foot passed in 4 hours 11 minutes.
2. ,, ,, ,, 4 ,, 11 ,,
3. ,, ,, ,, 4 ,, 0 ,,

EXPERIMENT IV.

On October 13th, 1879, a hole was bored in the solid coal at the face of the stenton out of the No. 3 Crosscut, going towards No. 4 Crosscut. See Plan No. 2, page 178, and Section No. 6.

Section No. 6.

CONDITIONS.

	Ft.	In.
The length of the borehole was	12	0
The diameter of ,, ...		2½
Diameter of pipe fixed in the hole		½
Gas space	6	0
Hole bored about 65 deg. to the cleat.		
Cover—depth of hole from surface	1,261 feet.	
Distance of hole from shaft	3,970 yards.	
Description of gauge used	Bourdon's.	

The hole was made tight with wooden washers, oakum, and India-rubber washers alternately, and the whole screwed firmly up. The whole of the face of the coal was cemented in the same way as is shown in Section No. 5, page 178.

On October 13th, at 2 P.M., the gauge was screwed on, and the readings regularly noted.

Pressure of Gas.

RESULTS.—SEE TABLE, PAGE 233.

	Gauge. Lbs.	Barometer. Inches	Thermometer. Degrees.
October 13th, at 5 P.M., the readings were	25	31·10	71
„ 15th, at 3 A.M. (maximum pressure)	31	31·05	70
„ 19th, at 11 P.M., the readings were	29	30·00	70
„ 22nd, at 10 A.M., „	28	30·61	70

It was suspected that this place was within the gas drainage of the No. 4 Crosscut; the experiment was therefore discontinued.

EXPERIMENT V.

On October 14th, a hole was bored in the solid coal at the face of north wall out of the No. 4 Crosscut. See Plan No. 2, page 178.

CONDITIONS.

	Ft.	In.
The length of the borehole was	25	6
The diameter of „		2½
Diameter of pipe fixed in the hole		½
Gas space	6	0

Hole bored about 65 deg. to the cleat.

Cover—depth of hole from surface ... ... 1,261 feet.

Distance of hole from shaft ... ... 3,970 yards.

Description of gauge used ... ... Bourdon's.

The hole was made tight in the same manner as in No. IV. Experiment.

RESULTS.—SEE TABLE, PAGE 235.

Pressure of Gas.

	Gauge. Lbs.	Barometer. Inches.	Thermometer. Degrees
The gauge registered 107 lbs. within a few minutes after having been attached, and on			
October 14th, at 12 A.M., the readings were	107	30·92	70
„ „ 12 P.M. (maximum pressure)	125	31·03	69
„ 16th, at 10 A.M., the readings were	115	31·03	69
„ „ 11 „ „ „	119	31·07	69

This rise of 4 lbs. could not be accounted for, unless it was caused by water in the pipe. The barometer was almost stationary. Various other fluctuations occurred during the experiment; sometimes there would be a rise of 1 lb. or more when the barometer was falling. Throughout the experiment the readings were noted every hour, and on October 22nd, at 10 A.M., were :—Gauge, 102 lbs.; barometer, 30·61; thermometer, 70 degrees.

The experiment was then discontinued, as it was suspected that this place was within the gas drainage of No. 4 Crosscut.

When the coal was subsequently taken out and the inner end of the hole exposed, it was found to have entered the roof 3 feet, the last 18 inches being wholly in the stone.

EXPERIMENT VI.

On October 14th, 1879, a hole was bored in the solid coal at the face of No. 3 Crosscut. See Plan No. 2, Page 178.

CONDITIONS.

	Ft.	In.
The length of the borehole was	37	0
The diameter of „		$2\frac{1}{2}$
The diameter of pipe fixed in the hole		$\frac{1}{2}$
Gas space	6	0

Hole bored about 65 deg. to the cleat.
Cover—depth of hole from surface ... ... 1,261 feet.
Distance of hole from shaft ... . 3,970 yards.
Description of gauge used ... ... Bourdon's.

The hole was made tight as in No. IV. Experiment.

RESULTS.—See Table, Page 237.

Pressure of Gas.

	Gauge. Lbs.	Barometer. Inches.	Thermometer. Degrees.
The pressure rose almost immediately to 198 lbs., and on			
October 14th, at 7 P.M., the readings were...	198	31·02	69
„ 15th, at 9 „ „ ...	213	31·08	69
The increase of pressure was constant up to this time, the barometer also showing a steady increase.			
October 15th, at 10 P.M., the readings were	211	31·08	69
„ „ 11 „ „ ...	209	31·08	69
„ 16th, at 3 A.M. „ ...	210	31·07	69
„ „ 8 P.M. „ ...	221	30·95	70

A pressure of 221 lbs. was maintained for three hours; then a decrease commenced, which went on for 28 hours, the barometer slightly falling most of the time. The readings on October 18th, at 2 A.M., were:—Gauge, 218 lbs.; barometer, 30·67; thermometer, 69 deg. After this hour, the pressure again began to increase at a slow rate, rising to 222 lbs. on October 19th, at 9 A.M., or 4 lbs. in 31 hours, the barometer falling very slowly

Pressure of Gas.

throughout that time. The pressure after this began to fluctuate, sometimes remaining perfectly steady for several hours, with an occasional rise or fall of 1 lb.

On October 22nd, at 1 A.M., 7 days and 6 hours from the commencement, the maximum pressure was reached, the readings at that time being:—Gauge, 223 lbs.; barometer, 30·71; thermometer, 70 deg. This pressure was maintained for twelve successive hours, the barometer falling very slowly the whole of the time. A fall of 3 lbs., which continued three hours, then took place, the barometer having been steady five hours, after this the pressure rose to 223 lbs. again.

Quantity of Gas.

On October 23rd, at 9 P.M., the meter was attached to ascertain the quantity of gas given off. The gas was allowed to pass through the meter for twelve hours, and the readings were recorded every three hours, with the following results:—

	Cubic Feet.	Time per Cubic Foot. M. S.
9 P.M. to 12 P.M.	13·01	13·85
12 P.M. to 3 A.M.	12·49	14·41
3 A.M. to 6 A.M.	8·60	20·93
6 A.M. to 9 A.M.	8·30	21·68

Giving an average of 1 cubic foot of gas in 17 mins. 43 secs.

At 12 noon an experiment was made to test the meter and ascertain if it was registering correctly, by passing the gas from the meter into a pneumatic trough and measuring it in a glass jar:—

No. of Experiment.	Time in Filling Jar. M. S.	Time per Cubic Foot. M. S.
1	2·12	21·56
2	2·23	23·22
3	2·8	21·16
4	2·7	21·6
5	2·0	19·57
6	1·57	19·26

Pressure of Gas.

On October 27th, at 7 P.M., the pressure gauge was screwed on, and its readings, with those of the barometer and thermometer, again recorded every hour.

	Gauge. Lbs.	Barometer. Inches.	Thermometer. Degrees.
October 27th, at 7 P.M., the readings were...	30	31·15	69
„ „ 9 „ „ ...	110	31·19	69
„ „ 11 „ „ ...	140	31·20	69

On October 30th, at 9 A.M., the pressure continued to increase until it reached 195 lbs., and the experiment was discontinued at 10 A.M. the same day.

EXPERIMENT VII.

On October 11th, 1879, a hole was bored in the solid coal at the face of No. 1 Crosscut. See Plan No. 2, page 178.

CONDITIONS.

	Ft.	In.
The length of the borehole was	47	0
The diameter of "		2½
The diameter of pipe fixed in the hole		½
Gas space	6	0
Hole bored about 65 deg. to the cleat.		
Cover—depth of hole from surface	1,261 feet.	
Distance of hole from shaft	3,971 yards.	
Description of gauge used	Bourdon's	

The hole was made tight in the same way as in No. IV. Experiment.

RESULTS.—See Table, Page 239.

Pressure of Gas.

On October 11th, at 6 P.M., the experiment commenced. The pressure rose to 70 lbs. in thirty minutes, and continued to rise somewhat rapidly until it was 182 lbs. on October 13th, at 5 A.M., when the readings were :—Gauge, 182 lbs. ; barometer, 31·28 ; thermometer, 71 degrees.

On October 16th, at 9 P.M., the readings were :—Gauge, 220 lbs. ; barometer, 30·90 ; thermometer, 70 deg. The gauge continued at 220 lbs. for nineteen hours, and in the next three hours fell 3 lbs.; after which it rose to 233 lbs.; the readings at this time (October 25th, 5 A.M.) were :—Gauge, 233 lbs.; barometer, 30·47 ; thermometer, 69 degrees.

The increasing pressure was not continuous, although it frequently remained stationary for many successive hours ; for example, when it reached 231 lbs., it remained so forty-three hours, and then rose to 232 lbs., at which it remained twenty hours; when it rose to the 233 lbs., named above, remaining stationary sixty-two hours at this pressure.

On October 27th, at 11 P.M., the readings were :—Gas pressure, 235 lbs. ; barometer, 31·20; thermometer, 69 deg. This was the maximum pressure 16 days and 5 hours from the commencement of the experiment, and it was maintained five hours. The barometer indicated a uniform pressure during the greater part of the experiment.

On October 29th, at 8 A.M., the readings were :—Gauge, 233 lbs.; barometer, 31·13 ; thermometer, 69 deg. These were the last readings recorded in this experiment.

Quantity of Gas.

On October 29th, at 9 A.M., the quantity of gas which was discharged was measured, when the following results were recorded, viz. :—

Oct. 29th, at 9 A.M., in 1 hour, 6·10 cub. ft. passed through meter... = 1 cub. ft. in 9 min. 50 secs.
Oct. 29th, at 10 P.M., in 12 hours 4·02 cub. ft. passed through meter... = 1 „ 2 hrs. 59 „ 6 „
Oct. 30th, at 9 A.M., in 11 hours 2·17 cub. ft. passed through meter... = 1 „ 5 hrs. 4 „ 9 „

The experiment was then discontinued to allow the place to resume work.

EXPERIMENT VIII.

On October 22nd, a hole was bored in the solid coal at the face of No. 2 Crosscut. See Plan No. 2, page 178.

CONDITIONS.

	Ft.	In.
The length of the borehole was	25	0
The diameter of „		$2\frac{1}{2}$
The diameter of pipe fixed in the hole...		$\frac{1}{2}$
Gas space	6	0

Hole bored about 65 deg. to the cleat.
Cover—depth of hole from surface ... ... 1,261 feet.
Distance of hole from shaft ... ... 3,971 yards.
Description of gauge used ... ... Bourdon's.

The hole was made tight in the same way as in No. IV. Experiment.

RESULTS.—SEE TABLE, PAGE 243.

Pressure of Gas.

	Gauge. Lbs.	Barometer. Inches.	Thermometer. Degrees.
October 22nd, at 1 A.M., the readings were	75	30·60	71
„ „ 2 „ „	193	30·60	71
„ „ 5 „ „	200	30·62	70
The pressure increased slowly up to 220 lbs., the barometer rising gently.			
On October 23rd, at 9 P.M. the readings were	220	30·69	68

The pressure continued for six hours, after which several small fluctuations of a pound up or down occurred; it then remained steady for several hours. On October 24th, at 4 P.M., 2 days 3 hours after the commencement of the experiment, the maximum pressure was reached, the readings being then :—Gauge, 221 lbs. ; barometer, 30·47 inches ; thermometer, 69 deg. After continuing three hours the pressure fell 1 lb.; and after seventeen hours it rose to 221 lbs. again.

Pressure of Gas.

This experiment was characterized throughout by the constant variations of the pressure. For example:—

	Gauge. Lbs	Barometer. Inches.	Thermometer. Degrees.
October 27th, at 4 P.M., the readings were	211	31·12	69
Having fallen 9 lbs. in six hours.			
October 27th, at 6 P.M., the readings were	210	31·13	69
" " 7 " "	215	31·15	69
" 28th, at 10 A.M. "	220	31·19	69
" " 12 A.M. "	208	31·17	69
" " 5 P.M. "	215	31·11	69
" 29th, at 7 A.M. "	208	31·13	69
" " 6 P.M. "	214	31·21	69
" " 11 P.M. "	210	31·29	69
" 30th, at 10 A.M. "	208	31·25	69

The gauge was now taken off, and the gas meter attached; but the quantity of gas issuing from the hole was not sufficient to move the index. The experiment was then discontinued.

When the coal was taken out the end of the hole was found to be 15 inches below the roof, and therefore wholly in the coal.

THE EXPERIMENTS MADE AT BOLDON COLLIERY.

The Boldon Colliery was opened out about the year 1869—11 years before the experiments was made. The following being the account of the strata sunk through in the No. 2 or Downcast Pit:—

TOWNSHIP OF BOLDON, DURHAM.

Sheet 7 of Ordnance Map. Lat. 54° 57′ 15″, Long. 1° 27′ 29″.

Commenced 19th March, 1866. Sunk to Bensham Seam, June 7th, 1869.

Approximate surface level 100 feet above sea (Ordnance datum).

	Fs.	Ft.	In.	Fs.	Ft.	In.
Soil	0	0	8			
Yellow clay	0	3	0			
Dark brown clay ...	6	5	0			
Sand, with a little water	0	0	7			
Strong stony clay ...	5	4	3			
				13	1	6
Strong brown freestone	3	2	6			
						*
	0	3	8			
Soft brown metal ...	1	1	0			
Carried forward	5	1	2	13	1	6

	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward	5	1	2	13	1	6
COAL, mixed with stone	0	0	4			
Grey metal thill, with ironstone balls ...	0	3	8			
Brown metal... ...	1	1	0			
Brown post girdle ...	0	1	0			
Brown metal... ...	0	5	3			
COAL	0	0	2			
				8	0	7
Carried forward				21	2	1

* Approximate sea level (Ordnance datum).

	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward				21	2	1
Grey metal thill ...	0	1	6			
Grey post, with water	0	2	4			
Blue metal	0	3	9			
COAL	0	0	1			
				1	1	8
Grey metal thill, with ironstone balls ...	0	5	3			
Strong grey post ...	0	4	4			
Blue metal post girdle	0	2	4			
Post girdles	0	2	0			
Grey post	0	3	10			
Strong post girdle ...	0	2	6			
Grey metal, with post girdles	0	5	0			
Dark blue metal ...	3	0	0			
COAL, mixed with stone	0	0	4			
				7	1	7
Grey metal, with balls of ironstone ...	0	2	7			
Strong grey metal ...	0	0	10			
Strong brown post, mixed with whin and water	5	0	0			
Soft dark grey metal	1	3	8			
COAL, mixed with stone	0	1	2			
				7	2	3
Grey metal thill ...	0	1	8			
White post girdle ...	0	1	6			
Brown metal... ...	1	0	0			
COAL, mixed with stone	0	0	7			
Grey metal thill, mixed with *coal*	0	3	1			
Black stone	0	0	4			
COAL	0	0	10			
				2	2	0
Grey metal thill ...	0	2	7			
White post	0	4	3			
Grey metal	0	1	0			
Post girdles	0	1	2			
Blue metal	0	5	9			
Black stone, mixed with *coal*	0	2	2			
Grey metal thill ...	0	1	1			
Strong post girdle ...	0	2	10			
Blue metal parting ...	0	0	5			
Post girdle	0	1	2			
Blue metal	0	0	9			
Black stone, with *coal pipes*	0	1	2			
Grey metal thill, with ironstone balls ...	0	3	0			
Black stone, with *coal pipes*	0	0	3			
Grey metal thill, with ironstone balls ...	0	1	5			
COAL	0	0	6			
				4	5	6
Carried forward				44	3	1

	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward				44	3	1
Dark grey metal, with ironstone balls ...	0	3	5			
Strong grey metal ...	0	4	0			
Post girdle	0	0	3			
Blue metal	0	4	2			
Black stone	0	0	6			
White post girdle ...	0	0	8			
Blue metal	3	3	1			
White post, with water (metal partings) ...	0	5	7			
Grey post	0	1	3			
White post girdle ...	0	1	2			
Grey metal	3	0	6			
COAL	0	0	5			
				10	1	0
Black stone	0	0	4			
Thill grey metal ...	0	4	3			
Grey metal, with ironstone balls... ...	1	5	9			
Blue metal	0	2	7			
Black stone	0	1	10			
Grey post, with a little water	0	4	7			
Post girdle	0	2	2			
Strong grey metal ...	4	2	8			
Black metal	0	2	8			
COAL, mixed with metal	0	0	10			
				9	3	8
Grey metal thill, with balls of ironstone...	0	2	3			
Blue metal, with balls of ironstone ...	0	5	10			
Strong brown post ...	0	4	0			
Grey metal thill ...	1	0	2			
Green metal	2	2	0			
Grey post	0	4	7			
Blue metal	0	2	0			
White post girdle ...	0	1	8			
Dark grey metal ...	0	5	0			
Grey metal post girdles	1	3	6			
Strong grey metal ...	1	4	0			
Black stone	0	0	4			
Strong grey metal ...	1	5	8			
Light grey metal thill	0	2	0			
Grey metal	3	3	0			
Soft hitch stone, mixed with post	4	0	0			
COAL	0	1	3			
				20	5	3
Soft hitch stone ...	3	2	0			
COAL	0	0	5			
				3	2	5
Soft hitch stone ...	2	5	7			
Post girdles, mixed with whin... ...	0	3	0			
COAL	0	0	5			
				3	3	0
Soft blue hitch stone	4	2	7			
Carried forward	4	2	7	92	0	5

	Ft.	In.	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward			4	2	7	92	0	5
COAL ...	1	4						
Grey metal band	0	3						
COAL ...	1	2						
			0	2	9			
						4	5	4
Soft hitch stone ...			8	4	7			
Grey post			5	4	0			
White post, with *coal pipes*			9	3	0			
Dark metal			2	1	0			
COAL			0	0	8			
Black stone and *coal*			0	0	3	26	1	6
Blue metal			1	2	0			
White post, with salt water			1	3	0			
Blue metal and thill stone			2	0	0			
White post			7	0	0			
Soft hitch stone ...			6	5	0			
White post, with a leader up at trouble			4	2	0			
Grey metal			1	5	10			
COAL			0	1	0			
Thill stone			0	2	4			
COAL } *Drift*			0	2	3			
Thill stone } *Drift*			0	1	6	26	0	11
White post			7	3	0			
Grey metal			1	0	0			
White post			1	3	0			
Grey metal			0	4	0			
Dark slaty metal ...			0	2	0			
COAL, black slaty...			0	0	8	11	0	8
Thill stone			0	0	10			
White post			1	3	2			
Grey metal			0	3	9½			
White post, mixed with whin and a little water ...			9	0	0			
Dark blue metal ...			0	4	10			
COAL			0	2	0	12	2	7½
Thill stone			1	1	2			
Strong blue metal ...			2	0	8			
Strong white post ...			1	0	6			
Grey metal			1	0	7			
Black slaty stone ...			0	1	3			
Thill stone			0	1	6			
Strong blue metal ...			1	1	6			
Strong white post ...			3	4	0			
Grey metal			1	1	5			
Black slaty stone ...			1	0	0			
Carried forward			13	0	7	172	5	5½

	Ft.	In.	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward			13	0	7	172	5	5½
COAL (supposed *Main Coal*) ...	1	6						
Band	0	2						
COAL, very coarse splinty, mixed with bands ...	1	4						
			0	3	0			
						13	3	7
Dark *coaly* stone, with *coal pipes*			0	0	9			
Seggar or thill stone			0	2	0			
Strong grey metal ...			3	5	0			
Grey metal, with post girdles			3	1	10			
Strong white post and a little water ...			9	4	7			
COAL—*Brass Thill*			0	2	7			
						17	4	9
Strong seggar ...			0	2	6			
Strong grey metal, with post girdles ...			1	3	6			
Black metal stone ...			1	4	0			
COAL			0	0	4			
						3	4	4
Strong dark metal stone			2	1	0			
Grey post			0	4	6			
Strong grey metal ...			0	3	6			
Strong white post ...			1	4	3			
Strong grey metal ...			2	2	6			
COAL			0	0	9			
						7	4	6
Thill stone, mixed with *coal pipes*			0	3	0			
COAL	0	3						
Band	0	1½						
COAL	0	3½						
			0	0	8			
						0	3	8
Strong grey post, with whin girdles ...			1	1	6			
Dark blue metal, with ironstone girdles ...			2	5	0			
Yard Seam—								
COAL ...	1	4						
Band ...	0	4						
COAL ...	1	4						
			0	3	0			
						4	3	6
Carried forward						220	5	9½

			Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward						220	5	9½
Thill stone			0	3	0			
White post			1	0	0			
Dark blue metal, ironstone girdles ...			1	1	0			
Grey metal			1	2	0			
Grey post			2	0	0			
Grey metal, with ironstone girdles ...			3	0	0			
BENSHAM SEAM—	Ft.	In.						
COAL, top	3	1						
Splint ...	0	2½						
COAL, coarse	0	1½						
COAL, bottom	2	1						
			0	5	6			
						9	5	6
Grey post			1	1	0			
Grey metal, with ironstone balls... ...			3	2	0			
Splint...			0	0	5			
COAL, good ...			0	1	0			
						4	4	5
Strong grey post ...			1	0	0			
Grey metal			1	0	0			
Black stone			0	1	9			
COAL			0	0	7			
						2	2	4
Grey post			1	0	6			
White post and whin girdles			1	0	9			
Blue metal			0	0	7			
White post			0	1	11			
Blue metal			0	0	6½			
White post			0	2	9			
Carried forward			3	1	0½	238	0	0½

			Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward			3	1	0½	238	0	0½
Blue metal and whin girdles			0	3	9			
Five-Quarter Seam—	Ft.	In.						
COAL ...	1	7½						
Splint ...	1	0						
			0	2	7½			
						4	1	5
Dark grey post, with whin girdles ...			3	1	6			
Strong white post ...			4	2	5			
Strong grey metal, with post girdles ...			2	0	0			
Grey metal			0	4	0			
Grey post			0	2	0			
Blue metal			0	3	1			
Tyne Low Main, Hutton Seam on Wear—	Ft.	In.						
COAL, good	4	0						
COAL, bottom ...	0	7						
			0	4	7			
						11	5	7
						254	1	0½
Sump—								
Seggar, with ironstone balls			0	1	6			
Strong grey metal, with ironstone balls			3	4	0			
Strong grey metal, with post girdles ...			2	2	9			
White post, with metal partings			0	5	7			
						7	1	10
Total						261	2	10½

The whole of the experiments were made in the north-west district of the Bensham Seam at a point about 2,200 yards north-west from the shaft, and about 352 yards from some long-wall goaf, the dip of the strata being towards the south-east.

The roof is composed of bad blue metal. The thill is of grey metal.

The coal is exceedingly bright, moderately hard, and bituminous, and is used for household purposes and gas-making.

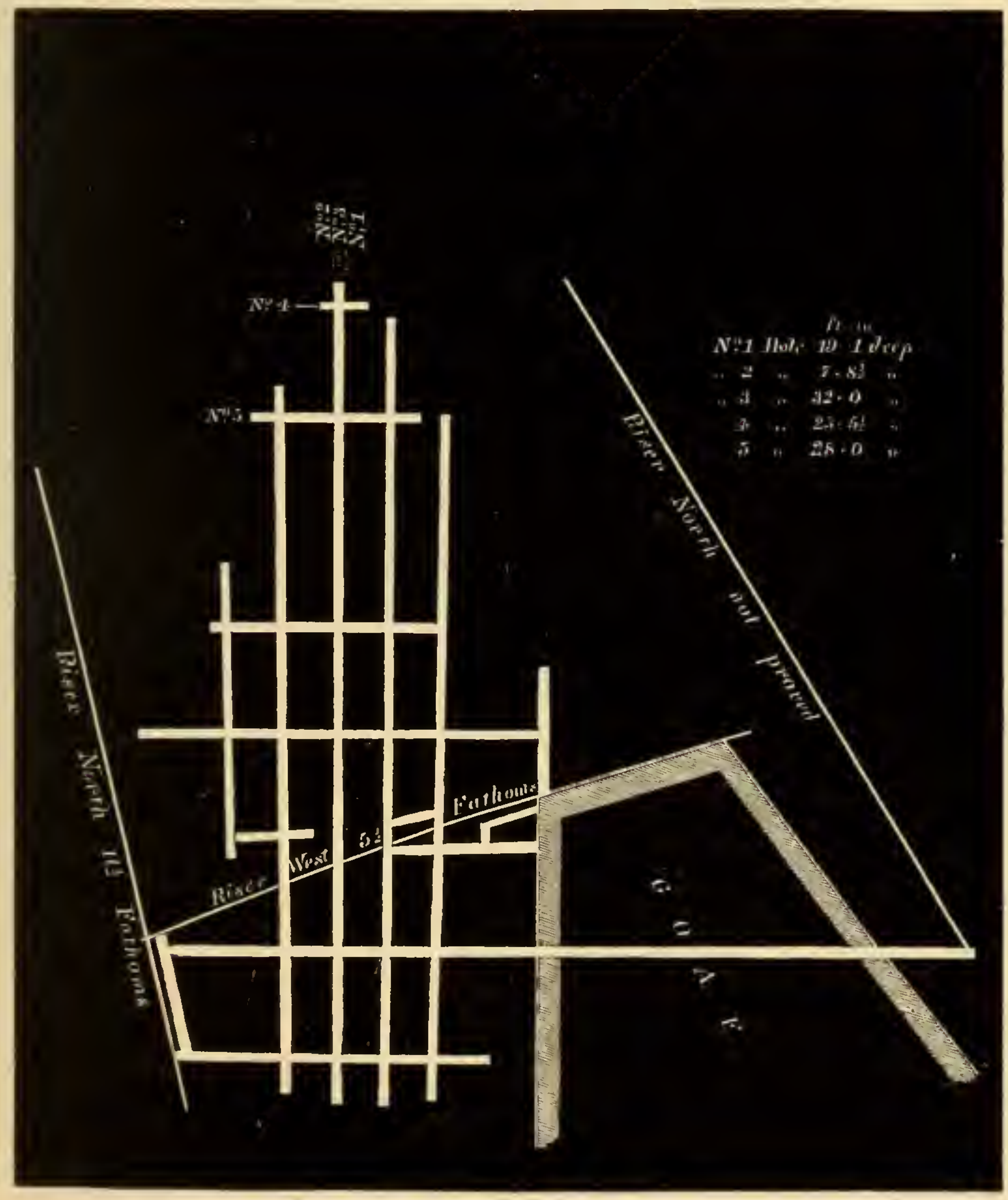
The coal is not worked in any seam either above or below.

The following is an analysis of the coal :—

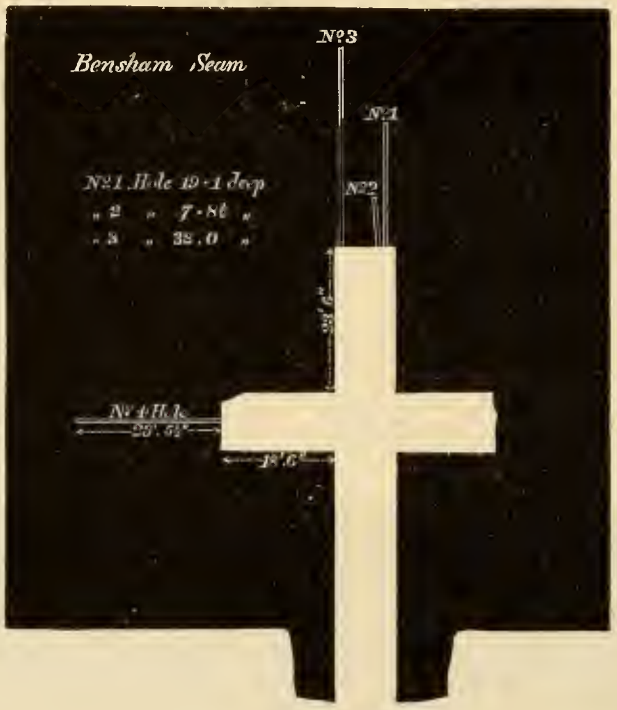
Carbon	79·58
Hydrogen	4·87
Oxygen	5·21
Nitrogen	1·64
Sulphur	2·02
Ash	5·53
Water	1·15
	100·00

The specific gravity is 1·20.

Plan No. 3 showing the position of the workings in which the experiments were made.



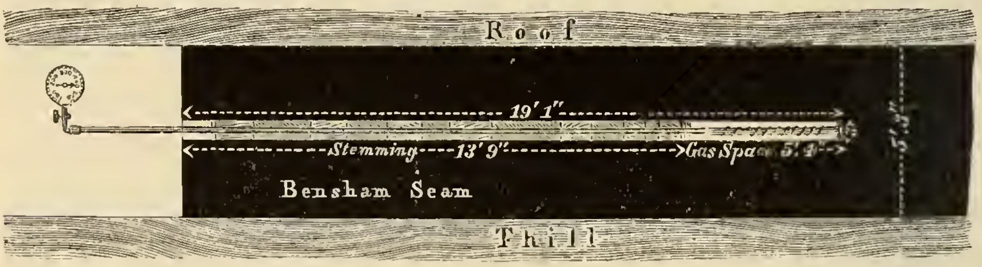
Plan No. 4, being an enlargement of a portion of Plan No. 3, showing the position of the holes bored for the first four experiments.



EXPERIMENT I.

On May 11th, 1880, a hole was bored in the solid coal at the face of a narrow board. See Plans Nos. 3 and 4, and Section No. 7.

SECTION NO. 7.



The tool which was used to bore the hole was broken and the end left in during the experiment.

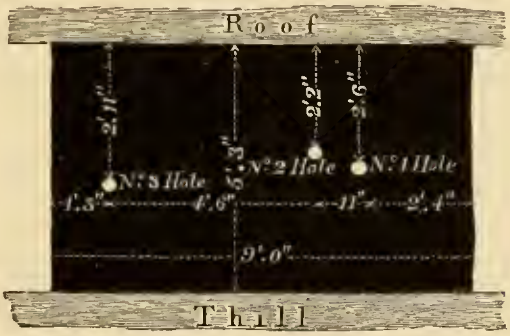
CONDITIONS.

	Ft.	In.
The length of the borehole was	19	1
The diameter of "		3
The diameter of pipe fixed in the hole		½
Gas space	5	4

Hole at right angles to the cleat.
Cover—depth of hole from surface ... ... 1,268 feet.
Distance of hole from shaft ... ... 2,200 yards.
Description of gauge used ... Schaeffer and Budenberg's.
Capacity of gas space, allowing for broken tool, 389·64 cubic inches.

The hole was stemmed alternately with oakum steeped in cement, and wooden plugs, to a depth of 13 feet 9 inches, in the following way:—First, about an inch of dry oakum and then an inch of saturated oakum, followed by a wooden cylinder, and so on alternately. The innermost two cylinders composed a spigot and faucet joint, which served to keep the pipe firm.

Elevation No. 1, showing the position of the first three holes in the face of the board.



On May 14th, at 1·40 P.M., one of Schaeffer and Budenberg's patent steel tube gauges, registering 500 lbs. pressure, was put on to the end of the pipe:—

RESULTS.—SEE TABLE, PAGE 246.

			Lbs. per sq. inch. Pressure of Gas.
May 14.—At	1·40 P.M.	... ...	
,,	2·20	,, the pressure rose to	25
,,	2·50	,, ,, ,, ...	40
,,	5·00	,, ,, ,, ...	100
,,	9·00	,, ,, ,, ...	202
,,	11·00	,, ,, ,, ...	246
		At this hour the boring of No. 3 Hole was commenced, and on	
May 15.—At	1·00 A.M.,	the pressure was	314
,,	3·30	,, ,, ,, ...	331
,,		At 3·45 the gauge fell back 2 lbs. owing to a small blower coming off at No. 3 Hole. This, however, took up, and on	
May 15.—At	6·00 A.M.,	the pressure rose to	335
,,	8·00 P.M.	,, ,, ...	369

The top of No. 2 Hole, was now opened, the pressure run off, and the meter attached.

Pressure of Gas.

	Lbs. per sq. inch.
May 15.—At 9·00 P.M., The boring of No. 3 Hole was stopped, when the pressure was	373
„ At 12·00 NOON, the pressure was	379
„ At 2·30 A.M., the stemming of No. 3 Hole was commenced.	
May 16.—At 4·00 A.M., the pressure was run off No. 2 Hole, and the meter re-attached, the pressure in No. 1 rising to	383
„ At 9·00 A.M., the pressure was	382
and the stemming of No. 3 Hole completed, the pressure then remained the same till 1·55 P.M., when the gauge was taken off.	

It is interesting to observe that during this experiment in No. 1 Hole the pressure continued to rise during most of the time, notwithstanding that only 5 feet 5 inches distant No. 3 Hole was in progress, and therefore free to allow of any escape of gas.

On May 17th, at 4·0 P.M., the pressure gauge was re-attached, and on May 22nd, at 10·30 A.M., registered the maximum pressure, 425 lbs. per square inch, which pressure was continued until May 25th, at 5·0 A.M., when the gauge was taken off, and on May 27th, at 1·15 P.M., the pressure gauge was again applied, with the undermentioned results :—

	Lbs. per sq. inch.
May 27th, at 1·40 P.M., the pressure was	29
May 28th, at 7·45 A.M. „	324
„ 9·00 P.M. „	355

At this time the pressure was again blown off, and the gas measured, and on

Quantity of Gas.

					Cub. ft. per hour
May 28th, at	10·20 P.M.,	the meter	stood at	0013·00	
„	10·30 „	„	„	0013·226	= 1·356
„	10·40 „	„	„	0013·435	= 1·254
„	10·50 „	„	„	0013·630	= 1·170
„	11·00 „	„	„	0013·830	= 1·200
„	11·10 „	„	„	0014·015	= 1·110
„	11·20 „	„	„	0014·210	= 1·170

Average cubic feet per hour, 1·210.

During this experiment the other gauges indicated—

	Lbs. per sq. inch.
No. 2	0
No. 3	354

On May 28th, at 11·45 P.M., the gauge was put on No. 1 Hole, and on

Pressure of Gas.

	Lbs. per sq. inch.
May 29th, at 2·20 A.M., the pressure was … … …	182
„ 30th, at 5·30 „ „ „ … …	362
„ 31st, at 8·00 „ „ „ … …	372
June 1st, at 8·10 „ „ „ … …	381
„ 2nd, at 8·10 „ „ „ … …	386

In conclusion, on June 3rd, the amount of gas exuding from the hole was measured by the testing meter of the South Shields Gas Company, with the following results :—

Quantity of Gas.

June 3rd, at 8·40 A.M., the meter stood at … 0271·00
„ 4th, at 7·40 „ „ … 0291·00 = 20 cubic feet.
Which would give ·87 feet per hour.

The other gauges during this experiment were standing at—

	Lbs. per sq. inch.
No. 2 … … … … …	248
No. 3 … … … … …	402
No. 4 … … … … …	280

EXPERIMENT II.

On May 11th, 1880, a second hole was bored in the same board. See Elevation No. 1, page 197, and Section 8.

SECTION NO. 8.

CONDITIONS

	Ft.	In.
The length of the borehole was … … … …	7	8½
The diameter of „ … … … …		2½
The diameter of pipe fixed in the hole … … …		½
Gas space … … … … … … …	1	10

Hole at right angles to the cleat.
Cover—depth of hole from surface … … 1,268 feet.
Distance of hole from shaft … … … 2,200 yards.
Description of gauge used … Schaeffer and Budenberg's.
The gas space contained 107·99 cubic inches.

The position of No. 2 Hole, with regard to the holes Nos. 1 and 3, is shown in Elevation No. 1, page 197, and generally, with regard to the workings, in Plans Nos. 3 and 4, pages 195, 196.

The total length of stemming was 5 feet 10½ inches, and the mode of performing the operation exactly the same as in No. 1 Hole. This hole, however, was much shorter, being only 7 feet 8½ inches. It was also put in a little higher up in the seam, as shown in the Elevation.

On May 14th, a 300 lbs. gauge was attached to the hole.

RESULTS.—SEE TABLE, PAGE 246.

Pressure of Gas.

			Lbs. per sq. inch.
May 14th.—At	1·40 P.M.,	the gauge was put on.	
,,	2·20 ,,	the pressure rose to	70
,,	2·50 ,,	,, ,, ...	112
,,	5·00 ,,	,, ,, ...	210
,,	9·00 ,,	,, ,, ...	252
,,	11·00 ,,	,, ,, ...	263
,,	At this hour the boring of No. 3 Hole was commenced.		
May 15th.—At	1·00 A.M.,	the pressure was	272
,,	3·30 ,,	,, ,, ...	283
,,	4·00 ,,	,, ,, ...	284
,,	6·00 ,,	,, ,, ...	282
,,	2·00 P.M.	,, ,, ...	280
,,	4·00 ,,	,, ,, ...	273
,,	6·00 ,,	,, ,, ...	260
,,	8·00 ,,	,, ,, ...	259

From May 15th, at 3·30 P.M., the gauge showed a steady decrease in pressure, no doubt owing to the boring of No. 3 Hole alongside, which was begun at 11·0 P.M. the previous day.

This being a very short hole, it undoubtedly came within the gas drainage of No. 3 Hole, and in consequence could not sustain its pressure; in this it differed from No. 1 Hole, which kept increasing its pressure during the boring of No. 3 Hole, clearly showing that it was not affected by it.

It will be observed that, from the moment the gauges were applied, the pressure increased more rapidly in No. 3 Hole than in No. 1, this was owing to No. 3 having only 1 foot 10 inches of gas space, whereas No. 1 had 5 feet 4 inches.

On May 16th, at 3·45 P.M., one of Schaeffer and Budenberg's 500 lb. gauges was put on to the pipe end, and the maximum pressure of 266 lbs. was attained on May 19th, at 11·0 A.M., when it was run off.

Pressure of Gas.

The gauge was started again at 11·30 on the same day, and on

	Lbs. per sq. inch.
May 19th, at 5·00 P.M., the pressure was	205
,, 20th, at 5·00 ,, ,, ,, ...	280
,, 21st, at 5·00 ,, ,, ,, ...	291
,, 22nd, at 5·00 ,, ,, ,, ...	297
,, 23rd, at 5·45 A.M. ,, ,, ...	297
,, 24th, at 4·30 ,, ,, ,, ...	297
,, 25th, at 5·00 ,, ,, ,, ...	298

On May 25th, at 12·5 P.M., the pressure was run off, and a gas meter was attached to the hole, and at

Quantity of Gas.

	Feet.		Cubic feet per hour.
12·15 P.M. the meter passed	·071	=	·43
12·25 ,, ,, ...	·075	=	·45
12·35 ,, ,, ...	·081	=	·49

Average, ·457 cubic feet of gas per hour. Water given off, 2 cubic inches per hour.

May 27th, at 1·15 P.M., the pressure gauge was attached to the hole, and on the same day

Pressure of Gas.

	Lbs. per sq. inch.
At 1·40 P.M., the pressure was	57
,, 28th, at 7·45 A.M. ,, ,, ...	221
,, ,, 9·00 P.M. ,, ,, ...	214

The pressure was then blown off again, and on May 28th, at 9·15 P.M., a testing meter of the South Shields Gas Co. was attached.

Quantity of Gas.

	Feet.		Cubic feet per hour.
9·15 P.M. meter standing at	0012·00	=	...
9·25 ,, ,, ,, ...	0012·080	=	·48
9·35 ,, ,, ,, ...	0012·180	=	·60
9·45 ,, ,, ,, ...	0012·260	=	·48
9·55 ,, ,, ,, ...	0012·328	=	·41
10·5 ,, ,, ,, ...	0012·400	=	·43
10·15 ,, ,, ,, ...	0012·460	=	·36

Average, ·46 cubic feet of gas per hour.

During this experiment the gauges on the other holes were:—

Pressure of Gas.

	Lbs. per sq. inch.
No. 1	355
No. 3	354
No. 4	298

Pressure of Gas. The pressure gauge was re-attached on May 28th, at 11 P.M., and on

	Lbs. per sq. in.
May 29th, at 2·20 A.M., the pressure was	157
„ 30th, at 5·30 „ „ „	253
„ 31st, at 8·00 „ „ „	257
June 1st, at 8·10 „ „ „	259
„ 2nd, at 8·10 „ „ „	269

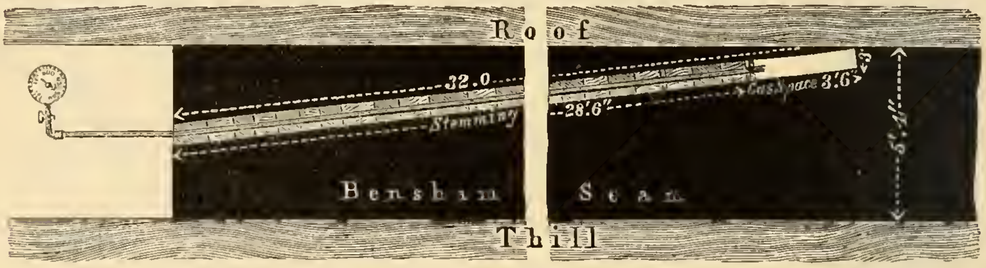
The pressure was run off, and a gas meter put on to the hole on June 4th, at 8 5 A.M.

Quantity of Gas. It was then standing at ... ... 0291·00
June 5th, at 12·35 A.M., it stood at... ... 0301·00 = 10 feet.
Average, ·60 cubic feet per hour.

EXPERIMENT III.

On May 14th, at 11·0 P.M., another hole was bored in the same board as Nos. 1 and 2 Holes, about half-way up the seam, and to the extreme left of the place. See Plan No. 4, page 196, Elevation No. 1, page 197, and Section No. 9. The boring was finished at 9·0 P.M. on the following day, in exactly 22 hours. The stemming was begun on May 15th, at 2·30 A.M., and finished at 9·0 A.M. the same day, in 6½ hours.

SECTION NO. 9.



CONDITIONS.

	Ft.	In.
The length of the borehole was	32	0
The diameter of „		3
The diameter of pipe fixed in the hole		½
Gas space	3	6

Hole at right angles to the cleat.
Cover—depth of hole from surface ... ... 1,268 feet.
Distance of the hole from the shaft... ... 2,200 yards.
Description of gauge used ... ... Schaeffer and Budenberg's.

This hole was put in in the usual manner, but it touched the roof when the above-mentioned length was bored. It was stemmed in the same way as were Nos. 1 and 2 Holes. A Davy lamp held close to the hole previous to its being stemmed would not fire. There was a little water coming out of the hole.

On May 16th, at 2·13 P.M., the Schaeffer and Budenberg 500 lb. gauge, which had been taken off No. 1 Hole to allow of the gas being measured, was attached:—

RESULTS.—SEE TABLE, PAGE 247.

Pressure of Gas.

		Lbs. per sq. inch.
May 16.	—At 3·00 P.M. the gauge had shown no indication of moving. It was then examined and found to be all right. It was put on again at 3·15 P.M. and	
”	At 3·45 P.M., it registered	8
”	5·00 ” ”	35
”	At 5·30 P.M. a leak was discovered in the cement at the outer-end of the hole. This was put right, and	
”	At 6·00 P.M., the pressure was	58
”	7·00 ” ” ”	105
”	9·00 ” ” ”	241
”	At 9·15 ” a leak at the joint next the gauge was discovered, and the gauge fell back very fast. Pressure was noted every half-hour, and at	
”	11·00 P.M., the pressure was	214
”	11·30 ” ” ”	210
May 17.	—At 5·00 A.M. ” ”	214
”	3·00 P.M. ” ”	210
	The pressure was then run off and the gauge detached.	
May 16th, at 9·00 P.M., the maximum pressure was obtained, namely		241
And on May 17th, at 3·00 P.M., when the gauge was detached, the pressure was		210
Having lost in 18 hours		31

Or nearly 2 lbs. per hour.

Pressure of Gas.

On May 17th, at 4·10 P.M., one of Schaeffer and Budenberg's 1,000 lb. patent steel tubed pressure gauges was put on, and on

	Lbs. per sq. inch.
May 17th, at 4·45 P.M., the pressure was	0
„ 5·00 „ „ „	25
„ 7·30 „ „ „	120
„ 9·00 „ „ „	240
May 18th, at 5·00 A.M. „ „	442
„ 19th, at 1·30 „ „ „	456
„ „ 12·00 NOON (maximum pressure)	461
„ „ 2·40 P.M., the pressure was	441

The fittings were closely examined, and a leak was found at a joint just below the tap. A steady decrease of pressure ensued on that account, so that on

May 19th, at 8·00 P.M., the pressure was	437
„ 20th, at 1·00 A.M., „ „	400
„ „ 10·00 „ „ „	330
„ „ 2·30 P.M., „ „	280
The gauge then took a rise, registering at 7·00 P.M. ...	300
May 21st, at 10·00 A.M., the pressure rose to	322
„ 22nd, 7·30 P.M., „ „	383
„ 25th, 5·00 A.M., the pressure was only	335

At which time it was run off.

From May 25th, at 12·00 NOON, until May 27th, at 12·00 NOON, the gas was allowed to drain freely from the hole, and at 12·7 P.M. the pressure gauge was put on, and up to 1·40 P.M. had not moved.

It was not read again until

	Lbs. per sq. inch.
May 28th, at 7·45 A.M., when the pressure was	390
„ 9·00 P.M., the pressure was only	354

This diminution in pressure was owing to a leakage from the tap.

Quantity of Gas.

The gauge was again blown off and the testing meter attached. Subjoined are the measurements:—

	Feet.		Cubic feet per hour.
May 28th, at 11·45 P.M., meter standing at...	0015·000	=	...
„ 11·55 „ „ ...	0015·090	=	·54
May 29th, at 12·5 A.M. „ ...	0015·180	=	·54
„ 12·15 „ „ ...	0015·265	=	·51
„ 12·25 „ „ ...	0015·340	=	·45
May 29th, at 12·35 „ „ ..	0015·415	=	·45
„ 12·45 „ „ ...	0015·483	=	·41

Average, ·483 cubic feet per hour.

During this experiment, the other gauges were standing at :—

Pressure of Gas.

	Lbs. per sq. inch.
No. 1	83
No. 2	110
No. 4	302

On May 29th, at 1·15 P.M., the pressure gauge was re-attached, and at 2·20 P.M. it had risen to 50
May 30th, at 5·30 A.M. „ 418
On May 31st, at 8·00 A.M., it began to leak, and only registered 397
June 1st, at 8·10 A.M., the pressure was 373
„ 2nd, at 8·10 „ „ „ 390
In conclusion the gauge was taken off, and the gas measured on

Quantity of Gas.

June 2nd, at 8·30 A.M., the meter standing at... 0254·00
„ 3rd, at 8·30 „ the meter indicated ... 0270·46 = 16·46 feet.

Average, ·68 cubic feet per hour.

During this experiment the pressures were as follows :—

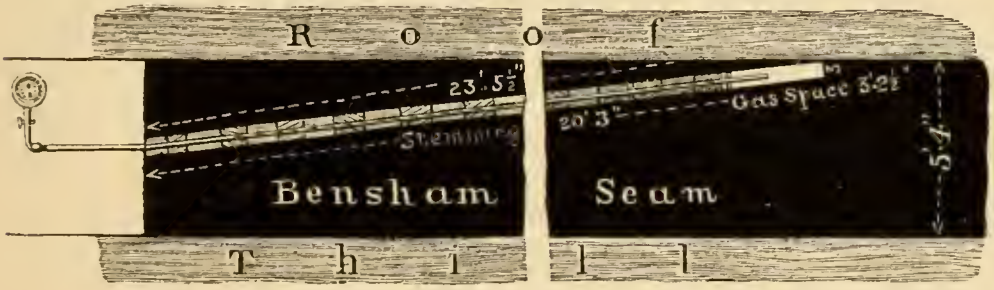
Pressure of Gas.

	Lbs. per sq. inch.
No. 1	382
No. 2	268
No. 4	278

EXPERIMENT IV.

On May 14th, 1880, a hole was bored in the solid coal at the face of a stenton about 14 yards to the outbye side of Nos. 1, 2, and 3 Holes, and on the left-hand side. See Plans Nos. 3 and 4, pages 195 and 196, and Section No. 10.

SECTION No. 10.



CONDITIONS.

	Ft.	In.
The length of the borehole was … … … …	23	5½
The diameter of ,, … … … …		3
The diameter of pipe fixed in the hole … … …		½
Gas space … … … … … … …	3	2½

Hole parallel with the cleat.

Cover—depth of hole from surface … …	1,268 feet.
Distance of hole from shaft … … …	2,196 yards.
Description of gauge used … …	Schaeffer and Budenberg's.

Elevation No. 2, showing the position of the hole in the face of the stenton :—

The stemming of this hole was begun on May 16th, at 10·0 A.M., and finished at 2·0 P.M. on the same day in four hours, including a stoppage of twenty minutes, caused by the rods having got unscrewed in the hole.

One of Schaeffer and Budenberg's 400 lb. gauges was put on to the hole on May 16th, at 3·00 P.M., with the following results :—

RESULTS.—SEE TABLE, PAGE 247.

Pressure of Gas.

	Lbs. per sq. inch.
May 16th, at 4·30 P.M., the pressure was … … …	8
,, 5·00 ,, ,, ,, … …	47
,, 6·00 ,, ,, ,, … …	120
,, 7·00 ,, ,, ,, … …	170
,, 8·00 ,, ,, ,, … …	295
,, 12·00 MIDNIGHT ,, ,, … …	342
May 17th, at 9·00 A.M., the pressure was … …	371
,, 9·30 ,, ,, ,, … …	372
,, 2·00 P.M. ,, ,, … …	377
,, 4·00 ,, ,, ,, … …	380
,, 4·12 ,, ,, ,, … …	381

The pressure was then run off, and the gauge removed.

One of Schaeffer and Budenberg's 1,000 lb. gauges was attached on May 17th, at 4·30 P.M., and registered as follows :—

Pressure of Gas.

	Lbs. per sq. inch.
May 17th, at 4·45 P.M., the pressure was	45
,, 6·00 ,, ,, ,, ...	220
,, 7·30 ,, ,, ,, ...	302
,, 11·30 ,, ,, ,, ...	338
May 18th, at 7·00 A.M. ,, ,, ...	350
,, ,, 1·00 ,, ,, ,, ...	348
,, 21st, at 9·30 P.M. ,, ,, ...	348

After 1·0 P.M., the gauge did not move for 25½ hours, at the end of this time it dropped to 344 lbs., and then at 4·30 P.M. to 340 lbs. per square inch, and stood there until May 25th, at 5 A.M., when the pressure was run off, and the gauge disconnected.

Quantity of Gas.

The gas was then allowed to drain from the hole from May 25th, at 5 A.M., until May 27th, at 11·30 A.M., a period of 54 hours 30 minutes, when a test meter was attached, and left on for 30 minutes, and the average quantity of gas given off was found to be 1·4616 cubic feet per hour; the water given off was 20 cubic inches per hour.

The gas was again measured as under:—

	Feet.		Cubic feet per hour.
May 29th, 1·5 A.M., meter standing at ...	0016·00	=	...
,, 1·15 ,, ,, ,, ...	0016·51	=	3·06
,, 1·25 ,, ,, ,, ...	0016·99	=	2·88
,, 1·35 ,, ,, ,, ...	0017·43	=	2·64
,, 1·45 ,, ,, ,, ...	0017·85	=	2·52
,, 1·55 ,, ,, ,, ...	0018·265	=	2·49
,, 2·5 ,, ,, ,, ...	0018·645	=	2·28

Average, 2·645 cubic feet per hour.

Pressure of Gas.

During this experiment the pressure gauges showed in—

	Lbs. per sq. inch.
No. 1 Hole	170
No. 2 Hole	153
No. 3 Hole	40

Quantity of Gas.

On May 29th, at 2·20 A.M., the testing meter was put on again and left on until June 2nd. The readings were:—

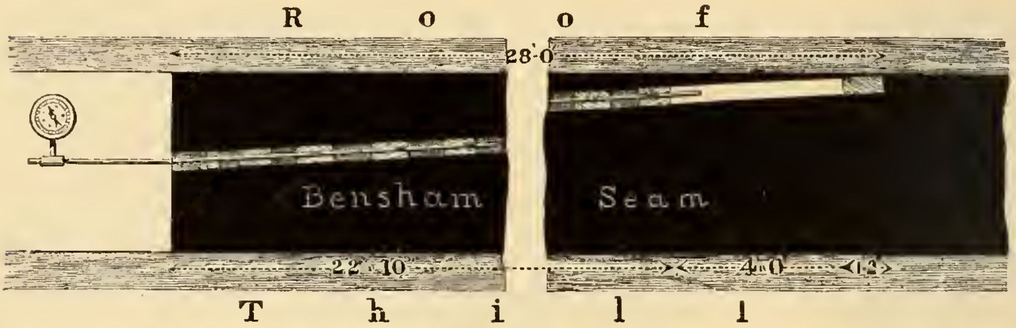
	Feet.		Cubic feet per hour.
May 29th, at 2·20 A.M., meter standing at...	0020·00	=	...
,, 30th, at 5·30 ,, ,, ,, ...	0086·00	=	2·43
,, ,, 5·40 ,, ,, ,, ...	0086·38	=	2·28
,, 31st, 8·10 ,, ,, ,, ...	0147·68	=	2·31
,, ,, 8·40 ,, ,, ,, ...	0148·90	=	2·44
June 1st, 8·10 ,, ,, ,, ...	0200·81	=	2·21
,, ,, 8·40 ,, ,, ,, ...	0201·88	=	2·14
,, 2nd, 8·10 ,, ,, ,, ...	0252·70	=	2·16

Average, 2·281 cubic feet per hour.

EXPERIMENT V.

On June 14th, 1880, a hole was bored in the solid coal in the face of a stenton, to the outbye side of where No. 4 Hole was bored. See Plans Nos. 3 and 4, pages 195 and 196, and Section No. 11.

SECTION NO. 11

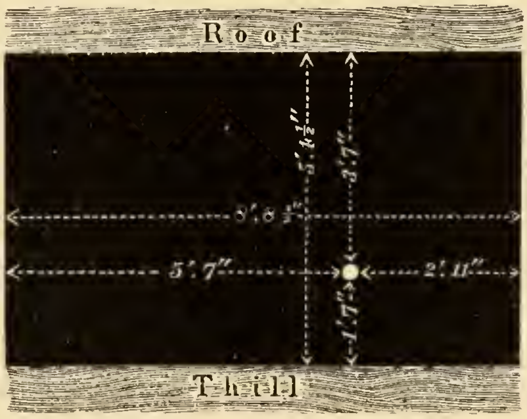


CONDITIONS.

	Ft.	In.
The length of the borehole was	28	0
The diameter of ,, ...		2½
The diameter of pipe fixed in hole		½
Gas space	4	0
Hole parallel with the cleat.		
Cover—depth of hole from surface...	1,268 feet.	
Distance of hole from shaft	2,080 yards.	
Description of gauge used	Schaeffer and Budenberg's.	

Elevation No. 3, showing the position of the hole in the face of the stenton :—

ELEVATION NO. 3.



In stemming the hole, the spigot and faucet plugs broke away the ferrule at the end of the pipe, and had therefore to be driven to the far end of the hole and left, thus diminishing the gas space by 1 foot 2 inches, and accounting for the seeming discrepancy between the length of stemming and gas space and the total length of hole, as stated above.

The boring of this hole was commenced with on June 14th, at 3·00 A.M., and finished 1·00 P.M. on the same day in 10 hours. The stemming was begun on June 14th, at 11·45 P.M., and finished on June 15th, at 3·40 A.M., in 3 hours 55 minutes. It was stemmed in the same manner as the preceding holes, with oakum and cement and wooden plugs.

On June 15th, one of Schaeffer and Budenberg's 300 lb. pressure gauges was put on.

RESULTS.—See Table, Page 250.

Pressure of Gas.

	Lbs. per sq. inch.
June 15th, at 4·15 A.M., gauge attached.	
„ 4·20 „ the pressure was	53
„ 4·25 „ „ „	93
„ 5·15 „ „ „	134

At 5·15 A.M., the joint below the tap began to leak, and by 5·20 A.M. the pressure had fallen to 130 lbs. per square inch. The joints were made tight again, and on

June 15th, at 5·45 A.M., the pressure was	131
„ 9·00 „ „ „	141
„ 4·00 P.M. „ „	162

At 4·15 P.M., a 500 lb. gauge was attached without running off the pressure, and on

June 15th, at 11·30 P.M., the pressure was	165
„ 16th, at 6·45 A.M. „ „	170
„ „ 11·30 A.M. „ „	172
„ 17th, at 4·30 „ „ „	174
„ „ 3·00 P.M. „ „	176
„ 18th, at 12·30 NOON „ „	175

The gauge was left in the hole until February 2nd, at 9 A.M., when the pressure still stood at 175 lbs ; the gauge was then detached.

Quantity of Gas.

	Cubic Feet.
July 2nd, at 9 A.M., the gas testing meter was attached, registering	0432·00
July 4th, at 5 A.M., 44 hours after, it registered ...	0887·00
	455·00

Average, 10·34 cubic feet per hour.

THE EXPERIMENTS MADE AT HARTON COLLIERY.

The Harton Colliery was opened out about the year 1825, 55 years before the experiment was made, the following being the account of the strata passed through:—

TOWNSHIP OF HARTON, DURHAM.

Sheet 4 of Ordnance Map. Lat. 54° 58′ 14″, Long. 1° 26′ 5″.

Approximate surface level 75 feet above sea (Ordnance datum).

	Fs.	Ft.	In.	Fs.	Ft.	In.
Soil	0	1	0			
Yellow	0	3	0			
Blue leafy clay ...	1	1	0			
Blue gravelly clay	10	4	0	*		
	0	5	2			
Red clay	1	4	0			
Soft blue metal stone and water	1	3	0			
COAL	0	0	3			
				16	3	5
Dark grey metal and a little water ...	1	1	6			
COAL	0	0	3			
Dark grey metal or thill	2	0	3			
COAL and a little water	0	0	4			
Strong dark grey metal and post ...	1	3	2			
Strong grey post and water	1	1	10			
Grey metal	3	0	0			
Black metal	0	0	5			
COAL	0	1	0			
				9	2	9
Thill or grey metal ...	0	4	2			
Post girdles	0	0	10			
Grey metal post girdles and water	2	2	2			
White post girdles and water	0	3	5			
Black metal	0	2	9			
COAL	0	0	4			
				4	1	8
Thill	1	4	0			
Grey post	0	3	2			
Grey metal	0	2	6			
Grey post, with black partings	0	2	8			
Blue metal	0	5	8			
COAL	0	1	2			
				4	1	2
Carried forward				34	3	0

	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward						
Dark grey thill ...	0	4	6			
Grey metal	1	4	0			
COAL	0	1	2			
				2	3	8
Grey metal band ...	0	0	4			
COAL	0	0	6			
Post, with whin girdles and water	1	1	0			
Grey metal and water	0	3	4			
COAL	0	0	6			
Band	0	0	3			
COAL	0	0	3			
				2	0	2
Grey metal, with post girdles	1	2	4			
COAL	0	0	3			
Grey metal	0	5	2			
COAL	0	0	2			
Grey metal, with post girdles and water ...	3	5	7			
	Ft.	In.				
COAL ...	1	3½				
Brassy band ...	0	3				
COAL ...	1	3½				
	0	2	10			
				6	4	4
Grey thill	0	4	0			
Grey metal post girdles and water	2	3	1			
Post and water on north or rise side of pit	1	3	0			
Post and water on south or dip side of pit	6	0	0			
Dark grey metal ...	2	0	0			
COAL	0	1	8			
				12	5	9
Carried forward				58	4	11

* Approximate sea level (Ordnance datum).

	Fs.	Ft.	In.	Fs	Ft.	In.
Brought forward				58	4	11
Grey metal or thill ...	0	4	0			
Grey post and water...	0	5	2			
White post and metal partings and water	19	2	8			
Dark grey metal ...	2	4	3			
COAL	0	0	8			
				23	4	9
Dark grey metal or thill	2	4	3			
COAL	0	0	5			
				2	4	8
Brown thill	0	0	6			
Grey post, with metal partings and water	1	1	3½			
Red and white post, very damp ...	8	5	8½			
COAL, stony ...	0	0	3			
Soft grey metal or thill stone	1	1	0			
Strong black metal, or white catheads and *coal*	0	1	5			
COAL	0	0	2½			
				11	4	4½
Strong light-coloured grey post, white metal partings, and whin girdles near top of bed, with a little water ...	1	4	0			
Dark grey metal ...	1	4	7			
COAL	0	0	2			
Black band	0	0	2			
COAL	0	0	3½			
Black band	0	0	1½			
COAL	0	0	11			
				3	4	3
Grey metal stone, with whin girdles ...	4	3	4			
Dark grey metal, with ironstone girdles ...	2	3	10			
COAL, foul... ...	0	0	5			
Thill, or dark grey metal	0	2	6			
Dark grey metal stone and post girdles ...	2	0	0			
COAL	0	0	5			
				9	4	6
Grey metal	0	1	8			
White post, with girdles and water ...	4	0	11			
COAL, good ...	0	0	4			
COAL, black slaty...	0	1	1			
Thill or grey metal ...	0	2	7			
COAL	0	0	6			
				5	1	1
Dark grey metal stone, with post and whin girdles and water, and *coal pipes* at bottom ...	2	2	1			
Carried forward	2	2	1	115	4	6½

	Fs.	Ft.	In.	Fs.		
Brought forward	2	2	1	115	4	6½
White post, with metal partings	2	1	11½			
Grey metal	0	1	4			
COAL, strong and good	0	2	6			
Splint	0	0	6			
Grey metal	0	1	6			
Strong white post and water	7	1	7½			
Black stone	0	0	3½			
COAL, black slaty...	0	1	5½			
Grey metal, with post girdles	2	3	8			
Black metal, with ironstone girdles ...	0	3	0			
COAL	0	0	1½			
				16	2	0½
Dark grey metal, with post and whin girdles	2	4	1			
Hard white post, mixed with whin in beds, very coarse in the grain, much mixed with small metal and ironstone balls of various colours, and a little water (supposed *Seventy-Fathoms Post*) ...	12	2	6			
Dark blue metal, with metal balls and ironstone girdles at a depth of 1 fathom. From the top of this stratum a mussel bed of from 4 to 5 inches thick was passed through ...	1	3	0			
Grey metal, with post girdles	1	0	0			
Black stone	2	1	5			
COAL, strong and good	0	0	6			
				19	5	6
Grey metal, with post girdles	3	3	0			
White post, with a little water (supposed *Main Post*)...	3	1	0			
Grey metal, with ironstone girdles ...	1	0	0			
Supposed Main Coal—						
Ft. In.						
COAL ... 1 2						
Black slaty band ... 0 1						
COAL ... 0 2½						
	0	1	5½			
				7	5	5½
Carried forward				159	5	6½

	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward				159	5	6½
Black slaty stone ...	0	3	0			
Black slaty stone, mixed with *coal pipes*	0	0	6			
Grey thill stone ...	0	5	6			
Grey metal stone ...	3	3	0			
Grey metal, with post girdles	5	3	0			
Strong grey post, with metal partings, whin girdles, and a little water	7	2	2			
Blue metal girdle ...	0	2	0½			
White post girdle. with metal partings ...	0	2	3			
COAL (supposed *Metal Coal*) ...	0	1	10			
				18	5	3½
Grey thill, with ironstone balls	0	4	0			
Strong grey metal, with post girdles ...	1	4	0			
Strong dark grey metal and post girdles ...	2	2	0			
COAL, splint ...	0	0	5			
Grey metal, with post girdles	1	4	0			
Strong white post, with whin girdles...	2	0	0			
Grey whin	1	2	0			
Grey metal stone and ironstone girdles ...	5	3	1			
Black slaty stone ...	0	1	0			
COAL	0	0	9			
Swad	0	0	3			
Thill	0	4	0			
Grey metal stone, with whin girdles ...	1	1	9			
COAL	0	0	3			
Grey metal, with post and whin girdles ...	4	1	3			
Carried forward	21	4	9	178	4	10

	Ft.	In.	Fs.	Ft.	In.	Fs.	Ft.	In.
Brought forward			21	4	9	178	4	10
Yard Coal Seam—								
COAL ...	0	8½						
Band ...	0	3½						
COAL ...	3	2						
			0	4	2			
						22	2	11
Thill stone			0	4	2			
Black stone			0	0	5½			
COAL, splinty ...			0	0	2½			
Grey metal			0	1	2			
Dark grey metal. with ironstone girdles ...			1	0	2			
Grey metal, with ironstone girdles ...			1	5	3			
Grey post, with metal partings and whin girdles			2	3	0			
Dark grey metal. with ironstone girdles ...			1	2	0			
White post, with whin girdles			0	5	6			
Grey post, with scaling metal partings and whin			3	4	2			
Black metal			0	0	4			
BENSHAM SEAM—								
COAL, top	3	0						
Splint ...	0	2½						
COAL, bottom ...	2	9½						
			1	0	0			
						13	2	5
Sump—								
Blue metal, with whin, white post, and ironstone girdles ...			4	1	4			
Six-Quarter Seam—								
COAL, splinty	2	0						
COAL, good	1	8						
			0	3	8			
Left off in strong grey post			0	3	0			
						5	2	0
Total						220	0	2

The whole of the experiments were made in the No. 1 Holder House District, Bensham Seam, at a point about 3,000 yards south-east from the shaft, about 440 yards from some old workings, and 594 yards from the nearest goaf, the dip of the strata being towards the south-west.

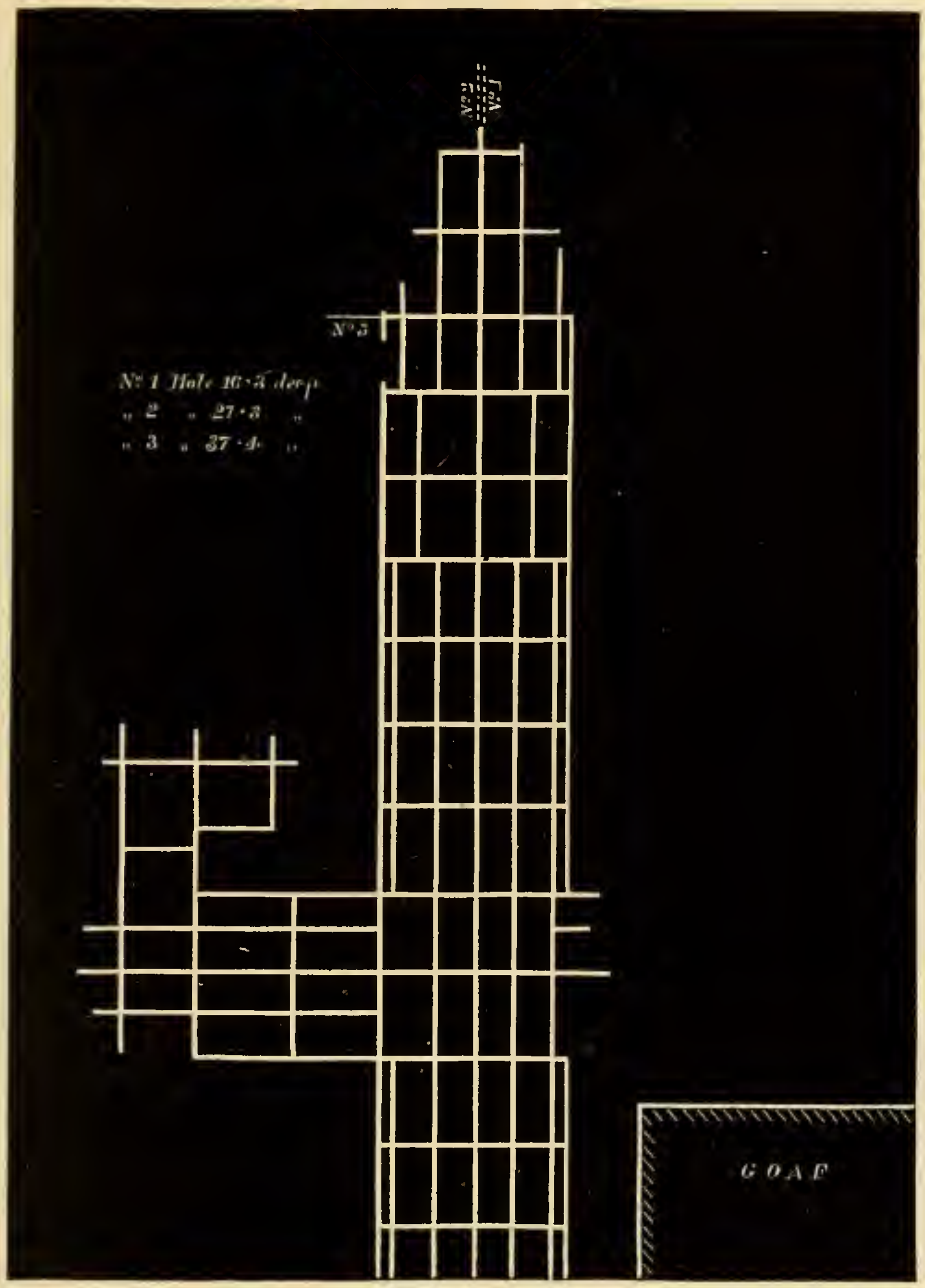
The roof is good, of blue metal, and the thill is also of blue metal.

The coal is bright and bituminous, and is used for household purposes. The cleavage is well defined and the texture open.

No coal is worked in any seam either above or below.

The specific gravity is 1·21.

Plan No. 5, showing the workings in No. 1 Holder House District :—



EXPERIMENT I.

On June 1st, 1880, No. 1 Hole was bored in the solid coal at the face of a winning (narrow board). See Plan No. 5, and Section No. 12.

This hole came in contact with the roof.

SECTION No. 12.

CONDITIONS.

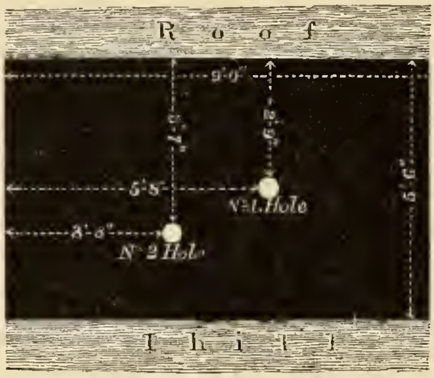
	Ft.	In.
The length of the borehole was...	16	2
The diameter of ,, ...		3
The diameter of pipe fixed in the hole...		½
Gas space	3	0

Hole at right angles to the cleat.
Cover—depth of hole from surface ... ... 1,215 feet.
Distance of hole from shaft about ... ... 3,000 yards.
Description of gauge used ... Schaeffer and Budenberg's.

The holes were stemmed in exactly the same manner as those at Boldon Colliery, with wooden plugs, oakum, and cement.

This hole took 5 hours to bore and 3 hours 15 minutes to stem.

Elevation No. 4, showing the position of Nos. 1 and 2 Holes in the narrow board.



Pressure of Gas.

On June 6th, at 3·30 A.M., one of Schaeffer and Budenberg's 500 lb. pressure gauges was put on.

RESULTS.—SEE TABLE, PAGE 251.

			Lbs. per sq. inch.
June 6th, at	3·35 A.M.,	pressure was	10
,,	4·10 ,,	,, ,, ...	30
,,	7·5 ,,	,, ,, ...	80
June 6th, at	8·20 ,,	,, ,, ...	100
,,	4·00 P.M.	,, ,, ...	157
June 7th, at	1·00 A.M.	,, ,, ...	170
,,	1·00 P.M.	,, ,, ...	178
June 8th, at	1·00 ,,	,, ,, ...	186
,, 9th, at	1·00 ,,	,, ,, ...	191
,, 10th, at	1·00 ,,	,, ,, ...	195
,, 11th, at	1·00 ,,	,, ,, ...	196

Pressure of Gas.

	Lbs. per sq. inch.
June 12th, at 1·00 P.M., the pressure was	197
„ 13th, at 1·00 „ „ „	195
„ 14th, at 1·00 „ „ „	196
„ 15th, at 12·00 A.M. „ „	193

The pressure was then run off, and a 300 lb. gauge put on and started at 12·45 P.M., and on

June 15th, at 1·00 P.M., it had risen to	11
„ 4·00 „ „	119

A leak was discovered in the pipes which reduced the pressure, so that on June 15th, at 5·0 P.M., the pressure was only 100 lbs. per square inch. The leak seems, however, to have taken up, and the pressure rose gradually until June 16th, at 5 A.M., when the gauge registered 146 lbs. per square inch. The pressure at this time was run off and the gauge detached.

At 5·45 another 300 lb. gauge was fixed to the hole, and on June 16th, at 5·0 P.M., registered 197 lbs. per square inch.

EXPERIMENT II.

On June 1st a second hole was bored in the solid coal at the face of the same winning (narrow board). See Elevation No. 4, page 214, and Section No. 13.

This hole also came in contact with the roof.

SECTION NO. 13.

CONDITIONS.

	Ft.	In.
The length of the borehole was	27	6
The diameter of „		3
The diameter of pipe fixed in the hole		½
Gas space	3	6

Hole at right angles to the cleat.

Cover—depth of hole from surface	1,215 feet.
Distance of hole from shaft	3,000 yards.
Description of gauge used ...	Schaeffer and Budenberg's.

This hole was bored in a similar manner to No. 1, in 7 hours 15 minutes, and stemmed in 5 hours 45 minutes.

One of Schaeffer and Budenberg's 1,000 lb. patent steel tubed gauges was attached with the undermentioned results:—

RESULTS.—See Table, Page 251.

Pressure of Gas.

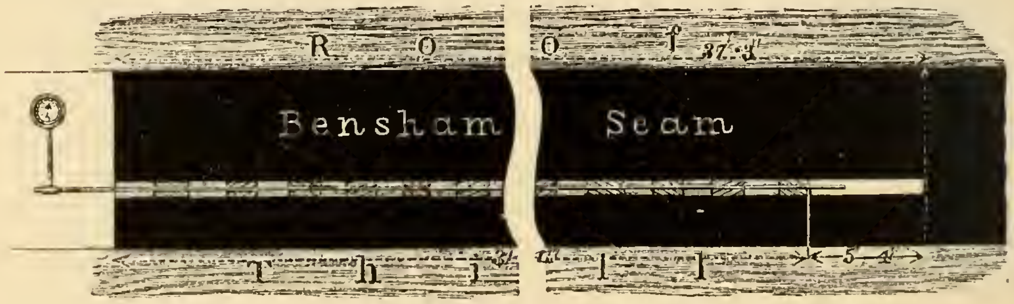
			Lbs. per sq. inch.
June 6th, at	3·30 A.M.,	pressure gauge put on.	
,,	4·15 ,,	the gauge had not moved.	
,,	4·20 ,,	it rose to	10
,,	5·15 ,,	the pressure was	50
,,	6·20 ,,	,, ,, ...	100
,,	2·10 P.M.	,, ,, ...	200
,,	7·00 ,,	,, ,, ...	207
June 7th, at	1·00 A.M.	,, ,, ...	208
,,	9·00 P.M.	,, ,, ...	219
June 8th, at	7·00 A.M.	,, ,, ...	220
,, 9th, at	7·00 ,,	,, ,, ...	225
,, 10th, at	7·00 ,,	,, ,, ...	227

This pressure continued until June 11th, at 10·0 A.M. At 11·0 A.M. the pressure was 228 lbs. per square inch, and rose to 230 lbs. at 9 P.M. on the same day, at which it remained for 92 hours, except from 1 to 4 A.M. on the 15th, when it was a pound higher. A leak at the joint reduced the pressure to 226 lbs. per square inch. The leakage, however, took up, and on June 16th, at 5·0 P.M., the pressure rose to 230 lbs. per square inch.

EXPERIMENT III.

On June 2nd, a hole was bored in the solid coal at the face of a stenton in the No. 1 District. See Section No. 14, and Elevation No. 5, page 217.

Section No. 14.



	Ft.	In.
The length of the borehole was...	37	3
The diameter of ,, ...		2½
Diameter of pipe fixed in the hole		½
Gas space	5	4
Hole parallel with the cleat.		
Cover—depth of hole from surface	1,215 feet.	
Distance of hole from shaft about	3,000 yards.	
Description of gauge used ...	Schaeffer and Budenberg's.	

The hole was stemmed in precisely the same manner as Nos. 1 and 2.

The time occupied in boring was 6 hours 25 minutes, and in stemming 8 hours 20 minutes.

The hole was commenced on June 2nd, at 2·50 A.M., and finished on June 6th, at 3·15 A.M.

Elevation No. 5, showing the position of No. 3 Hole in the stenton:—

ELEVATION NO. 5.

At 10·0 P.M., on June 10th, one of Schaeffer and Budenberg's 1,000 lb. gauges was put on.

RESULTS.—SEE TABLE, PAGE 251.

June 10th, at 10·0 P.M., the gauge was put on; at 11·0 P.M. the pressure was 104 lbs. per square inch. It was then found that all three tap joints were leaking at this hole. The pressure, however, still rose, and on June 11th, at 3·30 A.M., registered 220 lbs. per square inch, and at 8·30 A.M. 237 lbs. Pressure of Gas.

At this point the leakage became worse, and the gauge fell 11 lbs. in 15 minutes. The taps were tightened and the gauge again began to rise.

Pressure of Gas.

	Lbs. per sq. in.
June 11th, at 12·00 NOON, the pressure was	259
„ „ at 12·00 P.M. „ „	278
June 12th, at 6·00 A.M. „ „	280
„ „ at 6·30 P.M. „ „	280
June 13th, at 6·00 A.M. „ „	293
„ „ at 6·00 P.M. „ „	294
June 14th, at 6·00 A.M. „ „	295
This pressure continued until	
June 14th, at MIDNIGHT, when the pressure was ...	294
„ 15th, at 9·00 A.M. „ „ ...	292
„ 16th, at NOON „ „ ...	291
„ „ at 6·00 P.M. „ „ ...	290

After this the readings were discontinued.

Quantity of Gas.

A series of experiments were then made to test the quantity of gas given off from the Nos. 1, 2, and 3 Boreholes at Harton Colliery; a test meter belonging to the South Shields Gas Company being used for the purpose.

On June 18th the pressure was allowed to ease off from all the holes, and after each had stood about twenty minutes the gas meter was put for an hour on each hole separately, the readings being taken every ten minutes.

No. 1 Hole.

MEASUREMENT OF GAS GIVEN OFF PER HOUR.

Date.	Hour.	Reading of Meter.	Equal per Hour.
		Cubic Feet.	Cubic Feet.
June 18 ...	7·40 a.m. ...	300·00	...
„ ...	7·50 „ ...	300·21	1·26
„ ...	8·00 „ ...	300·40	1·14
„ ...	8·10 „ ...	300·57	1·02
„ ...	8·20 „ ...	300·74	1·02
„ ...	8·30 „ ...	300·91	1·02
„ ...	8·40 „ ...	301·09	1·08

Average, 1·09 cubic foot per hour.

No. 2 Hole.

Measurement of Gas given off per Hour.

Date.	Hour.	Reading of Meter.	Equal per Hour.
		Cubic Feet.	Cubic Feet.
June 18	9·00 a.m.	301·00	...
„	9·10 „	301·45	2·70
„	9·20 „	301·88	2·58
„	9·30 „	302·29	2·46
„	9·40 „	302·68	2·34
„	9·50 „	303·00	1·92
„	10·00 „	303·34	2·04

Average, 2·34 cubic feet per hour.

No. 3 Hole.

Measurement of Gas given off per Hour.

Date.	Hour.	Reading of Meter.	Equal per Hour.
		Cubic Feet.	Cubic Feet.
June 18	10·20 a.m.	303·00	...
„ „	10·30 „	303·83	4·98
„ „	10·40 „	304·78	5·70
„ „	10·50 „	305·60	4·92
„ „	11·00 „	306·45	5·10
„ „	11·10 „	307·23	4·68
„ „	11·20 „	308·02	4·74

Average, 5·02 cubic feet per hour.

On July 13th the meter was again attached to No. 1 Borehole, and left on for one week, when it was taken off and put on No. 2 Hole for the same length of time. It was then put on to No. 3 Hole, where it stood until August 20th.

The readings were taken every twenty-four hours except at the week ends, and were as follows:—

No. 1 Hole.

Measurement of Gas given off per Hour.

Date.	Hour.	Reading of Meter.	Equal per Hour.
		Cubic Feet.	Cubic Feet.
July 13	8·50 a.m.	000·15	...
„ 14	8·50 „	015·71	·65
„ 15	8·45 „	027·14	·48
„ 16	8·45 „	037·65	·44
„ 16	10·30 p.m.	043·62	·43
„ 19	8·45 a.m.	068·97	·42
„ 20	7·45 „	078·63	·42

Average, ·47 cubic foot per hour.

No. 2 Hole.

Measurement of Gas given off per Hour.

Date.		Hour.	Reading of Meter.	Equal per Hour.
			Cubic Feet.	Cubic Feet.
July 20	...	8·30 a.m.	080·44	...
„ 21	...	8·30 „	108·21	1·16
„ 22	...	8·30 „	129·45	·88
„ 23	...	8·30 „	149·40	·83
„ 23	...	8·30 p.m.	159·65	·85
„ 26	...	8·30 a.m.	208·27	·81
„ 27	...	8·30 „	227·75	·81

Average, ·89 cubic foot per hour.

No. 3 Hole.

Measurement of Gas given off per Hour.

Date.		Hour.	Reading of Meter.	Equal per Hour.
			Cubic Feet.	Cubic Feet.
July 28	...	9·15 a.m.	0240·48	...
„ 29	...	9·15 „	0342·50	4·25
„ 30	...	9·15 „	0440·60	4·09
Aug. 1	...	6·30 „	0625·30	4·09
„ 2	...	9·30 „	0735·10	4·07
„ 3	...	9·15 „	0832·40	4·09
„ 4	...	9·15 „	0929·35	4·04
„ 5	...	9·15 „	1026·28	4·04
„ 6	...	9·15 „	1122·40	4·01
„ 9	...	9·15 „	1410·10	3·99
„ 11	...	9·15 „	1589·10	3·73
„ 13	...	9·15 „	1763·14	3·63

Average, 4·00 cubic feet per hour.

No. 3 HOLE.—EXPERIMENT 3a.

On April 12th, 1881, the pressure was allowed to ease off from No. 3 Borehole, and a 400 lb. pressure gauge was attached.

The pressure had been retained in the hole by having the pipe end screwed up, since the close of the former experiments on August 20th, 1880, a period of 33 weeks.

RESULTS.

Pressure of Gas.

			Lbs. per sq. inch.
April 12th, at	4·45 A.M.,	the gauge was attached.	
,,	5·30 ,,	the pressure rose to	3
,,	5·45 ,,	,, ,, ...	20
,,	6·00 ,,	,, ,, ...	42
,,	6·30 ,,	,, ,, ...	85
,,	7·00 ,,	,, ,, ...	107
,,	10·00 ,,	,, ,, ...	136
,,	3·45 P.M.	,, ,, ...	137
,,	12·00 NIGHT	,, ,, ...	141
April 13th, at	9·00 A.M.	,, ,, ...	149
,,	9·00 ,,	,, ,, ...	155
,,	9·00 ,,	,, ,, ...	158
,,	9·00 ,,	,, ,, ...	159
,,	9·00 ,,	,, ,, ...	158

SUMMARY.

From the foregoing remarks it will be seen that the experiments were made in five distinct groups or collieries—

1 at Elemore.
1 at Hetton.
8 at Eppleton.
5 at Boldon, and
3 at Harton.

The highest pressure was obtained at Boldon, being 461 lbs., and equal to 84 per cent. of that due to a column of water the same height as the thickness of the cover, but this occurred in one instance only; in most of the other cases it scarcely reached 50 per cent. of the pressure due to the column, and in one, Elemore, where the highest pressure exhibited was only 28 lbs., it was only 8¾ per cent., the lowest pressures being obtained in the collieries that had been the longest opened out.

For instance, at Boldon, where 84 per cent. was obtained, the pit has been opened out only eleven years, whereas at Elemore, where only 8¾ per cent. was obtained, the pit has been at work for fifty-three years.

It will, however, be seen that the pressures are not the same in all cases where the thickness of cover is the same; as only one experiment, was tried at Elemore, and one at Hetton; any variation which might exist at those collieries was not ascertained, but in the other three collieries, and especially at Eppleton, this variation was very apparent, and seems to show that the pressure bears some relation to the distance from the face of the coal in the workings in which it is ascertained.

In endeavouring to ascertain what relation this increase of pressure bears to the increase of depth of hole, there seems to be an indication that under similar circumstances of cover, the pressure varies as the square root of the depth of the hole. For example, take the Eppleton experiments, and exclude Nos. 4 and 5, which were abandoned because it was suspected that incorrect results were being obtained by them, and then apply this formula, and taking the sixth hole as the standard for comparison, the results will be as shown in Table A.

TABLE A.

No. of Experiment.	Depth of Hole in Feet.	√ of the Depth of Hole.	Calculated Pressure. Lbs.	Actual Pressure.	Difference.
1	3·5	1·87	69	54·75	– 14·25
2	7·5	2·74	100	104·5	+ 4·5
3	24·5	4·94	181	204	+ 23
8	25·0	5·0	183	221	+ 38
6	37·0	6·08	223	223	=
7	47·0	6·85	251	235	– 16

Thus giving a mean deviation from the rule of about 3⅓ per cent. on the average pressures exhibited.

If the Boldon experiments are compared in the same way, excluding the fifth (which seems for some reason to have given less pressures than any of the other holes, some of which were much shorter, probably because the end of the hole was blocked up by the plug, which had got loose), and taking the third hole as the standard of comparison, the results will be as shown in Table B.

TABLE B.

No of Experiment.	Depth of Hole in Feet	√ of the Depth of Hole.	Calculated Pressure.	Actual Pressure.	Difference.
2	7·7	2·77	226	298	+ 72
1	19·1	4·37	356	425	+ 69
4	23·5	4·84	395	381	– 14
3	32·0	5·65	461	461	=

This gives a mean deviation from the rule of about 8 per cent. on the average pressures exhibited. Extending the comparison to the Harton experiments, where there seems to have been no exceptional circumstance requiring the exclusion of any of them, the results will be as shown in Table C.

TABLE C.

No. of Experiment.	Depth of Hole in Feet.	√ of the Depth of Hole.	Calculated Pressure.	Actual Pressure.	Difference.
1	16·2	4·02	194	197	+ 3
2	27·5	5·24	253	231	− 22
3	37·2	6·10	295	295	=

These give a mean deviation from the rule of about 2½ per cent. on the average pressures exhibited.

If for the sake of comparison the rule of the pressure, being in proportion to the √ of the depth, be applied to the five sets of experiments in order to give a pressure at a uniform depth of hole of say 30 feet, the results would be as shown in Table D.

TABLE D.

Years. Opened.	Colliery.	Depth of Hole.	Pressure indicated in Experiment.	At a Depth of.	Probable Pressure at 30 Feet.	Thickness of Cover.	Pressure due to a column of water the height of the Cover.
		Ft.	Lbs.	Ft.		Feet.	
11	Boldon ...	As √32	: 461	:: √30 =	446	1,268	549
43	Eppleton ...	„ √37	: 223	:: √30 =	200	1,261	546
54	Elemore ...	„ √ 7	: 28	:: √30 =	58	750	324
55	Harton ...	„ √37·25	: 295	:: √30 =	265	1,215	526
58	Hetton ...	„ √ 9	: 45	:: √30 =	82	1,228	531

Tables A, B, C, and D, are further illustrated in Plate XLIV.

The experiments seem to indicate that the direction of the hole with reference to the cleat has no influence on the pressure.

With respect to the quantities of gas coming from the different holes, Table E, page 224, gives a synoptical exposure of all the conditions and results of the experiments, and shows the nature of the data ascertained. In the Boldon experiments the largest quantity of gas given off per square foot per hour was obtained considerably after the time that the least quantity noted was ascertained, whereas in the other experiments the least quantities noted were always after the greatest had been obtained.

The places where the pressure of the gas in the coal have been the highest do not seem to give off the greatest quantities of gas, and there appears to be no connection whatever between the length of the hole and these quantities; but the results show that there is no connection between the variations of the barometrical column and the temperature, with the quantities of gas evolved, and it may be observed that the number of different circumstances acting together or in opposite directions, either separately or in groups, form a series of combinations which would take more time than the writer has at his disposal to reduce to a reliable standard of comparison. It is hoped, however, that this paper will have disclosed many facts that may be interesting, and which may pave the way to more elaborate research hereafter.

ISSUING FROM HOLES BORED IN THE SOLID COAL.

QUANTITIES OF GAS.

	Gas Space.		Surface of Gas Space.		Greatest observed amount of Gas given off.			Least observed amount of Gas given off.	
	Diameter.	Length.	In Square Inches.	In Sq. Feet.	Cubic Feet Per Hour.	Cub. Ft. ℔ Hr. ℔ sq. Ft. of Surface.	Before or after minimum pressure observed.	Cubic Feet Per Hour.	Cub. Ft. ℘ Hr. ℘ sq. Ft. of Surface.
	In.	Ft. In.							
...	2¼	2 6	216·03	1·500	...	...	...	...	...
...	2½	2 0	193·40	1·343	...	...	...	...	...
...	1½	2 0	114·86	·797	...	...	...	...	...
...	1¼	2 0	95·47	·663	...	...	...	...	...
...	2½	4 0	381·90	2·652	15·72	5·927	15 days before.	6·20	2·337
within No. 4	2½	6 0	570·39	3·961	...	...	...	...	...
do. of en- d par-	2½	6 0	570·39	3·961	...	...	...	...	...
...	2½	6 0	570·39	3·961	4·3	1·086	12 hours before.	2·8	·706
...	2½	6 0	570·39	3·961	6·1	1·540	24 hours before.	·2	·505
...	2½	6 0	570·39	3·961	...	...	...	...	...
...	3	5 4	610·25	4·237	1·2	·283	D. H. M. 6 8 40 before.	·87	·205
hin the No. 3	2½	1 10	177·69	1·234	·6	·486	10 12 20 after.	·45	·373
.. ...	3	3 6	402·91	2·798	·68	·243	5 7 45 after.	·41	·146
.. ...	3	3 2½	369·92	2·569	2·645	1·031	1 14 35 after.	1·462	·057
hole ...	2½	4 0	381·90	2·652	10·34	3·899	...	...	...
.. ...	3	3 0	346·36	2·405	1·09	·453	32 0 5 before.	·42	·174
.. ...	3	3 6	402·91	2·798	2·34	·836	38 23 30 before.	·81	·289
...	2½	5 4	507·56	3·524	5·02	1·424	55 22 55 before.	3·63	1·030

TABLE E SHOWING THE RESULTS OF ALL EXPERIMENTS MADE TO ASCERTAIN THE PRESSURE AND QUANTITY OF GAS ISSUING FROM HOLES BORED IN THE SOLID COAL.

PRESSURE OF GAS.																					QUANTITIES OF GAS.								
																					Gas Space.		Surface of Gas Space.		Greatest observed amount of Gas given off.			Least observed amount of Gas given off.	
No. of Experiment	Name of Colliery.	Name of Seam.	Years the Colliery has been opened out.	Nature of the Coal.	Nature of the Roof.	Nature of the Thill.	Distance from Workings above.	Distance from Workings below.	Distance from any other Pit Workings	Distance from Goaf.	Cover.	Pressure due to a Column of Water the height of the Cover.	Distance of Hole from Shaft.	Direction of Hole from Shaft.	Dip of Strata.	Angle of Cleat to Hole.	Length of Hole Bored.	Greatest pressure obtained.	Time after commencement of Experiment the greatest pressure was obtained.	Remarks.	Diameter.	Length.	In Square Inches.	In Sq. Feet.	Cubic Feet Per Hour.	Cub Ft. ⅌ Hr ⅌ sq. Ft. of Surface.	Before or after minimum pressure observed.	Cubic Feet Per Hour.	Cub. Ft. ⅌ Hr ⅌ sq. Ft. of Surface.
							Feet.	Feet.	Yards.	Yards.	Feet.	Lbs.	Yards.				Ft. In.	Lbs.	D. H. M.		In.	Ft. In.							
...	Elemore..	Low Main	54	Bituminous House Coal.	Grey Metal and Post Girdle, tender.	Strong Seggar Clay.	114	78	60	60	750	324	319	S.E.	E.	90°	7 0	28	0 11 35	... ...	2¼	2 6	216·03	1·500	..	...	...	...	...
...	Hetton	Hutton ...	58	„	Grey Metal and Post Girdles, fairly good.	Soft Seggar Clay.	Not worked.	Not worked.	...	100	1,228	531	3,530	E.	E.	Parallel	9 0	45	2 8 30	... ...	2½	2 0	193·40	1·343	...	...	...	...	...
1	Eppleton	Hutton ..	43	„	Blue and Grey Metal and Post Girdles, fairly good.	Soft Seggar Clay.	„	„	396	396	1,261	546	4,000	N.E.	E.	65°	3 6	54¾	1 14	... ...	1½	2 0	114·86	·797	...	...	...	...	...
2	„	..	„	„	„	„	„	„	„	„	„	„	3,970	„	„	„	7 6	104½	1 10 32	... ...	1¼	2 0	95·47	·663	...	...	...	...	...
3	„	„	„	„	„	„	„	„	„	„	„	„	„	„	„	„	24 6	204	4 10 0	... ...	2½	4 0	381·90	2·652	15·72	5·927	15 days before.	6·20	2·337
4	„	„	„	„	„	„	„	„	„	„	„	„	„	„	„	„	12 0	31	1 13 0	Supposed to be within the drainage of No. 4 cross-cut.	2½	6 0	570·39	3·961	...	...	...	...	...
5	„	„	„	„	„	„	„	„	„	„	„	„	„	„	„	„	25 6	125	12 0	Do. do. do. do. Hole penetrated roof entirely for 18in. and partially 18in.	2½	6 0	570·39	3·961	...	...	...	...	...
6	„	„	„	„	„	„	„	„	„	„	„	„	„	„	„	„	37 0	223	7 6 0	... ...	2½	6 0	570·39	3·961	4·3	1·086	12 hours before.	2·8	·706
7	„	„	„	„	„	„	„	„	„	„	„	„	3,971	„	„	„	47 0	235	16 5 0	... ...	2½	6 0	570·39	3·961	6·1	1·540	24 hours before.	·2	·505
8	„	„	„	„	„	„	„	„	„	„	„	„	„	„	„	„	25 0	221	2 3 0	... ...	2½	6 0	570·39	3·961	...	...	...	...	...
1	Boldon...	Bensham..	11	Bituminous House and Gas Coal.	Blue Metal. bad.	Grey Metal moderate.	„	„	„	352	1,268	549	2,200	N.W.	S.E.	90°	19 1	425	7 20 50	... ...	3	5 4	610·25	4·237	1·2	·283	D. H. M. 6 8 40 before.	·87	·205
2	„	„	..	„	„	„	„	„	„	„	„	„	„	„	„	„	7 8½	298	7 4 50	Supposed to be within the gas drainage of No. 3	2½	1 10	177·69	1·234	·6	·486	10 12 20 after.	·45	·373
3	„	„	..	„	„	„	„	„	„	„	„	„	„	„	„	„	32 0	461	2 21 47	Hole touched roof	3	3 6	402·91	2·798	·68	·243	5 7 45 after.	·41	·146
4	„	„	„	„	„	„	„	„	„	„	„	„	2,196	„	„	Parallel	23 5½	381	1 1 9	Hole touched roof	3	3· 2½	369·92	2·569	2·645	1·031	1 14 35 after.	1·462	·057
5	„	„	„	„	„	„	„	„	„	„	„	„	2,080	„	„	„	28 0	176	2 10 45	Plug in far end of hole ...	2½	4 0	381·90	2·652	10·34	3·899	...	...	...
1	Harton...	Bensham..	55	Bituminous House Coal.	Blue Metal, good.	Blue Metal.	„	„	440	594	1,215	526	3,000	S.E.	S.W.	90°	16 2	197	5 13 30	Hole touched roof	3	3 0	346·36	2·405	1·09	·453	32 0 5 before.	·42	·174
2	„	„	„	„	„	„	„	„	„	„	„	„	„	„	„	„	27 6	231	8 22 30	Hole touched roof	3	3 6	402·91	2·798	2·34	·836	38 23 30 before.	·81	·289
3	„	„	„	„	„	„	„	„	„	„	„	„	„	„	„	Parallel	37 3	295	3 12 0	... ...	2½	5 4	507·56	3·524	5·02	1·424	55 22 55 before.	3·63	1·030

TABLES SHOWING FULL PARTICULARS OF THE EXPERIMENTS MADE TO ASCERTAIN THE PRESSURE OF GAS IN THE SOLID COAL.

I.—THE HETTON EXPERIMENTS.

ELEMORE COLLIERY.

Time.	Lbs. Pressure.	Time.	Lbs. Pressure.	Time.	Lbs. Pressure.
1879.					
Aug. 28.		Aug. 29.		Sept. 1.	
A.M.		P.M.		P.M.	
9·25	6 [1]	6·0	27	4·0	24½
9·30	8	7·0	27	5·0	24½
9·35 [2]	...	8·0	27	6·0	24½
9·40	13	9·0	27	7·0	24½
9·55	15	10·0	27	8·0	24½
10·2	18	11·0	27	Sept. 2.	
10·10	21	12·0	26½	A.M.	
10·16	22	Aug. 30.		10·50	24 [3]
10·27	23	A.M.		11·0 [4]	...
10·45	24	1·0	26½	11·30	20
11·9	25	2·0	26½	P.M.	
12·0	25½	3·0	26½	4·0	23
P.M.		4·0	26½	11·0	23
1·0	26	5·0	26½	Sept. 3.	
2·0	27	6·0	26	8·0 A.M.	23
3·0	27½	7·0	26	4·0 P.M.	23
4·0	27½	8·0	26	12·0 „	23
5·0	27½	9·0	26	Sept. 4.	
6·0	27½	10·0	26	8·0 A.M.	23
7·0	27½	11·0	26	4·0 P.M.	23
8·0	27½	12·0	26	12·0 „	23
9·0	28	P.M.		Sept. 5.	
10·0	28	1·0	26	8·0 A.M.	23
11·0	28	2·0	26	4·0 P.M.	22½
12·0	28	3·0	25½	12·0 „	22½
Aug 29.		4·0	25½	Sept. 6.	
A.M.		5·0	25½	8·0 A.M.	22½
1·0	27½	6·0	25½	4·0 P.M.	22½
2·0	27½	7·0	25½	12·0 „	22½
3·0	27½	8·0	25½	Sept. 7.	
4·0	27½	9·0	25½	8·0 A.M.	22½
5·0	27½	10·0	25½	4·0 P.M.	22½
6·0	27½	11·0	25½	12·0 „	21½
7·0	27½	12·0	25½	Sept. 8.	
8·0	27½	Aug. 31.		8·0 A.M.	21
9·0	27½	A.M.		4·0 P.M.	21
10·0	27	1·0	25½	12·0 „	21
11·0	27	2·0	25	Sept. 9.	
12·0	27	P.M.		8·0 A.M.	21
P.M.		12·0	25	4·0 P.M.	20½
1·0	27	Sept. 1.		12·0 „	20
2·0	27	A.M.		Sept. 10.	
3·0	27	1·0	25	8·0 A.M.	19
4·0	27	2·0	25	4·0 P.M.	18½
5·0	27	3·0	24½	12·0 „	18½

[1] Put gauge on.

[2] Hole not quite tight; screwed India-rubber further up, and filled remainder of hole with cement.

[3] Took gauge off and allowed gas and water to rush out for 10 minutes.

[4] Gauge put on again.

ELEMORE COLLIERY.—*Continued.*

Time.	Lbs. Pressure.	Time.	Lbs. Pressure.	Time.	Lbs. Pressure.
Sept. 11.		Sept. 16.		Sept. 19.	
8·0 A.M.	18½	8·0 A.M.	16½	12·0 P.M.	13
4·0 P.M.	18½	4·0 P.M.	16½	Sept. 20.	
12·0 ,,	18	12·0 ,,	16	8·0 A.M.	13
Sept. 12.		Sept. 17.		4·0 P.M.	12½
8·0 A.M.	18	8·0 A.M.	16	Sept. 21.	
4·0 P.M.	18	12·0 P.M.	15½	8·0 A.M.	12
12·0 ,,	18½	Sept. 18.		12·0 P.M.	10
Sept. 14.		8·0 A.M.	16	Sept. 22.	
12·0 P.M.	16½	4·0 P.M.	15	8·0 A.M.	10½
Sept. 15.		12·0 ,,	15	12·0 P.M.	8¾
8·0 A.M.	16	Sept. 19.		Sept. 23.	
4·0 P.M.	16	8·0 A.M.	14½	1·0 P.M.	8¼ [5]
12·0 ,,	16½	4·0 P.M.	13½		

HETTON COLLIERY.

1879.					
Sept. 1.		Sept. 2.		Sept. 3.	
P.M.		P.M.		P.M.	
10·0 [6]	0	5·0	37	2·0	39½
10·5	8½	6·0	37	3·0	39½
11·0	29	7·0	37½	4·0	39½
12·0	33	8·0	35	5·0	40
Sept. 2.		9·0	37	6·0	40
A.M.		10·0	37½	7·0	40
1·0	40½	11·0	37¼	8·0	39½
1·30	40½	12·0	37	9·0	39½
2·0	40	Sept. 3.		10·0	40
3·0	40	A.M.		11·0	39½
4·0	40	1·0	36	12·0	39½
5·0	40	2·0	36½		
6·0	39½	3·0	37	Sept. 4.	
7·0	39½	4·0	37	A.M.	
8·0	39¼	5·0	37	1·0	39½
9·0	39	6·0	38	2·0	40
10·0	38½	7·0	38	3·0	40
11·0	38	8·0	38½	4·0	40
12·0	38	9·0	38½	5·0	30½
P.M.		10·0	38½	6·0	39½
1·0	37½	11·0	39	6·30	45
2·0	37½	12·0	39	7·0	40
3·0	37½	P.M.		Sept. 5.	
4·0	37½	1·0	39	...	40 [6A]

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[5] Gauge taken off and hole abandoned to allow work to be recommenced in the place.

[6] Gauge put on.

[6A] Gauge taken off and hole abandoned to allow work to be resumed in the place. Coal, tender.

EPPLETON COLLIERY.—NO. 1 HOLE.

Time.	Lbs. Pressure.	Time.	Lbs. Pressure.	Time.	Lbs. Pressure.
1879.					
Aug. 29.		Aug. 29.		Aug. 29.	
A.M.		A.M.		P.M.	
8·46 [7]	...	9·17	50	2·0	50½
8·58½	30	9·20	51		
9·1	35	9·24	52	Aug. 30.	
9·5	40	9·29	53	A.M.	
9·9	45	9·36	54	1·30	51¾ [8]
9·14	48	10·0	54¾		

EPPLETON COLLIERY.—NO. 2 HOLE.

1879.					
Sept. 1.		Sept. 1.		Sept. 3.	
A.M.		P.M.		A.M.	
9·50 [9]	...	10·0	80	3·0	90
9·56 [10]	...	11·0	81	4·0	91
10·3 [11]	...	12·0	91	5·0	90½
10·5	10	Sept. 2.		6·0	92
10·7	15	A.M.		7·0	91½
10·9	20	1·0	92	8·0	92
10·12	25 [12]	2·0	92	9·0	92½
10·14	30	3·0	91	10·0	92
10·17	35	4·0	90	11·0	92
10·22	40	5·0	91	12·0	92
10·34	45	6·0	90½	P.M.	
10·40	50	7·0	90½	1·0	91½
10·42	51	8·0	91½	2·0	92
10·44	52	11·0	93½	3·0	92
10·49	53	12·0	93½	4·0	91½
10·52	54	P.M.		5·0	92
10·57	55	1·0	93	6·0	91
11·0	56	2·0	93	7·0	90½
11·7	57	3·0	92	8·0	92
11·16	58	4·0	93½	9·0	91
11·27	59	5·0	92	10·0	92
11·38	60	6·0	92	11·0	91½
11·50	61¾	7·0	92½	12·0	93
11·55	62	8·0	92½	Sept. 4.	
12·0	62½	8·13	100	A.M.	
P.M.		8·22	104½	12·20	97
2·0	65	8·27	100	1·0	98
4·0	93½	10·0	95	2·0	93
5·0	92	11·0	93	3·0	92½
6·0	90	12·0	92	4·0	91
7·0	90	Sept. 3.		5·0	90½
7·55	85	A.M.		6·0	91
8·0	85	1·0	91	7·0	90½
9·0	80	2·0	90½	8·0	90 [13]

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[7] Gauge put on.

[8] Gauge taken off for a short time. Tried on again and registered 45 lbs. in 30 minutes. Hole then abandoned.

[9] Gauge put on.

[10] Opened tap; gauge registered 8½ lbs. Gauge not tight at screw; taken off, and made perfectly tight.

[11] Gauge replaced and tap opened.

[12] Hole not tight; screwed India-rubber further up and began to cement the hole.

[13] Continued at about 90 lbs. until 4·0 a.m., on September 5th, when the gauge was taken off and hole abandoned to allow work to be recommenced in the place.

EPPLETON COLLIERY.—NO. 3 HOLE.

Time.	Lbs. Pressure.	Time.	Lbs. Pressure.	Time.	Lbs. Pressure.
1879.					
Sept. 5.		Sept. 5.		Sept. 6.	
A.M.		P.M.		P.M.	
11·0 [13A]	...	12·17½	102	3·0	183
11·2	21	12·18½	103	4·0	184
11·4	25	12·20	104	5·0	185
11·7	30	12·21½	105	6·0	185½
11·9	35	12·23	106	7·0	185
11·12	40	12·24½	107	8·0	185
11·15½	45	12·26½	108	9·0	185
11·20	50	12·28	109	10·0	185
11·24	55	12·29½	110	11·0	185
11·28½	60	12·31½	111	12·0	185
11·30	61	12·33	112	Sept. 7.	
11·31	62	12·35	113	A.M.	
11·32	63	12·37	114	1·0	186
11·32½	64	12·39½	115	2·0	186
11·33½	65	12·42	116	3·0	187
11·34½	66	12·45	117	4·0	187
11·35½	67	12·48	118	5·0	188
11·36½	68	12·51	119	6·0	188
11·37½	69	12·54	120 [14]	7·0	188
11·38½	70	1·9	120	8·0	188
11·39½	71	1·11	121	9·0	188
11·41	72	1·16	123	9·5	189
11·42	73	1·22	125	10·0	189
11·43	74	2·0	141	11·0	189
11·44	75	3·0	151	12·0	189
11·45	76	4·0	157	P.M.	
11·46	77	5·0	161	1·0	189
11·47	78	6·0	165	2·0	189
11·48	79	7·0	165	3·0	189½
11·49	80	8·0	165	4·0	190 [17]
11·50½	81	9·0	165	5·0	191
11·52	82	10·0	165	6·0	191
11·53	83	11·0	165 [15]	7·0	190
11·54	84	12·0	165	8·0	191
11·55	85	Sept. 6.		9·0	191
11·56	86	A.M.		10·0	191
11·57	87	1·0	165	11·0	191
11·58½	88	2·0	165	12·0	191
12·0	89	2·15	171 [16]	Sept. 8.	
P.M.		3·0	175	A.M.	
12·1	90	4·0	179	1·0	192
12·2½	91	5·0	181	2·0	192
12·4	92	6·0	179	3·0	192
12·5	93	7·0	179	4·0	192
12·6½	94	8·0	181	5·0	192
12·8	95	9·0	181	6·0	192
12·9½	96	10·0	181	7·0	193
12·11	97	11·0	181	8·0	193
12·12	98	12·0	182	9·0	193
12·13	99	P.M.		10·0	193
12·14½	100	1·0	183	11·0	193
12·16	101	2·0	184	12·0	193

[13A] Gauge put on.

[14] This gauge was taken off and another registering 200 lbs. per square inch substituted.

[15] The face of gauge being broken, a piece of glass prevented the pointer from rising.

[16] This being removed, the gauge now registered correctly.

[17] Gauge taken off, and one registering 300 lbs. substituted.

EPPLETON COLLIERY.—NO. 3 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Thermometer.	Time.	Lbs. Pressure.	Barometer.	Thermometer.
Sept. 8.				Sept. 10.			
P.M.				P.M.			
1·0	193	...	...	7·0	203	30·77	71
2·0	194	...	...	8·0	202	30·77	71
3·0	194	...	...	9·0	202	30·77	71
4·0	194	...	...	10·0	202	30·78	71
5·0	194	...	...	11·0	202	30·78	71
6·0	195	...	...	12·0	202	30·78	71
7·0	194	...	...	Sept. 11.			
8·0	194	...	...	A.M.			
9·0	194	...	...	1·0	202	30·78	71
10·0	194	...	...	2·0	202	30·78	71
11·0	194	...	...	3·0	202	30·78	71
12·0	194	...	...	4·0	202	30·77	71
Sept. 9.				5·0	202	30·77	71
A.M.				6·0	202	30·77	71
1·0	193	...	...	7·0	200	30·70	71
2·0	193	...	...	8·0	200	30·65	71
3·0	193	...	...	9·0	200	30·60	71
4·0	193	...	...	10·0	200	30·60	71
4·25	184	...	...	11·0	200	30·65	71
5·0	184	...	...	12·0	200	30·65	70
6·0	184	30·12	72	P.M.			
7·0	184	30·12	72	1·0	200	30·65	71
8·0	184	30·12	72	2·0	200	30·64	71
9·0	184	30·12	71	3·0	201	30·63	71
10·0	184	30·12	71	4·0	201	30·63	71
11·0	184	30·10	72	5·0	201	30·62	71
12·0	190	30·10	...	6·0	201	30·62	71
P.M.				7·0	200	30·58	71
1·0	190	30·20	72	8·0	200	30·51	70
2·0	190	30·20	72	9·0	200	30 50	70
3·0	192	30·20	72	10·0	200	30·48	70
4·0	193	30·20	72	11·0	200	30·45	70
5·0	197	30·30	72	12·0	200	30·41	70
6·0	201	30·30	72	Sept. 12.			
7·0	203	30·40	72	A.M.			
8·0	203	30·40	72	1·0	200	30·38	72
9·0	204	30·45	72	2·0	200	30·37	72
10·0	204	30·50	72	3·0	200	30·30	71
11·0	204	30·50	72	4·0	200	30 30	72
12·0	203	30·55	71	5·0	200	30·30	72
Sept. 10.				6·0	199	30 30	72
A.M.				7·0	198	30·30	72
1·0	203	30·55	71	8·0	198	30·30	72
2·0	203	30·60	71	9·0	199	30·34	72
3·0	203	30·70	71	10·0	199	30·36	72
4·0	203	30·70	72	11·0	199	30·30	72
5·0	202	30·70	72	12·0	199	30·31	72
6·0	201	30·70	73	P.M.			
7·0	201	30·70	73	1·0	199	30·31	72
8·0	201	30·72	72	2·0	199	30·32	71
9·0	203	30·72	72	3·0	199	30·32	71
10·0	203	30·72	72	4·0	198	30·31	71
11·0	203	30·72	72	5·0	198	30·31	70
12·0	203	30·72	72	6·0	198	30·31	70
P.M.				7·0	198	30·31	70
1·0	203½	30·73	72	8·0	198	30·31	70
2·0	202	30·73	72	9·0	198	30·31	70
3·0	202	30·73	72	10·0	198	30·31	70
4·0	202½	30·74	71	11·0	198	30·34	70
5·0	202½	30·74	71	12·0	198	30·38	70
6·0	203	30·74	71				

EPPLETON COLLIERY.—NO. 3 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Thermometer.	Time.	Lbs. Pressure.	Barometer.	Thermometer.
Sept. 13.				Sept. 15.			
A.M.				A M.			
1·0	198	30·38	71	7·0	190	30·81	71
2·0	198	30·41	71	8·0	190	30·81	71
3·0	198	30·41	71	9·0	189	30·81	71
4·0	198	30·41	71	10·0	189	30·81	71
5·0	196	30·41	71	11·0	188	30·81	70
6·0	196	30·41	71	12·0	188	30·81	70
7·0	197	30·42	71	P.M.			
8·0	197	30·42	71	1·0	188	30·80	70
9·0	197	30·42	71	2·0	188	30·80	71
10 0	197	30·42	71	3·0	187	30·79	71
11·0	197	30·52	71	4·0	186	30·79	71
12·0	197	30·52	71	5·0	185	30·80	70
P.M.				6·0	185	30·80	70
1·0	197	30·52	71	7·0	185	30·82	70
2·0	197	30·52	71	8·0	185	30·84	70
3 0	197	30·54	71	9·0	185	30·85	70
4·0	195	30·54	71	10·0	185	30·85	70
5·0	194	30·55	71	11·0	185	30·85	70
6·0	193	30·55	71	12·0	186	30·85	70
7·0	194	30·58	70	Sept. 16.			
8·0	194	30·60	70	A.M.			
9 0	194	30·60	70	1·0	186	30·86	70
10·0	194	30·60	70	2·0	186	30·86	70
11·0	194	30·61	70	3 0	185	30·88	70
12·0	194	30·61	70	4·0	186	30·88	70
Sept. 14.				5·0	186	30·88	70
A.M.				6·0	185	30·88	71
1·0	193	30·62	70	7·0	185	30·88	71
2·0	193	30·62	70	8·0	185	30·88	71
3·0	193	30·64	70	9·0	185	30·88	71
4·0	192½	30·64	71	10·0	185	30·88	71
5·0	192½	30·64	72	11·0	185	30·90	70
6·0	192	30·65	72	12·0	185	30·90	71
7·0	192	30·66	71	P.M.			
8·0	192½	30·66	71	1·0	186	30·90	70
9·0	192½	30·66	71	2·0	186	30·90	71
10·0	192½	30·66	72	3·0	185	30·89	71
11·0	192	30·66	72	4·0	185	30·89	71
12·0	192	30·66	72	5·0	184	30·89	71
P.M.				6·0	184	30·89	71
1·0	192	30·67	72	7·0	184	30·89	70
2·0	192	30·67	72	8·0	183	30·90	70
3·0	192	30·67	72	9·0	183	30·90	70
4·0	192	30·68	72	10·0	183	30·90	70
5·0	190	30·68	72	11·0	183	30·90	70
6·0	190	30·68	71	12·0	183	30·90	70
7·0	190	30·74	70	Sept. 17.			
8·0	190	30·79	71	A.M.			
9·0	190	30·79	71	1·0	132	30·90	70
10·0	190	30·79	71	2·0	182	30·90	70
11·0	190	30·79	71	3·0	181	30·90	70
12·0	190	30·81	71	4·0	181	30·90	70
Sept. 15.				5·0	181	30·90	70
A.M.				6·0	181	30·88	71
1·0	190	30·81	71	7·0	181	30·88	71
2·0	190	30·81	71	8·0	180	30·88	71
3·0	190	30·81	71	9·0	180	30·88	71
4·0	190	30·81	71	10·0	180	30·88	71
5·0	190	30·81	71	11·0	180	30·86	71
6·0	190	30·81	71	12·0	180	30·86	71

EPPLETON COLLIERY.—NO. 3 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Thermometer.	Time.	Lbs. Pressure.	Barometer.	Thermometer.
Sept. 17.				Sept. 20.			
P.M.				A.M.			
1·0	177	30·88	71	1·0	168	30·97	70
2·0	177	30·88	71	2·0	167	30·96	70
3·0	177	30·87	71	3·0	167	30·95	70
4·0	180	30·85	70	4·0	167	30·93	70
5·0	181	30·85	70	5·0	168	30·91	70
6·0	180	30·85	70 [18]	6·0	169	30·88	70
Sept. 18.				7·0	168	30·88	70
P.M.				8·0	168	30·86	70
7·30	50	30·83	70	9·0	167	30·86	70
7·40	150	...	...	10·0	166	30·85	70
7·50	165	...	...	11·0	166	30·80	70
8·0	165	...	...	12·0	166	30·80	70
8·10	165	...	...	P.M.			
8·20	166	30·85	70	1·0	166	30·80	70
8·30	166	...	...	2·0	166	30·77	70
8·40	166	...	...	3·0	166	30·76	70
8·50	166	...	...	4·0	166	30·76	71
9·0	167	30·85	70	5·0	166	30·76	71
9·10	167	...	...	6·0	166	30·75	71
9·20	167	...	...	7·0	166	30·75	70
9·30	167	...	...	8·0	166	30·75	70
9·40	168	...	...	9·0	166	30·75	71
9·50	169	...	...	10·0	166	30·75	71
10·0	169	30·88	70	11·0	166	30·75	71
10·10	169	...	...	12·0	165	30·75	71
10·20	169	...	...	Sept. 21.			
10·30	170	...	...	A.M.			
10·40	170	...	...	1·0	165	30·74	71
10·50	170	...	...	2·0	165	30·74	71
11·0	170	30·88	70	3·0	165	30·74	70
11·10	170	...	...	4·0	165	30·74	70
12·0	170	30·89	71	5·0	165	30·74	70
Sept. 19.				6·0	165	30·76	70
A.M.				7·0	165	30·79	71
1·0	170	30·89	71	8·0	165	30·80	71
2·0	170	30·89	70	9·0	166	30·80	72
3·0	170	30·89	70	10·0	166	30·81	72
4·0	169	30·89	70	11·0	165	30·79	71
5·0	169	30·89	70	12·0	165	30·80	71
6·0	169	30·89	70	P.M.			
7·0	168	30·89	70	1·0	164	30·78	72
8·0	169	30·93	70	2·0	165	30·76	71
9·0	169	30·95	71	3·0	165	30·76	71
10·0	169	30·97	71	4·0	165	30·73	71
11·0	169	30·97	71	5·0	164	30·71	72
12·0	169	30·97	71	6·0	164	30·69	72
P.M.				7·0	164	30·66	72
1·0	169	30·99	71	8·0	164	30·65	72
2·0	169	30·99	71	9·0	162	30·64	72
3·0	169	30·99	71	10·0	162	30·63	72
4·0	169	31·00	71	11·0	160	30·62	72
5·0	169	31·00	71	12·0	158	30·61	72
6·0	169	31·00	71	Sept. 22.			
7·0	168	31·00	71	A.M.			
8·0	168	31·00	71	1·0	157	30·61	72
9·0	168	31·00	71	2·0	157	30·60	73
10·0	168	31·00	71	3·0	157	30·56	71
11·0	167	30·99	71	4·0	155	30·54	71
12·0	167	30·99	71	5·0	155	30·54	71

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[18] Gauge now taken off, and pipe allowed to remain open.

EPPLETON COLLIERY.—NO. 3 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Thermometer.	Time.	Lbs. Pressure.	Barometer.	Thermometer.
Sept. 22.				Sept. 24.			
A.M.				A.M.			
6·0	155	30·54	71	10·0	159	30·29	71
7·0	155	30·54	71	11·0	159	30·29	71
8·0	155	30·54	71	12·0	159	30·31	71
9·0	155	30·54	71	P.M.			
10·0	155	30·54	71	1·0	159	30·32	72
11·0	155	30·55	71	2·0	159	30·35	72
12·0	155	30·55	71	3·0	159	30·36	72
P.M.				4·0	159	30·37	72
1·0	155	30·57	71	5·0	159	30·39	71
2·0	155	30·58	71	6·0	159	30·42	71
3·0	155	30·59	70	7·0	159	30·48	71
4·0	155	30·60	70	8·0	159	30·50	71
5·0	155	30·60	71	9·0	158	30·58	72
6·0	154	30·60	71	10·0	158	30·55	72
7·0	154	30·60	72	11·0	158	30·58	72
8·0	155	30·60	73	12·0	158	30·58	71
9·0	156½	30·60	73	Sept. 25.			
10·0	158	30·58	72	A.M.			
11·0	161	30·54	71	1·0	158	30·60	71
12·0	162	30·50	71	2·0	158	30·60	71
Sept. 23.				3·0	158	30·60	71
A.M.				4·0	158	30·60	71
1·0	162	30·44	72	5·0	158	30·63	71
2·0	161½	30·33	72	6·0	158	30·67	71
3·0	160	30·20	71	7·0	158	30·69	71
4·0	160	30·16	71	8·0	158	30·70	71
5·0	160	30·10	71	9·0	158	30·72	71
6·0	160	30·08	71	10·0	158	30·74	71
7·0	160	30·08	71	11·0	157	30·72	71
8·0	160	30·07	71	12·0	157	30·74	71
9·0	160	30·08	71	P.M.			
10·0	160	30·08	71	1·0	157	30·75	71
11·0	160	30·11	71	2·0	157	30·77	71
12·0	160	30·13	71	3·0	157	30·79	71
P.M.				4·0	157	30·80	71
1·0	160	30·14	71	5·0	156	30·82	71
2·0	160	30·16	71	6·0	156	30·84	71
3·0	160	30·16	71	7·0	156	30·88	70
4·0	160	30·16	72	8·0	156	30·88	70
5·0	160	30·19	71	9·0	156	30·90	70
6·0	160	30·21	71	10·0	156	30·93	71
7·0	160	30·23	71	11·0	156	30·93	71
8·0	160	30·23	71	12·0	156	30·96	71
9·0	160	30·25	71	Sept. 26.			
10·0	160	30·27	71	A.M.			
11·0	160	30·29	71	1·0	156	30·96	71
12·0	160	30·29	71	2·0	156	30·96	71
Sept. 24.				3·0	156	30.96	71
A.M.				4·0	156	30·95	71
1·0	160	30·30	71	5·0	156	30·91	71
2·0	160	30·30	71	6·0	156	30·91	71
3·0	160	30·29	70	7·0	155	30·91	70
4·0	160	30·29	70	8·0	155	30·91	70
5·0	160	30·29	70	9·0	155	30·91	70
6·0	160	30·29	71	10·0 [19]	155	30·91	70
7·0	160	30·29	71	Oct. 1.			
8·0	160	30·29	71	A.M.			
9·0	160	30·29	71	10·0	152	...	...

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[19] No regular register kept after this time.

EPPLETON COLLIERY.—NO. 4 HOLE.

Time.	Lbs. Pressure.	Barometer.	Thermometer.
1879.			
Oct. 13.			
P.M.			
2·0 [20]	...	...	...
5·0	25	31·10	71
8·0	25	31·10	69
9·0	26	31·10	69
10·0	26	31·06	68
11·0	26	31·05	68
12·0	26	31·05	68
Oct. 14.			
A.M.			
1·0	27	31·03	68
2·0	27	31·03	68
3·0	27	31·02	69
4·0	27	31·00	70
5·0	27	30·96	70
6·0	27	30·94	70
7·0	27	30·92	70
8·0	27	30·93	70
9·0	28	30·93	70
10·0	28	30·94	70
11·0	28	30·94	70
12·0	27	30·92	70
P.M.			
1·0	27	30·92	70
2·0	30	30·93	70
3·0	30	30·93	70
4·0	30	30·94	70
5·0	30	30·95	70
6·0	30	30·96	70
7·0	30	31·02	69
8·0	30	31·02	69
9·0	30	31·02	69
10·0	30	31·02	69
11·0	30	31·02	69
12·0	30	31·03	69
Oct. 15.			
A.M.			
1·0	30	31·04	69
2·0	30	31·05	69
3·0	31	31·05	70
4·0	31	31·05	70
5·0	31	31·05	70
6·0	31	31·05	70
7·0	31	31·05	70
8·0	31	31·05	70
9·0	31	31·05	70
10·0	31	31·05	70
11·0	31	31·03	70
12·0	31	31·03	69
P.M.			
1·0	31	31·03	69
2·0	31	31·04	69
3·0	31	31·04	69
4·0	31	31·05	69
5·0	31	31·05	69
6·0	31	31·05	69
7·0	31	31·08	69
8·0	31	31·08	69
9·0	31	31·08	69
Oct. 15.			
P.M.			
10·0	31	31·08	69
11·0	31	31·08	69
12·0	31	31·08	69
Oct. 16.			
A.M.			
1·0	31	31·08	69
2·0	31	31·08	69
3·0	31	31·08	69
4·0	31	31·07	69
5·0	31	31·05	69
6·0	31	31·05	69
7·0	31	31·03	70
8·0	31	31·03	69
9·0	30	31·03	69
10·0	30	31·03	69
11·0	29	31·07	69
12·0	29	31·07	69
P.M.			
1·0	29	31·05	70
2·0	29	31·03	70
3·0	29	31·00	70
4·0	29	31·00	70
5·0	29	30·98	70
6·0	29	30·98	70
7·0	29	30·98	70
8·0	29	30·95	70
9·0	29	30·90	70
10·0	29	30·83	70
11·0	29	30·79	70
12·0	29	30·72	69
Oct. 17.			
A.M.			
1·0	29	30·66	69
2·0	29	30·60	69
3·0	29	30·57	69
4·0	29	30·55	69
5·0	29	30·52	69
6·0	29	30·49	69
7·0	29	30·49	69
8·0	29	30·47	69
9·0	29	30·46	69
10·0	29	30·44	69
11·0	29	30·44	69
12·0	29	30·43	69
P.M.			
1·0	29	30·43	69
2·0	29	30·50	69
3·0	29	30·55	69
4·0	29	30·55	69
5·0	29	30·55	69
6·0	29	30·58	69
7·0	29	30·61	69
8·0	29	30·61	69
9·0	29	30·61	69
10·0	29	30·65	69
11·0	29	30·67	69
12·0	29	30·67	69

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[20] Gauge put on.

EPPLETON COLLIERY.—NO. 4 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Thermometer.	Time.	Lbs. Pressure.	Barometer.	Thermometer.
Oct. 18.				Oct. 20.			
A.M.				A.M.			
1·0	29	30·67	69	6·0	29	29·88	70
2·0	29	30·67	69	7·0	29	29·88	70
3·0	29	30·69	69	8·0	29	29·88	70
4·0	29	30·69	69	9·0	29	29·88	70
5·0	29	30·70	69	10·0	29	29·91	70
6·0	29	30·70	69	11·0	29	29·94	70
7·0	29	30·72	69	12·0	29	29·98	69
8·0	29	30·74	69	P.M.			
9·0	29	30·77	69	1·0	29	30·01	69
10·0	29	30·77	69	2·0	29	30·05	69
11·0	29	30·77	70	3·0	29	30·08	69
12·0	29	30·77	70	4·0	29	30·11	69
P.M.				5·0	29	30·14	69
1·0	29	30·76	70	6·0	29	30·18	69
2·0	29	30·73	70	7·0	29	30·22	69
3·0	29	30·73	70	8·0	29	30·30	69
4·0	29	30·73	70	9·0	29	30·37	70
5·0	29	30·73	70	10·0	29	30·40	70
6·0	29	30·73	70	11·0	29	30·40	70
7·0	29	30·65	69	12·0	29	30·44	70
8·0	29	30·65	69	Oct. 21.			
9·0	29	30·60	69	A.M.			
10·0	29	30·56	69	1·0	29	30·46	70
11·0	28	30·51	69	2·0	29	30·46	70
12·0	28	30·50	69	3·0	28	30·50	70
Oct. 19.				4·0	28	30·50	69
A.M.				5·0	28	30·50	69
1·0	28	30·48	69	6·0	27	30·52	69
2·0	28	30·43	69	7·0	27	30·54	70
3·0	28	30·39	69	8·0	27	30·56	70
4·0	28	30·36	69	9·0	27	30·56	70
5·0	28	30·32	70	10·0	27	30·58	70
6·0	28	30·27	70	11·0	27	30·58	70
7·0	28	30·24	70	12·0	27	30·60	69
8·0	28	30·19	70	P.M.			
9·0	28	30·16	70	1·0	27	30·61	69
10·0	28	30·15	70	2·0	28	30·63	70
11·0	28	30·14	70	3·0	28	30·64	70
12·0	28	30·14	70	4·0	28	30·65	70
P.M.				5·0	28	30·68	70
1·0	28	30·13	70	6·0	28	30·67	70
2·0	28	30·13	70	7·0	28	30·70	70
3·0	28	30·13	70	8·0	28	30·70	70
4·0	29	30·12	70	9·0	28	30·71	70
5·0	29	30·11	70	10·0	28	30·71	70
6·0	29	30·09	70	11·0	28	30·71	70
7·0	29	30·10	70	12·0	29	30·71	70
8·0	29	30·05	70	Oct. 22.			
9·0	29	30·05	70	A.M.			
10·0	29	30·02	70	1·0	29	30·71	70
11·0	29	30·00	70	2·0	29	30·71	70
12·0	29	29·98	70	3·0	28	30·72	70
Oct. 20.				4·0	28	30·71	70
A.M.				5·0	28	30·68	70
1·0	29	29·95	70	6·0	28	30·68	70
2·0	29	29·95	70	7·0	28	30·67	70
3·0	29	29·90	70	8·0	28	30·65	70
4·0	29	29·88	70	9·0	28	30·61	70
5·0	29	29·88	70	10·0 [21]	28	30·61	70

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[21] Hole abandoned; expected to be within the gas drainage of No. 4 Crosscut.

EPPLETON COLLIERY.—NO. 5 HOLE.

Time.	Lbs. Pressure.	Barometer.	Thermometer.	Time.	Lbs. Pressure.	Barometer.	Thermometer.
1879.							
Oct. 14.				Oct. 16.			
A.M.				P.M.			
12·0 [21A]	...	...	...	3·0	116	31·00	70
P.M.				4·0	116	31·00	70
1·0	107	30·92	70	5·0	115	30·98	70
2·0	107	30·93	70	6·0	115	30·98	70
3·0	108	30·93	70	7·0	114	30·98	70
4·0	108	30·94	70	8·0	113	30·95	70
5·0	108	30·95	70	9·0	113	30·90	70
6·0	108	30·96	70	10·0	113	30·83	70
7·0	110	31·02	69	11·0	113	30·79	70
8·0	110	31·02	69	12·0	113	30·72	69
9·0	114	31·02	69	Oct. 17.			
10·0	119	31·02	69	A.M.			
11·0	123	31·02	69	1·0	113	30·66	69
12·0	125	31·03	69	2·0	113	30·60	69
Oct. 15.				3·0	113	30·57	69
A.M.				4·0	113	30·55	69
1·0	125	31·04	69	5·0	113	30·52	69
2·0	125	31·05	69	6·0	113	30·49	69
3·0	123	31·05	70	7·0	113	30·49	69
4·0	123	31·05	70	8·0	113	30·47	69
5·0	120	31·05	70	9·0	113	30·46	69
6·0	120	31·05	70	10·0	113	30·44	69
7·0	120	31·05	70	11·0	113	30·44	69
8·0	119	31·05	70	12·0	113	30·43	69
9·0	119	31·05	70	P.M.			
10·0	119	31·05	70	1·0	113	30·43	69
11·0	120	31·03	70	2·0	113	30·50	69
12·0	119	31·03	69	3·0	113	30·55	69
P.M.				4·0	112	30·55	69
1·0	119	31·03	69	5·0	112	30·55	69
2·0	118	31·04	69	6·0	112	30·58	69
3·0	118	31·04	69	7·0	111	30·61	69
4·0	118	31·05	69	8·0	111	30·61	69
5·0	117	31·05	69	9·0	111	30·61	69
6·0	117	31·05	69	10·0	111	30·65	69
7·0	116	31·08	69	11·0	111	30·67	69
8·0	116	31·08	69	12·0	111	30·67	69
9·0	116	31·08	69	Oct. 18.			
10·0	116	31·08	69	A.M.			
11·0	116	31·08	69	1·0	111	30·67	69
12·0	115	31·08	69	2·0	111	30·67	69
Oct. 16.				3·0	111	30·69	69
A.M.				4·0	111	30·69	69
1·0	115	31·08	69	5·0	111	30·70	69
2·0	115	31·08	69	6·0	111	30·70	69
3·0	116	31·07	69	7·0	111	30·72	69
4·0	116	31·07	69	8·0	111	30·74	69
5·0	116	31·05	69	9·0	111	30·77	69
6·0	116	31·05	69	10·0	111	30·77	69
7·0	116	31·03	69	11·0	112	30·77	70
8·0	116	31·03	69	12·0	111	30·77	70
9·0	115	31·03	69	P.M.			
10·0	115	31·03	69	1·0	111	30·76	70
11·0	119	31·07	69	2·0	111	30·73	70
12·0	119	31·07	69	3·0	111	30·73	70
P.M.				4·0	111	30·73	70
1·0	119	31·05	70	5·0	111	30·73	70
2·0	119	31·03	70	6·0	111	30·73	70

[21A] Gauge put on.

EPPLETON COLLIERY.—NO. 5 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Ther-mometer.	Time.	Lbs. Pressure.	Barometer.	Ther-mometer.
Oct. 18.				Oct. 20.			
P.m.				P.M.			
7·0	111	30·65	69	3·0	110	30·08	69
8·0	111	30·65	69	4·0	110	30·11	69
9·0	111	30·60	69	5·0	110	30·14	69
10·0	111	30·56	69	6·0	110	30·18	69
11 0	111	30·51	69	7·0	110	30·22	69
12·0	111	30·50	69	8 0	110	30·30	69
Oct. 19.				9·0	109	30·37	70
A.M.				10·0	109	30·40	70
1·0	111	30·48	69	11·0	108	30·40	70
2·0	111	30·43	69	12·0	108	30·44	70
3·0	111	30·39	69	Oct. 21.			
4·0	111	30·36	69	A.M.			
5·0	111	30·32	70	1·0	108	30·46	70
6·0	111	30·27	70	2·0	108	30·46	70
7·0	110	30·24	70	3·0	108	30·50	70
8·0	110	30·19	70	4·0	107	30·50	69
9·0	110	30·16	70	5·0	107	30·50	69
10·0	110	30·15	70	6·0	107	30·52	69
11 0	110	30·14	70	7·0	107	30·54	70
12·0	111	30·14	70	8·0	107	30·56	70
P.M.				9·0	107	30·56	70
1·0	111	30·13	70	10·0	107	30·58	70
2·0	111	30·13	70	11·0	107	30·58	70
3·0	111	30·13	70	12·0	107	30·60	69
4·0	111	30·12	70	P.M.			
5·0	111	30·11	70	1·0	107	30·61	69
6·0	111	30·09	70	2·0	108	30·63	70
7·0	110	30·10	70	3·0	108	30·64	70
8·0	110	30·05	70	4·0	108	30·65	70
9 0	110	30 05	70	5·0	108	30·68	70
10·0	110	30·02	70	6·0	108	30·67	70
11·0	110	30·00	70	7·0	106	30·70	70
12·0	110	29·98	70	8·0	106	30·70	70
Oct. 20.				9·0	105	30·71	70
A.M.				10·0	105	30·71	70
1·0	110	29·95	70	11·0	105	30·71	70
2·0	110	29·95	70	12·0	106	30·71	70
3·0	110	29·90	70	Oct. 22			
4·0	110	29·88	70	A.M.			
5·0	110	29·88	70	1·0	106	30·71	70
6·0	110	29·88	70	2·0	106	30·71	70
7·0	110	29·88	70	3·0	107	30·72	70
8·0	110	29·88	70	4·0	107	30·71	70
9·0	110	29·88	70	5·0	107	30·68	70
10·0	110	29·91	70	6·0	105	30·68	70
11·0	110	29·94	70	7·0	105	30·67	70
12·0	110	29·98	69	8·0	105	30·65	70
P.M.				9·0	103	30·61	70
1·0	110	30·01	69	10·0 [22]	102	30·61	70
2·0	110	30·05	69				

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[22] When the coal was taken off, and the extreme end of the hole exposed, it was found to have penetrated the roof to the extent of 3 feet; 18 inches of this roof penetration was half in stone and half in coal, and the remaining 18 inches was altogether stone.

EPPLETON COLLIERY.—NO. 6 HOLE.

Time.	Lbs. Pressure.	Barometer.	Thermometer.	Time.	Lbs. Pressure.	Barometer.	Thermometer.
1879.							
Oct. 14.				Oct. 16.			
P.M.				P.M.			
7·0	198	31·02	69	10·0	221	30·83	70
8·0	203	31·02	69	11·0	220	30·79	70
9·0	203	31·02	69	12·0	220	30·72	69
10·0	204	31·02	69	Oct. 17.			
11·0	204	31·02	69	A.M.			
12·0	204	31·02	69	1·0	220	30·66	69
Oct. 15.				2·0	220	30·60	69
A.M.				3·0	220	30·57	69
1·0	204	31·04	69	4·0	220	30·55	69
2·0	205	31·05	69	5·0	220	30·52	69
3·0	209	31·05	70	6·0	220	30·49	69
4·0	219	31·05	70	7·0	220	30·49	69
5·0	210	31·05	70	8·0	220	30·47	69
6·0	210	31·05	70	9·0	220	30·46	69
7·0	210	31·05	70	10·0	220	30·44	69
8·0	210	31·05	70	11·0	220	30·44	69
9·0	210	31·05	70	12·0	220	30·43	69
10·0	210	31·05	70	P.M.			
11·0	211	31·03	70	1·0	220	30·43	69
12·0	211	31·03	69	2·0	220	30·50	69
P.M.				3·0	220	30·55	69
1·0	212	31·03	69	4·0	219	30·55	69
2·0	212	31·04	69	5·0	219	30·55	69
3·0	212	31·04	69	6·0	219	30·58	69
4·0	213	31·05	69	7·0	218	30·61	69
5·0	213	31·05	69	8·0	218	30·61	69
6·0	213	31·05	69	9·0	218	30·61	69
7·0	213	31·08	69	10·0	218	30·65	69
8·0	213	31·08	69	11·0	218	30·67	69
9·0	213	31·08	69	12·0	218	30·67	69
10·0	211	31·08	69	Oct. 18.			
11·0	209	31·08	69	A.M.			
12·0	209	31·08	69	1·0	218	30·67	69
Oct. 16.				2·0	218	30·67	69
A.M.				3·0	220	30·69	69
1·0	209	31·08	69	4·0	220	30·69	69
2·0	209	31·08	69	5·0	220	30·70	69
3·0	210	31·07	69	6·0	220	33·70	69
4·0	210	31·07	69	7·0	220	30·72	69
5·0	210	31·05	69	8·0	220	30·74	69
6·0	210	31·05	69	9·0	220	30·77	69
7·0	210	31·03	70	10·0	220	30·77	69
8·0	213	31·03	69	11·0	220	33·77	70
9·0	215	31·03	69	12·0	220	30·77	70
10·0	214	31·03	69	P.M.			
11·0	219	31·07	69	1·0	220	30·76	70
12·0	219	31·07	69	2·0	220	30·73	70
P.M.				3·0	220	30·73	70
1·0	219	31·05	70	4·0	220	30·73	70
2·0	220	31·03	70	5·0	220	30·73	70
3·0	220	31·00	70	6·0	220	30·73	70
4·0	220	31·00	70	7·0	221	30·65	69
5·0	220	30·98	70	8·0	221	30·65	69
6·0	220	30·98	70	9·0	221	30·60	69
7·0	220	30·98	70	10·0	222	50·56	69
8·0	221	30·95	70	11·0	222	30·51	69
9·0	221	30·90	70	12·0	222	30·50	69

EPPLETON COLLIERY.—NO. 6 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Thermometer.
Oct. 19.			
A.M.			
1·0	222	30·48	69
2·0	222	30·43	69
3·0	222	30·39	69
4·0	222	30·36	69
5·0	222	30·32	70
6·0	222	30·27	70
7·0	222	30·24	70
8·0	222	30·19	70
9·0	222	30·16	70
10·0	221	30·15	70
11·0	221	30·14	70
12·0	221	30·14	70
P.M.			
1·0	221	30·13	70
2·0	221	30·13	70
3·0	221	30·13	70
4·0	222	30·12	70
5·0	222	30·11	70
6·0	222	30·09	70
7·0	220	30·10	70
8·0	220	30·05	70
9·0	220	30·05	70
10·0	220	30·02	70
11·0	220	30·00	70
12·0	220	29·98	70
Oct. 20.			
A.M.			
1·0	220	29·95	70
2·0	220	29·95	70
3·0	220	29·90	70
4·0	220	29·88	70
5·0	220	29·88	70
6·0	220	29·88	70
7·0	220	29·88	70
8·0	220	29·88	70
9·0	220	29·88	70
10·0	220	29·91	70
11·0	220	29·94	70
12·0	220	29·98	69
P.M.			
1·0	220	30·01	69
2·0	220	30·05	69
3·0	220	30·08	69
4·0	220	30·11	69
5·0	220	30·14	69
6·0	220	30·18	69
7·0	220	30·22	69
8·0	220	30·30	69
9·0	220	30·37	70
10·0	220	30·40	70
11·0	220	30·40	70
12·0	220	30·44	70
Oct. 21.			
A.M.			
1·0	220	30·46	70
2·0	220	30·46	70
3·0	220	30·50	70
4·0	220	30·50	69
5·0	220	30·50	69
Oct. 21.			
A.M.			
6·0	220	30·52	69
7·0	221	30·54	70
8·0	221	30·56	70
9·0	221	30·56	70
10·0	221	30·58	70
11·0	221	30·58	70
12·0	221	30·60	69
P.M.			
1·0	221	30·61	69
2·0	221	30·63	70
3·0	221	30·64	70
4·0	221	30·65	70
5·0	221	30·68	70
6·0	221	30·67	70
7·0	221	30·70	70
8·0	221	30·70	70
9·0	221	30·71	70
10·0	221	30·71	70
11·0	221	30·71	70
12·0	222	30·71	70
Oct. 22.			
A.M.			
1·0	223	30·71	70
2·0	223	30·71	70
3·0	223	30·72	70
4·0	223	30·71	70
5·0	223	30·68	70
6·0	223	30·68	70
7·0	223	30·67	70
8·0	223	30·65	70
9·0	223	30·61	70
10·0	223	30·61	70
11·0	223	30·61	70
12·0	223	30·60	69
P.M.			
1·0	223	30·60	71
2·0	220	30·60	71
3·0	220	30·60	70
4·0	220	33·60	69
5·0	221	30·62	70
6·0	221	30·65	70
7·0	223	30·66	70
8·0	223	30·66	70
9·0	223	30·66	70
10·0	223	30·70	70
11·0	223	30·70	70
12·0	223	30·73	70
Oct. 23.			
A.M.			
1·0	223	30·73	70
2·0	223	30·73	70
3·0	223	30·75	70
4·0	223	30·75	70
5·0	223	30·75	70
6·0	223	30·75	70
7·0	223	30·75	70
8·0	223	30·75	70
9·0[22A]	223	30·75	70

[22A] Gas meter attached to pipe.

EPPLETON COLLIERY.—NO. 6 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Thermometer.	Time.	Lbs. Pressure.	Barometer.	Thermometer
Oct. 27.				Oct. 29.			
P.M.				A.M.			
7·0[22B]	30	31·15	69	3·0	180	31·13	69
8·0	90	31·17	69	4·0	180	81·13	69
9·0	110	31·19	69	5·0	181	31·13	69
10·0	125	31·20	69	6·0	181	31·13	69
11·0	140	31·20	69	7·0	182	31·13	69
12·0	150	31·20	69	8·0	182	31·13	69
Oct. 28.				9·0	183	31·13	69
A.M.				10·0	184	31·13	69
1·0	156	31·19	69	11·0	184	31·13	69
2·0	158	31·19	69	12·0	184	31·13	69
3·0	157	31·19	69	P.M.			
4·0	158	31·19	69	1·0	185	31·13	69
5·0	161	31·19	69	2·0	185	31·13	69
6·0	161	31·19	69	3·0	186	31·13	69
7·0	163	31·19	69	4·0	186	31·13	69
8·0	163	31·19	69	5·0	186	31·17	69
9·0	164	31·19	69	6·0	186	31·21	69
10·0	164	31·19	69	7·0	186	31·22	69
11·0	166	31·18	69	8·0	186	31·24	69
12·0	168	31·17	69	9·0	186	31·27	69
P.M.				10·0	189	31·29	69
1·0	170	31·14	69	11·0	189	31·29	69
2·0	170	31·13	69	12·0	189	31·29	69
3·0	171	31·13	69				
4·0	171	31·11	69	Oct. 30.			
5·0	174	31·11	69	A.M.			
6·0	176	31·10	69	1·0	190	31·29	69
7·0	176	31·11	69	2·0	190	31·30	69
8·0	176	31·12	69	3·0	190	31·25	69
9·0	176	31·15	69	4·0	190	31·25	69
10·0	178	31·15	69	5·0	191	31·25	69
11·0	179	31·16	69	6·0	192	31·25	69
12·0	179	31·16	69	7·0	194	31·25	69
Oct. 29.				8·0	194	31·25	69
A.M.				9·0	195	31·25	69
1·0	179	31·14	69	10·0 [23]	195	31·25	69
2·0	179	31·13	69				

EPPLETON COLLIERY.—NO. 7 HOLE.

1879.							
Oct. 11.				Oct. 13.			
P.M.				P.M.			
6·0	...[24]	...	...	11·0	196	31·05	68
Oct. 12.				12·0	196	31·05	68
A.M.				Oct. 14.			
5·0	106	31·30	71	A.M.			
Oct. 13.				1·0	198	31·03	68
A.M.				2·0	198	31·03	68
5·0	182	31·28	71	3·0	198	31·02	69
P.M.				4·0	199	31·00	70
5·0	193	31·10	71	5·0	199	30·96	70
8·0	195	31·10	69	6·0	199	30·94	70
9·0	195	31·10	69	7·0	199	30·92	70
10·0	195	31·06	68	8·0	200	30·93	70

[22B] Meter again attached.

[23] Hole abandoned to allow work to be resumed in this place. This hole, when hewed off, was found to have entered 20 inches into roof stone. The last 2 feet of the hole rose rapidly towards the roof.

[24] Rose to 70 lbs. in 30 minutes.

EPPLETON COLLIERY.—NO. 7 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Thermometer.	Time.	Lbs. Pressure.	Barometer.	Thermometer.
Oct. 14.				Oct. 16.			
A.M.				P.M.			
9·0	200	30·93	70	1·0	219	31·05	70
10·0	200	30·94	70	2·0	219	31·03	70
11·0	200	30·94	70	3·0	219	31·00	70
12·0	200	30·92	70	4·0	219	31·00	70
P.M.				5·0	219	30·98	70
1·0	200	30·92	70	6·0	219	30·98	70
2·0	200	30·93	70	7·0	219	30·98	70
3·0	201	30·93	70	8·0	219	30·95	70
4·0	202	30·94	70	9·0	220	30·90	70
5·0	203	30·95	70	10·0	220	30·83	70
6·0	204	30·96	70	11·0	220	30·79	70
7·0	204	31·02	69	12·0	220	30·72	69
8·0	204	31·02	69	Oct. 17.			
9·0	204	31·02	69	A.M.			
10·0	204	31·02	69	1·0	220	30·66	69
11·0	204	31·02	69	2·0	220	30·60	69
12·0	205	31·03	69	3·0	220	30·57	69
				4·0	220	30·55	69
Oct. 15.				5·0	220	30·52	69
A.M.				6·0	220	30·49	69
1·0	205	31·04	69	7·0	220	30·49	69
2·0	205	31·05	69	8·0	220	30·47	69
3·0	205	31·05	70	9·0	220	30·46	69
4·0	205	31·05	70	10·0	220	30·44	69
5·0	205	31·05	70	11·0	220	30·44	69
6·0	204	31·05	70	12·0	220	30·43	69
7·0	204	31·05	70	P.M.			
8·0	204	31·05	70	1·0	220	30·43	69
9·0	205	31·05	70	2·0	220	30·50	69
10·0	205	31·05	70	3·0	220	30·55	69
11·0	205	31·03	70	4·0	219	30·55	69
12·0	205	31·03	69	5·0	218	30·55	69
P.M.				6·0	217	30·58	69
1·0	206	31·03	69	7·0	221	39·61	69
2·0	206	31·04	69	8·0	221	30·61	69
3·0	207	31·04	69	9·0	222	30·61	69
4·0	207	31·05	69	10·0	222	30·65	69
5·0	207	31·05	69	11·0	222	30·67	69
6·0	207	31·05	69	12·0	222	30·67	69
7·0	208	31·08	69	Oct. 18.			
8·0	208	31·03	69	A.M.			
9·0	208	31·08	69	1·0	223	30·67	69
10·0	209	31·08	69	2·0	223	30·67	69
11·0	209	31·08	69	3·0	223	30·69	69
12·0	209	31·08	69	4·0	223	30·69	69
				5·0	223	30·69	69
Oct. 16.				6·0	223	30·70	69
A.M.				7·0	223	30·72	69
1·0	210	31·08	69	8·0	223	33·74	69
2·0	210	31·08	69	9·0	223	30·77	69
3·0	209	31·07	69	10·0	223	30·77	69
4·0	209	31·07	69	11·0	223	30·77	70
5·0	209	31·05	69	12·0	223	30·77	70
6·0	210	31·05	69	P.M.			
7·0	210	31·03	70	1·0	223	30·76	70
8·0	215	31·03	69	2·0	223	30·73	70
9·0	217	31·03	69	3·0	223	30·73	70
10·0	218	31·03	69	4·0	224	30·73	70
11·0	219	31·07	69	5·0	225	30·73	70
12·0	219	31·07	69	6·0	226	30·73	70

EPPLETON COLLIERY.—NO. 7 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Thermometer.	Time.	Lbs. Pressure.	Barometer.	Thermometer.
Oct. 18.				Oct. 21.			
P.M.				A.M.			
7·0	226	30·65	69	1·0	230	30·46	70
8·0	226	30·65	69	2·0	230	30·46	70
9·0	226	30·60	69	3·0	230	30·50	70
10·0	226	30·56	69	4·0	230	30·50	69
11·0	227	30·51	69	5·0	230	30·50	69
12·0	227	30·50	69	6·0	230	30·52	69
Oct. 19.				7·0	230	30·54	70
A.M.				8·0	230	30·56	70
1·0	227	30·48	69	9·0	230	30·56	70
2·0	227	30·43	69	10·0	230	30·58	70
3·0	227	30·39	69	11·0	230	30·58	70
4·0	227	30·36	69	12·0	230	30·60	69
5·0	227	30·32	70	P.M.			
6·0	227	30·27	70	1·0	230	30·61	69
7·0	227	30·24	70	2·0	230	30·63	70
8·0	227	30·19	70	3·0	230	30·64	70
9·0	227	30·16	70	4·0	230	30·65	70
10·0	228	30·15	70	5·0	230	30·68	70
11·0	228	30·14	70	6·0	230	30·67	70
12·0	228	30·14	70	7·0	230	30·70	70
P.M.				8·0	230	30·70	70
1·0	228	30·13	70	9·0	230	30·71	70
2·0	228	30·13	70	10·0	230	30·71	70
3·0	228	30·13	70	11·0	230	30·71	70
4·0	229	30·12	70	12·0	230	30·71	70
5·0	229	30·11	70	Oct. 22.			
6·0	229	30·09	70	A.M.			
7·0	229	30·10	70	1·0	230	30·71	70
8·0	229	30·05	70	2·0	230	30·71	70
9·0	229	30·05	70	3·0	230	30·72	70
10·0	229	30·02	70	4·0	230	30·71	70
11·0	229	30·00	70	5·0	230	30·68	70
12·0	229	29·98	70	6·0	230	30·68	70
Oct. 20.				7·0	230	30·67	70
A.M.				8·0	230	30·65	70
1·0	229	29·95	70	9·0	230	30·61	70
2·0	229	29·95	70	10·0	230	30·61	70
3·0	229	29·90	70	11·0	230	30·61	70
4·0	229	29·88	70	12·0	230	30·60	70
5·0	229	29·88	70	P.M.			
6·0	229	29·88	70	1·0	230	30·60	70
7·0	229	22·88	70	2·0	231	30·60	70
8·0	229	29·88	70	3·0	231	30·60	70
9·0	229	29·88	70	4·0	231	30·60	69
10·0	229	29·91	70	5·0	231	30·62	70
11·0	229	29·94	70	6·0	231	30·65	70
12·0	229	29·98	69	7·0	231	30·66	70
P.M.				8·0	231	30·66	70
1·0	230	30·01	69	9·0	231	30·66	70
2·0	230	30·05	69	10·0	231	30·70	70
3·0	230	30·08	69	11·0	231	30·70	70
4·0	230	30·11	69	12·0	231	30·73	70
5·0	230	30·14	69	Oct. 23.			
6·0	230	30·18	69	A.M.			
7·0	230	30·22	69	1·0	231	30·73	70
8·0	230	30·30	69	2·0	231	30·73	70
9·0	230	30·37	70	3·0	231	30·75	70
10·0	230	30·40	70	4·0	231	30·75	70
11·0	230	30·40	70	5·0	231	30·75	70
12·0	230	30·44	70	6·0	231	30·75	70

EPPLETON COLLIERY.—NO. 7 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Thermometer.	Time.	Lbs. Pressure.	Barometer.	Thermometer.
Oct. 23.				Oct. 25.			
A.M.				P.M.			
7·0	231	30·75	70	1·0	233	30·56	69
8·0	231	30·75	70	2·0	233	30·57	69
9·0	231	30·75	70	3·0	233	30·57	69
10·0	231	30·75	70	4·0	233	30·58	69
11·0	231	30·78	69	5·0	233	30·60	69
12·0	231	30·79	69	6·0	233	30·63	68
P.M.				7·0	233	30·67	70
1·0	231	30·77	69	8·0	233	30·71	70
2·0	231	30·75	69	9·0	233	30·75	70
3·0	231	30·73	69	10·0	233	30·77	70
4·0	231	30·72	69	11·0	233	30·79	70
5·0	231	30·71	69	12·0	233	30·81	70
6·0	231	30·72	69	Oct. 26.			
7·0	231	30·70	69	A.M.			
8·0	231	30·70	69	1·0	233	30·85	70
9·0	231	30·69	68	2·0	233	30·88	70
10·0	231	30·66	68	3·0	233	30·90	70
11·0	231	30·66	68	4·0	233	30·90	69
12·0	231	30·66	70	5·0	233	30·90	69
Oct. 24.				6·0	233	30·93	68
A.M.				7·0	233	30·97	68
1·0	231	30·63	70	8·0	233	30·97	68
2·0	231	30·60	69	9·0	233	30·99	68
3·0	231	30·58	69	10·0	233	30·99	69
4·0	231	30·56	69	11·0	233	31·00	69
5·0	231	30·55	69	12·0	233	31·00	69
6·0	231	30·51	69	P.M.			
7·0	231	30·49	69	1·0	233	31·00	69
8·0	231	30·49	69	2·0	233	31·01	69
9·0	232	30·49	69	3·0	233	31·02	69
10·0	232	30·49	69	4·0	233	31·03	69
11·0	232	30·49	69	5·0	233	31·03	69
12·0	232	30·48	69	6·0	233	31·04	69
P.M.				7·0	233	31·04	69
1·0	232	30·47	69	8·0	233	31·07	69
2·0	232	30·47	69	9·0	233	31·09	69
3·0	232	30·46	69	10·0	233	31·11	69
4·0	232	30·47	69	11·0	233	31·11	69
5·0	232	30·48	69	12·0	233	31·11	69
6·0	232	30·48	69	Oct. 27.			
7·0	232	30·43	69	A.M.			
8·0	232	30·45	69	1·0	233	31·12	69
9·0	232	30·45	69	2·0	233	31·12	69
10·0	232	30·45	69	3·0	233	31·12	69
11·0	232	30·45	69	4·0	233	31·10	69
12·0	232	30·46	69	5·0	233	31·10	69
Oct. 25.				6·0	233	31·10	69
A.M.				7·0	233	31·10	69
1·0	232	30·47	69	8·0	233	31·12	69
2·0	232	30·47	69	9·0	233	31·13	69
3·0	232	30·47	69	10·0	233	31·13	69
4·0	232	30·47	69	11·0	233	31·14	69
5·0	233	30·47	69	12·0	233	31·14	69
6·0	233	30·47	69	P.M.			
7·0	233	30·47	69	1·0	233	31·12	69
8·0	233	30·47	69	2·0	233	31·12	69
9·0	233	30·49	69	3·0	233	31·13	69
10·0	233	30·49	69	4·0	233	31·12	69
11·0	233	30·52	69	5·0	233	31·13	69
12·0	233	30·54	69	6·0	233	31·13	69

EPPLETON COLLIERY.—NO. 7 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Thermometer.	Time.	Lbs. Pressure.	Barometer.	Thermometer.
Oct. 27.				Oct. 28.			
P.M.				P.M.			
7·0	234	31·15	69	2·0	233	31·13	69
8·0	234	31·17	69	3·0	233	31·13	69
9·0	234	31·19	69	4·0	233	31·11	69
10·0	234	31·20	69	5·0	233	31·11	69
11·0	235	31·20	69	6·0	233	31·10	69
12·0	235	31·20	69	7·0	233	31·11	69
Oct. 28.				8·0	233	31·12	69
A.M.				9·0	233	31·15	69
1·0	235	31·19	69	10·0	233	31·15	69
2·0	235	31·19	69	11·0	233	31·16	69
3·0	235	31·19	69	12·0	233	31·16	69
4·0	233	31·19	69				
5·0	233	31·19	69	Oct. 29.			
6·0	233	31·19	69	A.M.			
7·0	233	31·19	69	1·0	234	31·14	69
8·0	233	31·19	69	2·0	234	31·13	69
9·0	233	31·19	69	3·0	233	31·13	69
10·0	233	31·19	69	4·0	233	31·13	69
11·0	233	31·18	69	5·0	233	31·13	69
12·0	233	31·17	69	6·0	233	31·13	69
P.M.				7·0	233	31·13	69
1·0	233	31·14	69	8·0	233	31·13	69

EPPLETON COLLIERY.—NO. 8 HOLE.

1879.							
Oct. 22.				Oct. 23.			
P.M.				P.M.			
1·0	75	30·60	71	5·0	217	30·71	69
2·0	193	30·60	71	6·0	217	30·72	69
3·0	195	30·60	70	7·0	218	30·70	69
4·0	197	30·60	69	8·0	219	30·70	69
5·0	200	30·62	70	9·0	220	30·69	68
6·0	204	30·65	70	10·0	220	30·66	68
7·0	208	30·66	70	11·0	220	30·66	68
8·0	208	30·66	70	12·0	220	30·66	69
9·0	210	30·66	70	Oct. 24.			
10·0	210	30·70	70	A.M.			
11·0	211	30·70	70	1·0	220	30·63	70
12·0	211	30·73	70	2·0	220	30·60	70
Oct. 23.				3·0	219	30·58	69
A.M.				4·0	219	30·56	69
1·0	211	30·73	70	5·0	219	30·55	69
2·0	211	30·73	70	6·0	219	30·51	69
3·0	212	30·75	70	7·0	219	30·49	69
4·0	212	30·75	70	8·0	220	30·49	69
5·0	213	30·75	70	9·0	220	30·49	69
6·0	214	30·75	70	10·0	220	30·49	69
7·0	214	30·75	70	11·0	220	30·49	69
8·0	214	30·75	70	12·0	220	30·48	69
9·0	215	30·75	70	P.M.			
10·0	215	30·75	70	1·0	220	30·47	69
11·0	215	30·78	69	2·0	220	30·47	69
12·0	215	30·79	69	3·0	220	30·46	69
P.M.				4·0	221	30·47	69
1·0	215	30·77	69	5·0	221	30·48	69
2·0	217	30·75	69	6·0	221	30·48	69
3·0	217	30·73	69	7·0	220	30·48	69
4·0	217	30·72	69	8·0	220	30·45	69

EPPLETON COLLIERY.—NO. 8 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Ther-mometer.	Time.	Lbs. Pressure.	Barometer.	Ther-mometer.
Oct. 24.				Oct. 27.			
P.M.				A.M.			
9·0	220	30·45	69	1·0	218	31·12	69
10·0	220	30·45	69	2·0	218	31·12	69
11·0	220	30·45	69	3·0	218	31·12	69
12·0	220	30·46	69	4·0	218	31·10	69
				5·0	220	31·10	69
Oct. 25.				6·0	220	31·10	69
A.M.				7·0	220	31·10	69
1·0	220	30·47	69	8·0	220	31·12	69
2·0	220	30·47	69	9·0	220	31·13	69
3·0	220	30·47	69	10·0	220	31·13	69
4·0	220	30·47	69	11·0	219	31·14	69
5·0	220	30·47	69	12·0	216	31·14	69
6·0	220	30·47	69	P.M.			
7·0	220	30·47	69	1·0	216	31·12	69
8·0	220	30·47	69	2·0	212	31·12	69
9·0	220	30·49	69	3·0	212	31·13	69
10·0	220	30·49	69	4·0	211	31·12	69
11·0	220	30·52	69	5·0	211	31·13	69
12·0	221	30·54	69	6·0	210	31·13	69
P.M.				7·0	215	31·15	69
1·0	221	30·56	69	8·0	215	31·17	69
2·0	221	30·57	69	9·0	215	31·19	69
3·0	221	30·57	69	10·0	215	31·20	69
4·0	220	30·58	69	11·0	217	31·20	69
5·0	220	30·60	69	12·0	217	31·20	69
6·0	220	30·63	68	Oct. 28.			
7·0	220	30·67	70	A.M.			
8·0	220	30·71	70	1·0	217	31·19	69
9·0	220	30·75	70	2·0	217	31·19	69
10·0	220	30·77	70	3·0	217	31·19	69
11·0	220	30·79	70	4·0	220	31·19	69
12·0	220	30·81	70	5·0	220	31·19	69
				6·0	220	31·19	69
Oct. 26.				7·0	220	31·19	69
A.M.				8·0	220	31·19	69
1·0	220	30·85	70	9·0	220	31·19	69
2·0	220	30·88	70	10·0	220	31·19	69
3·0	220	30·90	70	11·0	210	31·18	69
4·0	220	30·90	69	12·0	208	31·17	69
5·0	220	30·90	69	P.M.			
6·0	220	30·93	68	1·0	208	31·14	69
7·0	220	30·97	68	2·0	208	31·13	69
8·0	220	30·97	68	3·0	210	31·13	69
9·0	220	30·99	68	4·0	210	31·11	69
10·0	220	30·99	69	5·0	215	31·11	69
11·0	220	31·00	69	6·0	215	31·10	69
12·0	220	31·00	69	7·0	217	31·11	69
P.M.				8·0	217	31·12	69
1·0	220	31·00	69	9·0	217	31·15	69
2·0	220	31·01	69	10·0	216	31·15	69
3·0	220	31·02	69	11·0	215	31·16	69
4·0	220	31·03	69	12·0	215	31·16	69
5·0	220	31·03	69	Oct. 29.			
6·0	220	31·04	69	A.M.			
7·0	220	31·04	69	1·0	215	31·14	69
8·0	220	31·07	69	2·0	215	31·13	69
9·0	218	31·09	69	3·0	215	31·13	69
10·0	217	31·11	69	4·0	215	31·13	69
11·0	218	31·11	69	5·0	214	31·13	69
12·0	218	31·11	69	6·0	210	31·13	69

EPPLETON COLLIERY.—NO. 8 HOLE.—*Continued.*

Time.	Lbs. Pressure.	Barometer.	Thermometer.	Time.	Lbs. Pressure.	Barometer.	Thermometer.
Oct. 29.				Oct. 29.			
A.M.				P.M.			
7·0	208	31·13	69	10·0	211	31·29	69
8·0	206	31·13	69	11·0	210	31·29	69
9·0	206	31·13	69	12·0	...	31·29	69
10·0	208	31·13	69				
11·0	209	31·13	69	Oct. 30.			
12·0	210	31·13	69	A.M.			
P.M.				1·0	100 [25]	31·29	69
1·0	212	31·13	69	2·0	160	31·30	69
2·0	212	31·13	69	3·0	164	31·25	69
3·0	212	31·13	69	4·0	170	31·25	69
4·0	213	31·13	69	5·0	185	31·25	69
5·0	213	31·17	69	6·0	200	31·25	69
6·0	214	31·21	69	7·0	204	31·25	69
7·0	214	31·22	69	8·0	208	31·25	69
8·0	214	31·24	69	9·0	208	31·25	69
9·0	214	31·27	69	10·0	208 [26]	31·25	69

[25] Went up to 100 lbs. in twenty minutes.

[26] Gauge taken off and pressure run down; meter attached, when the quantity of gas issuing from the hole was so small as not to turn the meter. This hole, when hewed off, was found to be 15 inches below the roof, and, therefore, wholly in the coal.

II.—THE BOLDON EXPERIMENTS.

BOLDON COLLIERY.—NOS. 1 AND 2 HOLES.

Time.	No. 1 Hole, 500 lb. Gauge.	No. 2 Hole, 300 lb. Gauge.
1880.		
May 14.		
P.M.		
1·40 [1]	0	0
2·20	25	70
2·50	40	112
3·00	46	128
3·30	58	155
4·00	72	180
4·30	88	198
5·00	100	210
5·30	110	218
6·00	125	226
6·30	140	234
7·00	157	238
7·30	177	243
8·00	187	246
8·30	192	249
9·00	202	252
9·30	216	256
10·00	228	258
10·30	235	261
11·00 [2]	246	263
11·30	260	266
12·00	278	268
May 15.		
A.M.		
12·30	297	270
1·00	314	272
1·30	322	275
2·00	328	276
2·30	329	279
3·00	330	281
3·30	331	283
4·00 [3]	329	284
4·30	329	283
5·00	330	282
5·30	332	282
6·00	335	282
6·30	341	282
7·00	344	282
7·30	348	282
8 00	349	282
8·30	349	282
9·00	349	282
9·30	350	282
10·00	351	282
10·30	352	282
11·00	353	282
May 15.		
A.M.		
11·30	354	282
12·00	354	282
P.M.		
12·30	355	282
1·00	356	282
1·30	356	282
2·00	357	280
2·30	359	280
3·00	360	280
3·30	360	278
4·00	361	273
4·30	362	268
5·00	363	265
5·30	364	262
6·00	365	260
6·30	366	260
7·00	367	258
7·30	368	258
8 00	369	259 [4]
8·30	370	...
9·00 [5]	373	...
9·30	375	...
10·00	377	...
10·30	378	...
11·00	377	...
11·30	378	...
12·00	379	...
May 16.		
A.M.		
12·30	380	...
1·00	380	...
1·30	380	...
2·00	381	...
2·30	383	...
3·00	383	...
3·30	383	...
4·00	383	...
4·30	383	...
5·00	383	...
5·30	383	...
6·00	382	...
6·30	382	...
7·00	382	...
7·30	382	...
8·00	381	...
8·30	382	...
9·00	382	...

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[1] Gauges put on.

[2] Commenced to bore No. 3 Hole.

[3] At 3·45 No. 1 gauge fell back 2 lbs. A small blower came off at No. 3 Hole.

[4] Ran off No. 2 gauge and attached gas meter.

[5] Ceased boring No. 3 Hole.

BOLDON COLLIERY.—NOS. 1, 2, (*continued*) 3, AND 4 HOLES.

Time.	No. 1 Hole, 500 lb. Gauge.	No. 2 Hole. 1,000 lb. Gauge.	No 3 Hole, 500 lb. Gauge.	No. 4 Hole, 400 lb. Gauge.
May 16.				
A.M.				
9·30	382	...	...	...
10·00	382	...	...	...
10·30	382	...	...	...
11·00	382	...	...	...
11·30	382	...	...	...
12·00	382	...	...	...
P.M.				
12·30	382	...	...	...
1·00	382	...	...	...
1·30	382	...	...	...
1·55	382[6]	...	...	...
2·13	...	..	0[7]	...
2·30	...	...	0	...
2·50	...	...	0	...
3·00	...	...	0	...
3·03	...	...	...	0[8]
3·45	...	0	8	0
4·00	...	15	12	0
4·15	...	37[9]	20[9]	0
4·30	...	50	24	8
4·45	...	67	30	26[10]
5·00	...	77	35	47
5·15	...	87	37	75
5·30	...	97	46[11]	110
5·45	...	103	50	120
6·00	...	108	58	120
6·15	...	113	67	120
6·30	...	118	80	120
6·45	...	121	92	121
7·00	...	125	105	170[12]
7·15	...	130	120	275
7·30	...	134	137	283
7·45	...	138	156	288
8·00	...	141	177	295
8·15	...	145	203[13]	300
8·30	...	148	224	305
8·45	...	152	238	310
9·00	...	155	241	315
9·15	...	157	241	320
9·30	...	159	239[14]	324
9·45	...	159	237	324
10·00	...	163	225	328
10·30	...	165	219	331
11·00	...	168	214	336
11·30	...	171	210[15]	340
12·00	...	175	218	342
May 17.				
A.M.				
12·30	...	179	222	346
1·00	...	182	221	350
1·30	..	183	221	352
2·00	...	184	221	354
2·30	...	185	218[16]	356
3·00	...	188	215	358
3·30	...	190	214	360
4·00	...	195	214	362
4·30	...	196	214	364
5·00	...	196	214	364
5·30	...	197	221	365
6·00	...	199	229	366
6·30	...	203	237	368
7·00	...	205	237	370
7·30	...	205	238	370
8·00	...	205	238	370
8·30	...	205	238	370
9·00	...	206	238	371
9·30	...	207	238[17]	372
10·00	...	209	236	373
10·30	...	211	236	374
11·00	...	212	237[18]	374
11·30	...	213	222	375
12·00	...	214	216	375
P.M.				
12·30	...	215	215	376
1·09	...	217	213	377
1·30	...	217	214	377
2·00	...	217	213	377
2·30	...	217	210	378
3·00	...	217	210	379
3·30	...	217	...[19]	380
4·00	...	219	...	380
4·10	500 lb. gauge put on.	...	00[20]	...
4·12	..	...	...	381[21]
4·30	20	219	0	0
4·45	30	220	0	45[22]
5·00	37	220	25	88
5·15	45	220	34	132
5·30	54	220	45	160
5·45	60	220	50	190
6·00	67	220	58	220
6·15	77	221	65	245
6·30	84	222	75	260
6·45	93	222	85	277
7·00	100	222	94	288

[6] Took gauge off No. 1 Hole and attached meter.

[7] At 2·13 put 500 lb. gauge on No. 3 Hole.

[8] Put gauge on No 4 Hole.

[9] Nos. 2 and 3 gauges rising rapidly.

[10] No. 4 gauge rising rapidly.

[11] Found a leakage in cement in No. 3.

[12] At 6·50 No. 4 gauge begun to rise very rapidly.

[13] No. 3 gauge rising very rapidly.

[14] A leakage at pipe end of No. 3 Hole.

[15] At 11·40 leakage took up and gauge begun to rise.

[16] No. 3 Hole began to leak again.

[17] No. 3 fell back 2 lbs. from 9½ to 10.

[18] 11 to 11½ No. 3 fell back from 237 to 222, leakage in fittings at pipe end.

[19] Commenced to take the 500 lb. gauge off No. 3 Hole.

[20] 1,000 lb. gauge put on to No. 3 Hole and started.

[21] Commenced to take 400 lb. gauge off No. 4 Hole.

[22] Put 1,000 lb. gauge on No. 4 Hole.

BOLDON COLLIERY.—NOS. 1, 2, 3, AND 4 HOLES.—*Continued.*

Time.	No. 1 Hole, 500 lb. Gauge.	No. 2 Hole, 1,000 lb. Gauge.	No. 3 Hole, 1,000 lb. Gauge.	No. 4 Hole. 1,000 lb. Gauge.
P.M.				
7·30	112	222	120	302
8·00	125	222	154	315
8·30	140	223	192	321
9·00	152	223	240[23]	326
9·30	164	224	296	329
10·00	172	224	346[24]	332
10·30	184	224	380	334
11·00	195	225	400	336
11·30	210	225	410	338
12·00	216	225	412	339
May 18.				
A.M.				
12·30	226	225	417	340
1·00	233	225	420	343
1·30	242	225	424	344
2·00	250	226	428	344
2·30	259	227	430	345
3·00	268	228	434	345
3·30	274	229	435	346
4·00	282	230	437	347
4·30	288	230	439	347
5·00	293	230	442	348
5·30	297	230	442	349
6·00	302	231	443	349
6·30	308	232	443	349
7·00	312	232	444	350
7·30	318	232	444	350
8·00	322	232	444	350
8·30	327	232	445	350
9·00	330	232	445	350
9·30	336	233	447	350
10·00	340	234	448	350
10·30	343	234	448	350
11·00	343	234	448	352
11·30	348	236	450	352
12·00	351	237	450	352
P.M.				
12·30	353	238	450	353
1·00	355	238	450	353
1·30	356	240	450	353
2·00	359	240	450	353
2·30	359	241	450	353
3·00	360	242	451	353
3·30	364	243	453	354
4·00	364	243	453	355
4·30	365	243	453	355
5·00	366	243	453	355
5·30	368	242	453	355
6·00	370	242	454	354
6·30	371	242	453	354
7·00	372	242	452	354
7·30	373	242	452	354
8·00	377	242	452	354
8·30	378	242	453	354
9·00	378	242	453	354
May 18.				
P.M.				
9·30	383	242	453	354
10·00	384	244	453	354
10·30	385	246	453	354
11·00	387	247	453	354
11·30	388	248	453	355
12·00	389	250	454	354
May 19.				
A.M.				
12·30	390	250	455	352
1·00	391	252	455	352
1·30	392	252	456	352
2·00	392	254	457	352
2·30	393	255	457	352
3·00	394	256	457	353
3·30	395	257	457	353
4·00	396	257	457	353
4·30	395	257	457	353
5·00	397	258	458	352
5·30	398	260	458	352
6·00	399	260	458	350
6·30	399	261	458	348
7·00	399	262	458	347
7·30	400	262	458	345
8·00	400	263	459	345
8·30	400	263	460	345
9·00	401	264	460	345
9·30	402	265	460	344
10·00	403	266	460	342
10·30	404	266	460	344
11·00	405	266	460	339
		Run off.		
11·30	Royal Comm'sers. inspected boreholes.			
12·00	406	32	461	332
P.M.				
12·30	406	63	461	335
1·00	407	103	461	340
1·30	407	120	461	343
2·00	407	140	461	344
2·30	408	156	460[25]	345
3·00	409	168	441	345
3·30	410	179	440	347
4·00	410	189	440	347
4·30	410	197	439	348
5·00	410	205	438	348
5·30	410	209	439	348
6·00	410	214	440	348
6·30	411	218	438	348
7·00	411	222	437	348
7·30	411	225	437	348
8·00	411	229	437	348
8·30	412	231	436	348
9·00	412	239	435[26]	348
9·30	413	237	423	348
10·00	414	239	420	351

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[23] From 9 to 9·30 No. 3 rose 56 lbs. and was still going up.

[24] From 10 to 10½ No. 3 rose 34 lbs.

[25] At 2·40 No. 3 began to leak. Began to leak at the joint below tap.

[26] From 9 to 9·30 No. 3 fell back 12 lbs. through a leakage at the joint.

BOLDON COLLIERY.—NOS. 1, 2, 3, AND 4 HOLES.—*Continued.*

Time.	No. 1 Hole, 500 lb. Gauge.	No. 2 Hole, 1,000 lb. Gauge.	No. 3 Hole, 1,000 lb. Gauge.	No. 4 Hole, 1,000 lb. Gauge.	Time.	No. 1 Hole, 500 lb. Gauge.	No. 2 Hole, 1,000 lb. Gauge.	No. 3 Hole, 1,000 lb. Gauge.	No. 4 Hole, 1,000 lb. Gauge.
May 19.					May 21.				
P.M.					A.M.				
10·30	414	241	418	352	12·30	421	288	311	348
11·00	414	243	415	352	1·00	421	289	309	348
11·30	414	245	408	352	1·30	421	289	308	348
12·00	415	247	400	352	2 00	221	289	308	348
May 20.					2·30	421	289	309	348
A.M.					3·00	421	289	309	349
12·30	416	248	400	352	3·30	421	289	312	349
1·00	415	250	400	353	4·00	421	290	315	350
1·30	415	251	395	353	4·30	421	291	315	350
2·00	415	252	390	353	5·00	421	291	315	350
2·30	415	254	385	353	5·30	422	292	317	350
3·00	415	256	380	353	6·00	422	292	318	351
3·30	415	257	372	353	6·30	422	292	320	351
4·00	415	258	372	353	7·00	422	292	319	352
4·30	416	259	372	353	7·30	422	293	319	352
5·00	417	260	370	353	8·00	422	293	320	352
5·30	418	261	365	353	8·30	422	293	322	352
6·00	418	262	362	353	9·00	422	294	322	350
6·30	418	263	356	353	9·30	422	294	326	350
7·00	418	264	350	353	10·00	423	294	322	350
7·30	418	265	253	353	10·30	423	295	334	350
8·00	418	266	242	353	11·00	423	295	334	350
8·30	418	267	242	353	11·30	423	296	338	350
9·00	418	267	340	353	12·00	423	296	338	350
9·30	418	267	335	353	P.M.				
10·00	418	269	330	353	12·30	423	297	340	350
10·30	418	270	322	353	1·00	423	297	340	348
11·00	419	271	315	353	1·30	424	297	340	348
11·30	419	272	304	353	2·00	424	297	340	348
12·00	415	273	298	353	2·30	424	297	340	348
P.M.					3·00	424	297	340	348
12·30	419	274	294	353	3·30	424	298	338	348
1·00	420	275	290	353	4·00	424	298	338	348
1·30	420	276	285	353	4·30	424	298	338	348
2·00	420	276	284	353	5·00	424	298	338	348
2·30	420	277	280	353	5·30	424	298	339	348
3·00	420	277	298[27]	353	6·00	424	298	339	348
3·30	420	279	294	353	6·30	424	299	339	348
4·00	420	280	299	353	7·00	424	299	339	348
4·30	420	280	290	351	7·30	424	299	337	348
5·00	420	280	292	350	8·00	424	299	337	348
5·30	420	281	298	350	8·30	424	299	337	348
6·00	421	282	298	348	9·00	424	299	337	348
6·30	421	282	299	348	9·30	424	299	337	348
7·00	421	283	300	348	10·00	424	297	337	348
7·30	421	284	305	346	10·30	424	296	337	348
8·00	421	284	307[28]	346	11·00	424	295	337	348
8·30	421	285	309	345	11·30	424	295	337	348
9·00	421	285	311	344	12·00	424	295	337	348
9·30	421	286	310	344	May 22.				
10·00	421	287	305	345	A.M.				
10·30	421	287	305	345	12·30	424	295	337	348
11·00	421	287	312	344	1·00	424	295	337	348
11·30	421	287	318	348	1·30	424	296	337	348
12·00	421	288	316[29]	348	2·00	424	296	337	348

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[27] No. 3 continued to fall until 2·30 p.m., when it began to go up.
[28] 100 drops of water per minute dropping from fittings of No. 3.
[29] No. 3 readings very unsteady, and the hole still leaking.

BOLDON COLLIERY.—NOS. 1, 2, 3, AND 4 HOLES.—*Continued.*

Time.	No. 1 Hole, 500 lb. Gauge.	No. 2 Hole, 1,000 lb. Gauge.	No. 3 Hole, 1,000 lb. Gauge.	No. 4 Hole, 1,000 lb. Gauge.	Time.	No. 1 Hole, 500 lb. Gauge.	No. 2 Hole, 1,000 lb. Gauge.	No. 3 Hole, 1,000 lb. Gauge.	No. 4 Hole, 1,000 lb. Gauge.
May 22.					May 22.				
A.M.					P.M.				
2·30	424	296	337	348	1·30	425	297	340	348
3·00	424	296	339	348	2·00	425	297	360	348
3·30	424	296	341	348	2·30	425	297	353	348
4·00	424	296	344	348	3·00	425	297	358	344
4·30	424	296	345	348	3·30	425	297	364	344
5·00	424	296	344	348	4·00	425	297	365	344
5·30	424	296	343	348	4·30	425	297	372	340
6·00	424	296	342	348	5·00	425	297	377	340
6·30	424	296	340	348	5·30	425	297	380	340
7·00	424	296	340	348	6·00	425	297	380	340
7·30	424	296	342	348	6·30	425	297	383	340
8·00	424	296	343	348	7·00	425	297	383	340
8·30	424	296	344	348	7·30	425	297	383	340[31]
9·00	424	296	345	348	May 23.				
9·30	424	297	344	348	A.M.				
10·00	424	297	344	348	5·45	425	297	383	340
10·30	425	297	340	348	May 24.				
11·00	425	297	318[30]	348	A.M.				
11·30	425	297	300	348	4·30	425	297	353	340
12·00	425	297	295	348	May 25.				
P.M.					A.M.				
12·30	425	297	310	248	5·00	425	298	335	340[32]
1·00	425	297	324	348					

BOLDON COLLIERY.—NO. 5 HOLE.

Time.	No. 5 Hole.	Time.	No. 5 Hole.	Time.	No. 5 Hole.
1880.					
June 15.					
A.M.					
4·15	0[32A]	8·15	138	1·45	159
4·20	53	8·30	140	2·00	159
4·25	93	8·45	140	2·15	159
4·30	115	9·00	141	2·30	160
4·35	123	9·15	144	2·45	161
4·40	130	9·30	148	3·00	161
4·45	133	9·45	149	3·15	162
4·50	134	10·00	149	3·30	162
4·55	135	10·15	149	3·45	162
5·00	135	10·30	150	4·00	162
5·15	134[33]	10·45	150	4·15	162
5·20	130	11·00	151	4·30	155[34]
5·30	131	11·15	151	4·45	157
5·45	131	11·30	151	5·00	158
6·00	132	11·45.	152	5·15	158
6·15	132	12·00	152	5·30	159
6·30	132	P.M.		5·45	159
6·45	133	12·15	153	6·00	159
7·00	133	12·30	153	6·15	160
7·15	134	12·45	154	6·30	160
7·30	134	1·00	156	6·45	160
7·45	135	1·15	157	7·00	160
8·00	137	1·30	158	7·15	160

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[30] At 10·40 the pressure on No. 3 begun to go back, the leakage increasing.

[31] No half hourly readings taken after this.

[32] Ran all the gauges off.

[32A] Put on gauge.

[33] Joint leaking 40 drops per m. Whilst making tight, the gauge fell from 134 to 130 lbs.

[34] 500 lb. gauge put on.

BOLDON COLLIERY.—NO. 5 HOLE.—*Continued.*

Time.	No. 5 Hole.	Time.	No. 5 Hole.	Time.	No. 5 Hole.
June 15.		June 16.		June 16.	
P.M.		A.M.		P.M.	
7·30	160	3·30	168	12·15	172
7·45	161	3·45	168	12·30	172
8·00	161	4·00	169	12·45	172
8·15	162	4·15	169	1·00	172
8·30	162	4·30	169	1·15	172
8·45	162	4·45	169	1·30	172
9·00	163	5·00	169	1·45	172
9·15	163	5·15	169	2·00	172
9·30	163	5·30	169	2·15	172
9·45	163	5·45	169	2·30	172
10·00	164	6·00	169	2·45	172
10·15	164	6·15	169	3·00	172
10·30	164	6·30	169	10·45	172
10·45	164	6·45	170		
11·00	164	7·00	170	June 17.	
11·15	165	7·15	170	A.M.	
11·30	165	7·30	171	2·00	173
11·45	165	7·45	171	4·30	174
12·00	164	8·00	171	7·00	175
		8·15	171	11·00	174
June 16.		8·30	171		
A.M.		8·45	171	P.M.	
12·15	164	9·00	171	1·15	175
12·30	165	9·15	171	3·00	176
12·45	166	9·30	171	5·45	175
1·00	166	9·45	171	10·45	174
1·15	166	10·00	171		
1·30	166	10·15	171	June 18.	
1·45	166	10·30	171	A.M.	
2·00	166	10·45	171	12·30	175
2·15	166	11·00	171	5·15	175[35]
2·30	166	11·15	171		
2·45	167	11·30	172	July 2.	
3·00	167	11·45	172	A.M.	
3·15	168	12·00	172	9·00	175[36]

THE HARTON EXPERIMENTS.

HARTON COLLIERY.—NOS. 1, 2, AND 3 HOLES.

Time.	No. 1 Hole.	No. 2 Hole.	No. 3 Hole.	Time.	No. 1 Hole.	No. 2 Hole.	No. 3 Hole.
1880.							
June 6.				June 6.			
A.M.				A.M.			
3·30	0	0	...[1]	4·25	37	15	...
3·35	10	0	...	4·30	38	18	...
3·40	13	0	...	4·35	40	22	...
3·45	20	0	...	4·40	41	25	...
3·50	22	0	...	4·45	41	30	...
3·55	25	0	...	4·50	43	35	...
4·00	27	0	...	4·55	45	38	...
4·05	28	0	...	5·00	47	40	...
4·10	30	0	...	5·05	50	42	...
4·15	32	0	...	5·10	52	44	...
4·20	35	10	...	5·15	52	50	...

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[35] Continued at this pressure until July 2. [36] Experiment discontinued. [1] Gauges put on.

HARTON COLLIERY.—NOS. 1, 2, AND 3 HOLES.—*Continued.*

Time.	No. 1 Hole.	No. 2 Hole.	No. 3 Hole.	Time.	No. 1 Hole	No. 2 Hole.	No. 3 Hole.
June 6.				June 6.			
A.M.				A.M.			
5·20	52	54	...	10·20	120	184	...
5·25	52	57	...	10·25	120	184	...
5·30	52	60	...	10·30	120	187	...
5·35	55	62	...	10·35	120	190	...
5·40	57	65	...	10·40	120	190	
5·45	58	70	...	10·45	121	190	...
5·50	60	75	...	10·50	122	190	...
5·55	60	80	...	10·55	122	192	...
6·00	60	83	...	11·00	125	195	...
6·05	61	87	...	11·05	125	196	...
6·10	61	90	...	11·10	127	196	...
6·15	62	94	...	11·15	128	196	...
6·20	64	100	...	11·20	128	196	...
6·25	65	100	...	11·25	129	196	...
6·30	68	100	...	11·30	130	197	...
6·35	70	103	...	11·40	132	197	...
6·40	72	110	...	11·50	132	197	...
6·45	73	115	...	12·00	135	198	...
6·50	75	118	...	P.M.			...
6·55	77	120	...	12·10	136	198	...
7·00	79	122	...	12·20	138	198	...
7·05	80	127	...	12·30	139	198	...
7·10	80	130	...	12·40	140	199	...
7·15	82	135	...	12·50	141	199	...
7·20	84	139	...	1·00	143	199	...
7·25	85	140	...	1·10	144	199	...
7·30	86	142	...	1·20	145	199	...
7·35	88	146	...	1·30	146	199	...
7·40	90	150	...	1·40	147	199	...
7·45	92	155	...	1·50	147	199	...
7·50	92	157	...	2·00	148	199	...
7·55	93	158	...	2·10	149	200	...
8·00	95	159	...	2·20	150	200	...
8·05	96	160	...	2·30	150	200	...
8·10	97	160	...	2·40	152	201	...
8·15	99	160	..	2·50	153	201	...
8·20	100	160	...	3·00	153	201	...
8·25	100	161	...	3·10	154	201	...
8·30	100	162	...	3·20	155	201	...
8·35	100	162	...	3·30	155	201	...
8·40	102	170	...	3·40	156	201	...
8·45	102	170	...	3·50	157	202	...
8·50	102	175	...	4·00	157	202	...
8·55	104	175	...	4·10	157	203	...
9·00	105	177	...	4·20	158	203	...
9·05	106	177	...	4·30	159	203	...
9·10	107	177	...	4·40	169	203	...
9·15	108	179	...	4·50	160	203	...
9·20	109	180	...	5·00	160	203	...
9·25	110	180	...	5·10	160	203	...
9·30	110	180	...	5·20	161	204	...
9·35	110	180	...	5·30	162	204	...
9·40	111	180	...	5·40	163	205	...
9·45	112	180	...	5·50	163	205	...
9·50	112	180	...	6·00	163	205	...
9·55	112	180	...	6·10	163	205	...
10·00	113	180	...	6·20	164	205	...
10·05	115	180	...	6·30	165	206	...
10·10	117	182	...	6·35	165	206	...
10·15	118	184	...	6·40	165	206	...

HARTON COLLIERY.—NOS. 1, 2, AND 3 HOLES.—*Continued.*

Time.	No. 1 Hole.	No. 2 Hole.	No. 3 Hole	Time.	No. 1 Hole.	No. 2 Hole.	No. 3 Hole.
June 6.				June 7.			
P.M.				A.M.			
6·45	165	206	...	8·45	176	216	...
6·50	165	206	...	9·00	176	217	...
6·55	165	206	...	9·15	176	217	...
7·00	165	207 [2]	...	9·30	176	217	...
7·15	166	206	...	9·45	176	217	...
7·30	168	206	...	10·00	177	217	...
7.45	167	207	...	10·15	177	217	...
8·00	167	207	...	10·30	177	218	...
8·15	168	207	...	10·45	177	218	...
8·30	168	207	...	11·00	177	218	...
8·45	169	207	...	11·15	177	218	...
9·00	169	208	...	11·30	177	218	...
9·15	169	208	...	11·45	177	218	...
9·30	169	208	...	12·00	177	218	...
9·45	169	208	...	P.M.			
10·00	170	208	...	12·30	177	218	...
10·15	170	208	...	1·00	178	218	...
10·30	170	208	...	1·30	178	218	...
10·45	170	208	...	2·00	178	218	...
11·00	170	208	...	2·30	178	218	...
11·15	170	208	...	3·00	179	218	...
11·30	170	208	...	3·30	179	218	...
11·45	170	208	...	4·00	179	218	...
12·00	170	208	...	4·30	180	219	...
				5·00	180	219	...
June 7.				5·30	180	219	...
A.M.				6·00	180	219	...
12·15	170	208	...	6·30	180	219	...
12·30	170	208	...	7·00	180	219	...
12·45	170	208	...	7·30	180	219	...
1·00	170	208	...	8·00	180	219	...
1·15	170	208	...	8·30	181	219	...
1·30	170	208	...	9·00	181	219	...
1·45	170	208	...	10·00	181	219	...
2·00	170	208	...	11·00	181	219	...
2·15	170	208	...	12·00	182	219	...
2·30	170	208	...	June 8.			
2·45	170	208	...	A.M.			
3·00	172	208	...	1·00	182	219	...
3·15	172	208	...	2·00	183	219	...
3·30	172	208	...	3·00	183	219	...
3·45	172	209	...	4·00	183	219	...
4·00	172	209	...	5·00	183	219	...
4·15	172	209	...	6·00	183	219	...
4·30	173	210	...	7·00	184	220	...
4·45	173	210	...	8·00	184	220	...
5·00	173	210	...	9·00	184	220	...
5·15	173	210	...	10·00	185	220	...
5·30	173	210	...	11·00	185	220	...
5·45	173	210	...	12·00	186	220	...
6·00	173	210	...	P.M.			
6·15	173	210	...	1·00	186	221	...
6·30	173	210	...	2·00	186	221	...
6·45	174	210	...	3·00	187	221	...
7·00	174	211	...	4·00	188	221	...
7·15	175	213	...	5·00	188	221	...
7·30	175	214	...	6·00	188	221	...
7·45	175	214	...	7·00	188	221	...
8·00	176	215	...	8·00	189	222	...
8·15	176	215	...	9·00	189	222	...
8·30	176	216	...	10·00	189	222	...

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[2] No. 2 gauge falling slowly.

HARTON COLLIERY.—NOS. 1, 2, AND 3 HOLES.—*Continued.*

Time.	No. 1 Hole.	No. 2 Hole.	No. 3 Hole.
June 8.			
P.M.			
11·00	189	222	...
12·00	189	222	...
June 9.			
A.M.			
1·00	190	222	...
2·00	190	223	..
3·00	190	223	...
4·00	190	223	...
5·00	190	224	...
6·00	190	224	...
7·00	190	225	...
8·00	190	225	...
9·00	190	225	...
10·00	191	225	...
11·00	191	225	...
12·00	191	225	...
P.M.			
1·00	191	225	...
2·00	191	225	...
3·00	191	225	...
4·00	191	225	...
5·00	192	225	...
6·00	192	225	...
7·00	192	225	...
8·00	192	225	...
9·00	193	226	...
10·00	193	226	...
11·00	193	226	...
12·00	193	226	...
June 10.			
A.M.			
1·00	193	226	...
2·00	193	226	...
3·00	193	226	...
4·00	193	227	...
5·00	193	227	...
6·00	193	227	...
7·00	194	227	...
8·00	194	227	...
9·00	194	227	...
10·00	194	227	...
11·00	194	227	...
12·00	194	227	...
P.M.			
1·00	195	227	...
2·00	195	227	...
3·00	195	227	...
4·00	195	227	..
5·00	195	227	...
6·00	195	227	...
7·00	195	...	...
8·00	195	...	...
9·00	195	...	...
10·00	195	227	0 [3]
10·15	...	...	25
10·30	...	...	57
10·45	...	...	80
11·00	195	227	104
11·15	...	...	124 [4]
June 10.			
P.M.			
11·30	...	...	146
11·45	...	...	162
12·00	195	227	175
June 11.			
A.M.			
12·15	...	...	183
12·30	...	...	192
12·45	...	...	198
1·00	195	227	202
1·15	..	...	205
1·30	...	...	211 [5]
1·45	...	...	211
2·00	195	227	210
2·15	...	...	210
2·30	...	...	209
2·45	...	...	209
3·00	195	227	212
3·15	...	...	217
3·30	...	...	220
3·45	...	...	223
4·00	195	227	225
4·15	195	227	226
4·30	...	...	227
4·45	...	...	228
5·00	196	227	229
5·15	...	...	230
5·30	...	...	231
5·45	...	...	233
6·00	196	227	235
6·15	...	...	236
6·30	...	...	236
6·45	...	...	237
7·00	196	227	238
7·15	...	...	239
7·30	...	...	241
7·45	...	...	241
8·00	196	227	236 [6]
8·15	...	...	237
8·30	...	...	237
8·45	...	...	226 [7]
9·00	196	227	226
9·15	...	...	237
9·30	...	...	240
9·45	...	...	242
10·00	196	227	243
10·15	...	...	246
10·30	...	...	251
10·45	...	...	254
11·00	196	228	255
11·30	...	...	257
12·00	196	228	259
P.M.			
12·30	...	...	261
1·00	196	228	262
1·30	...	...	263
2 00	196	228	263
2·30	...	...	263

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[3] No. 3 gauge put on.

[4] All three tap joints leaking at No. 3 Hole.

[5] Leaking in No. 3 Hole.

[6] Gas escaping from tap in No. 3 Hole.

[7] Pressure fell quickly, leakage stopped.

HARTON COLLIERY.—NOS. 1, 2, AND 3 HOLES.—*Continued.*

Time.	No 1 Hole.	No. 2 Hole.	No. 3 Hole.
June 11.			
P.M.			
3·00	196	228	261
3·30	...	...	260 [8]
4·00	196	228	262
4·30	...	...	264
5·00	197	229	267
5·30	...	...	270
6·00	197	229	273
6·30	...	...	274
7·00	197	229	274
7·30	...	...	275
8·00	197	229	275
8·30	...	...	273
9·00	197	230	273 [9]
9·30	...	...	274
10·00	197	230	275
10·30	...	...	276
11·00	197	229	276
11·30	...	...	276
12·00	197	230	278
June 12.			
A.M.			
12·30	...	...	280
1·00	197	230	280
1·30	...	...	279
2·00	197	230	279
2·30	...	...	278
3·00	197	230	278
3·30	...	...	278 [10]
4·00	197	230	272
4·30	197	...	275
5·00	...	230	279
5·30	...	...	279 [11]
6·00	197	230	280
6·30	...	...	280
7·00	197	230	280
7·30	...	...	280
8·00	197	230	280
8·30	...	...	280
9·00	197	230	280
9·30	...	...	280
10·00	197	230	280
10·30	...	...	280
11·00	197	230	280
11·30	...	...	280
12·00	197	230	280
P.M.			
12·30	...	...	280
1·00	197	230	280
1·30	...	...	280
2·00	197	230	280
2·30	...	...	280
3·00	197	230	280
3·30	...	...	280
4·00	197	230	280
4·30	...	...	279
5·00	179	230	279
5·30	...	...	279
6·00	197	230	279
June 12.			
P.M.			
6·30	...	...	280
7·00	197	230	281
7·30	...	...	281
8·00	197	230	282
8·30	...	...	282
9·00	197	230	283
9·30	...	...	283
10·00	197	230	283
10·30	...	...	283
11·00	197	230	283
11·30	..	...	284
12·00	197	230	285 [12]
June 13.			
A.M.			
1·00	197	230	287
2·00	197	230	287
3·00	197	230	288
4·00	197	230	289
5·00	197	230	291
6·00	197	230	293
7·00	197	230	292
8·00	197	230	291
9·00	196	230	291
10·00	196	230	291
11·00	195	230	291
12·00	195	230	292
P.M.			
1·00	195	230	292
2·00	195	230	293
3·00	195	230	293
4·00	195	230	293
5·00	195	230	293
6·00	195	230	294
6·30	195	230	294
7·00	195	230	294
8·00	...	...	295
9·00	...	...	295
10·00	...	...	295
11·00	...	...	295
12·00	...	...	295
June 14.			
A.M.			
1·00	...	...	295
2·00	194	230	295
3·00	...	...	295
4·00	...	...	295
5·00	...	...	295
6·00	193	230	295
7·00	191	238	295
8·00	193	230	295
9·00	194	230	295
10·00	195	230	296
11·00	195	230	295
12·00	196	230	295
P.M.			
1·00	196	230	295
2·00	197	230	295
3·00	197	230	295

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[8] Pipes leaking.

[9] Pipes still leaking at joint.

[10] Pressure escaping at a joint. Mended joint with cement.

[11] Joint leaking.

[12] No. 3 stopped leaking.

HARTON COLLIERY.—NOS. 1, 2, AND 3 HOLES.—*Continued.*

Time.	No. 1 Hole.	No. 2 Hole.	No. 3 Hole.	Time.	No. 1 Hole.	No. 2 Hole.	No. 3 Hole.
June 14.				June 15.			
P.M.				P.M.			
4·00	197	230	295	9·00	121	226	292
5·00	197	230	295	10·00	125	226	292
6·00	187	230	295	11·00	129	226	292
7·00	197	230	295	12·00	132	226	292
8·00	197	230	295	June 16.			
9·00	197	230	295	A.M.			
10·00	196	230	295	1·00	136	226	292
11·00	195	230	295	2·00	140[16]	227	292
12·00	195	230	294	3·00	140	228	292
June 15				4·00	147	229	292
A.M.				5·00	146	229	292
1·00	194	230	294	6·00	20[17]	228	292
2·00	194	231	293	7·00	40	228	292
3·00	194	231	293	8·00	41	228	293
4·00	194	231	293	9·00	51	227	292
5·00	194	230	293	10·00	55	227	292
6·00	194	230	293	11·00	88	227	292
7·00	194	230	293	12·00	113	227	291
8·00	194	230	293	P.M.			
9·00	193	230	292	1·00	148	228	290
10·00	193	230	292	1·00	165	229	290
11·00	193	230	292	2·00	182	229	290
12·00	193[13]	230	292	3·00	191	229	290
P.M.				4·00	194	229	290
1·00	11	230	292	5·00	197	230	290
2·00	20	230	292	6·00	...	230	290
3·00	27[14]	230	292	...	...	...	...
4·00	119	230	292	...	...	...	...
5·00	100	230	292	...	...	...	...
6·00	100	228	292	...	...	...	...
7·00	105[15]	227	292	...	...	...	...
8·00	114	226	292	...	...	...	...

[13] Pressure run off.

[14] Pipes of No. 1 leaking.

[15] No. 1 Hole leaking.

[16] No. 1 Hole leaking.

[17] Another gauge put on.

An abstract of these Tables is given in Plate XXXIX. showing the pressure of gas at the same hours and days after the boring of the holes, and these abstracts are further illustrated by diagrams in Plates XL. to XLIV.

To illustrate Mr. L. Woods paper on "Experiments made to ascertain the pressure and quantity of Gas in the solid Coal"

SYNOPTICAL TABLE SHOWING THE PRESSURES OF GAS AT THE SAME HOURS AND DAYS AFTER THE BORING OF THE HOLES

												Days 1		2		3		4		5		6		7		8		9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Hours.	1	2	3	4	5	6	8	10	12	16	20	24																																	
ELEMORE																																													
	23	25	25½	26	27	27½	27½	27½	28	27½	27½	27½	27	26	25½	25	25	24½	24½	24	23	23	23	23	23	23	22½	22½	22½	21	21	19	18½	18	18½	16½	16	16½	16	16	14½	13	12	10½	8½
HETTON																																													
	29	33	40½	40	40	40	39½	39¼	38½	37½	37	37½	38½	40	40	40	40																												
EPPLETON																																													
1	54¾	54¾	54¾	54¾	50½								51¾																																
2	54	61¾	62½	65	65	93½	90	85	80	92	90½	91¼	95	92	92	90																													
3	89	120	141	151	157	161	165	165	165	175	179	181	185	189	191	193	194	184	204	203	202	200	200	199	198	197	194	192	188	185	180	*	169	166	165	155	160	159	157	157					
4			25	25	25	25	26	26	27	27	28	30	30	31	31	29	29	29	29	29	28	28	29	29	29	28	29																		
5	107	107	108	108	108	108	110	119	125	123	119	119	115	119	113	113	111	111	111	111	110	110	108	107	106	102																			
6	198	203	203	204	204	204	205	219	210	210	212	213	210	220	220	219	220	220	222	222	220	220	220	221	223	221	223	*	*	*	*	*	176	186											
7	70							106					182	193	199	203	205	207	209	219	220	218	223	225	227	229	229	230	230	231	231	232	233	233	233	233	233								
8	75	193	195	197	200	204	208	210	211	212	214	215	220	220	220	221	220	220	218	216	217	208	215	210	210	208																			
BOLDON																																													
1	40	58	88	110	140	177	216	260	322	332	350	356	380	382	*	*	242	356	392	407	415	420	421	424	424	425	425	425	425	425															
2	112	155	198	218	234	243	256	266	275	282	282	282	*	*	183	217	225	240	252	120†	251	276	289	297	296	297	297	297	297	298															
3	8	20	37	67	120	203	225	218	221	229	236	213‡	428	450	457	461	390	284‡	308	340	337	360	383	383	353	353	335																		
4	8	47	120	170	295	315	336	350	358	370	374	379	345	353	353	345	353	353	349	348	348	344	340	340	340	340	340																		
5	134	132	134	138	144	149	153	159	162	162	164	169	172	174	176	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175	175									
HARTON																																													
1	38	52	68	86	100	110	130	146	155	168	170	172	179	183	187	190	191	193	195	195	196	197	197	197	195	194	197	194	140																
2	18	60	100	142	162	180	197	199	201	206	208	208	218	219	221	223	225	226	227	227	228	230	230	230	230	230	230	231	228																
3	104	175	202	210	212	225	235	236	243	263	273	275	280	283	291	295	296	295	292	292	292	290																							

* Gauges taken off for the length of time indicated by the column.

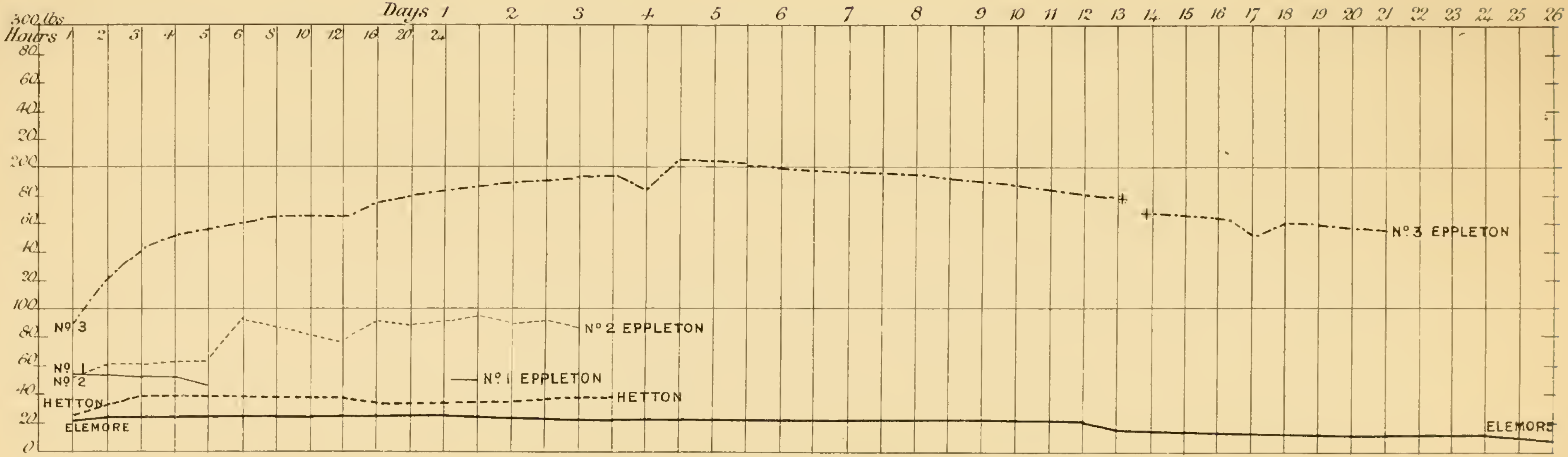
† Gauge had been taken off and only replaced two hours previous to this reading.

‡ Fell back owing to leakage.

Lith. Reid Newcastle

To illustrate Mr. L. Woods paper on "Experiments made to ascertain the pressure and quantity of Gas in the solid Coal."

Diagram shewing the Pressures of Gas at the same Hours and Days after the Boring of the Holes in the Elemore Experiment the Hetton Experiment and in Nos. 1, 2, and 3 Eppleton Experiments.



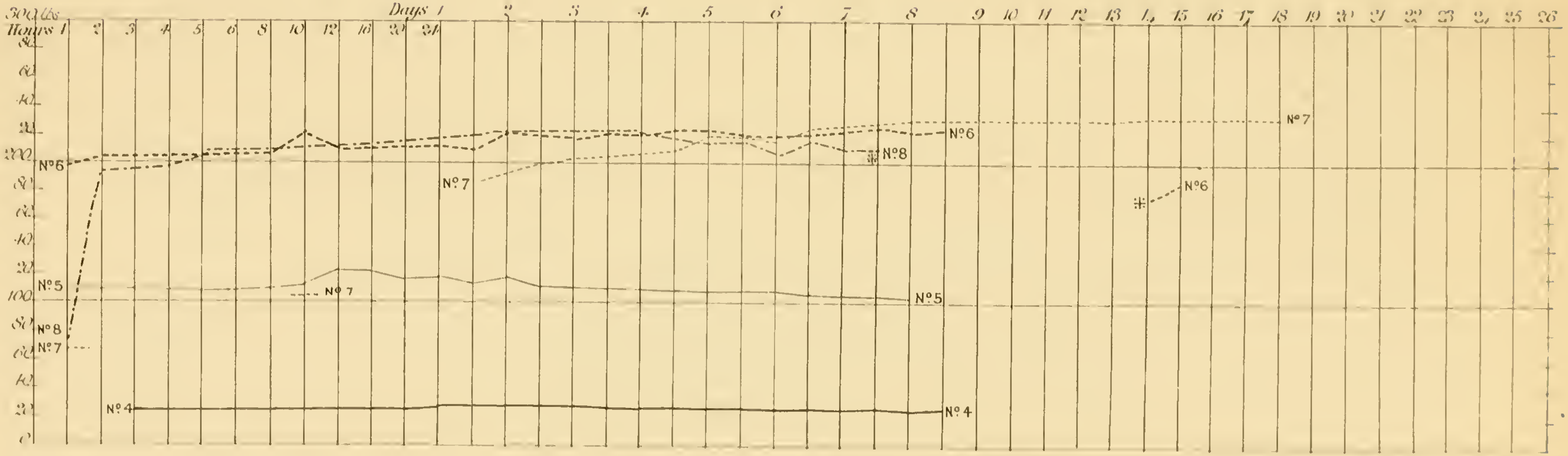
+ *During the interval the Gauge was off.*

Proceedings No. E 1 of M&M E 1880/81

Andw Reid Newcastle

To illustrate Mr. L. Woods paper on "Experiments made to ascertain the pressure and quantity of Gas in the solid Coal"

Diagram shewing the Pressures of Gas at the same Hours and Days after the Boring of the Holes in Nos. 4, 5, 6, 7, and 8 Eppleton Experiments.

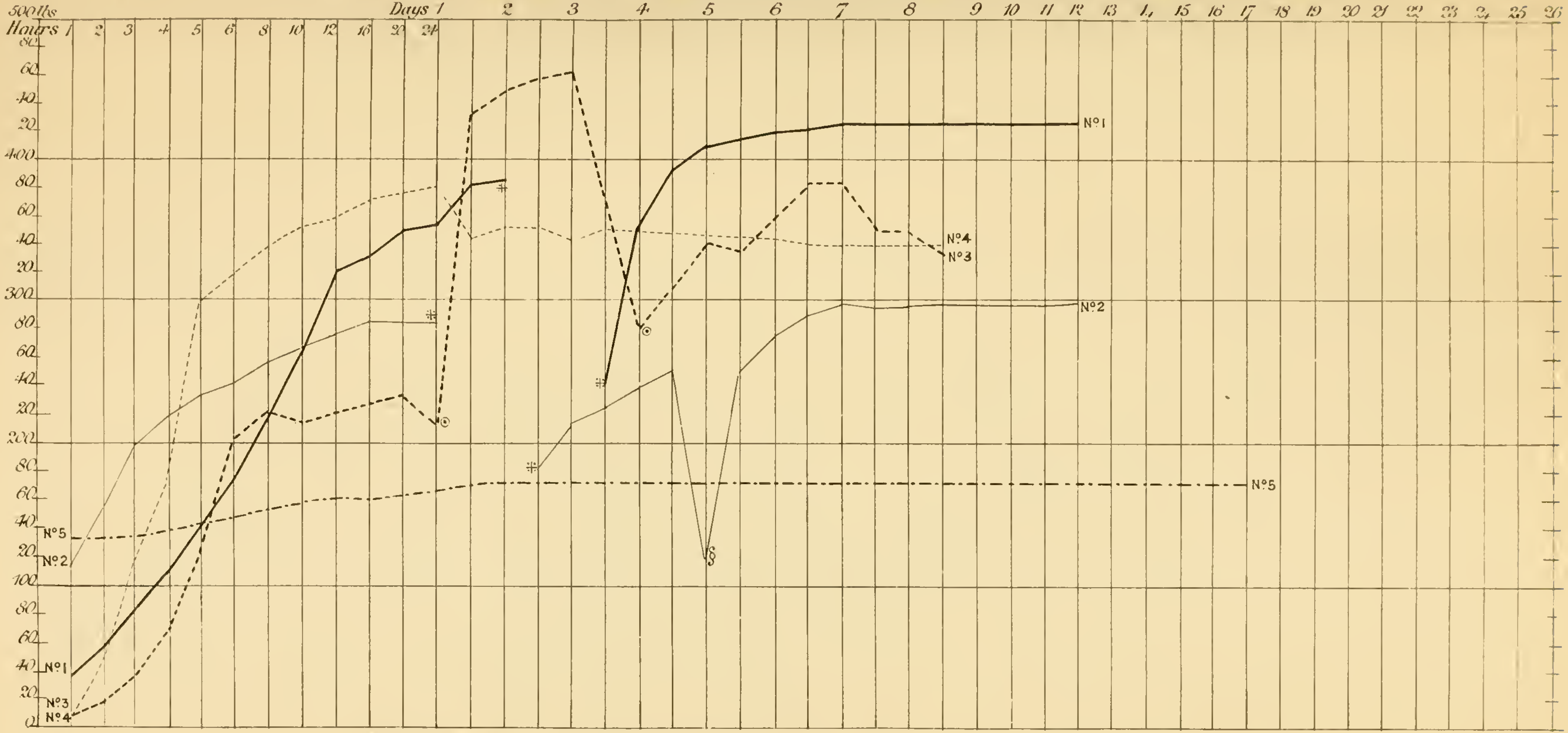


⁜ *During the interval the Gauge was off.*

Proceedings N° 4 of N.E.I.M.E. 1880-81

To illustrate Mr. L. Woods paper on "Experiments made to ascertain the pressure and quantity of Gas in the solid Coal"

DIAGRAM SHEWING THE PRESSURES OF GAS AT THE SAME HOURS AND DAYS AFTER THE BORING OF THE HOLES IN NOS. 1, 2, 3, 4, AND 5 BOLDON EXPERIMENTS.



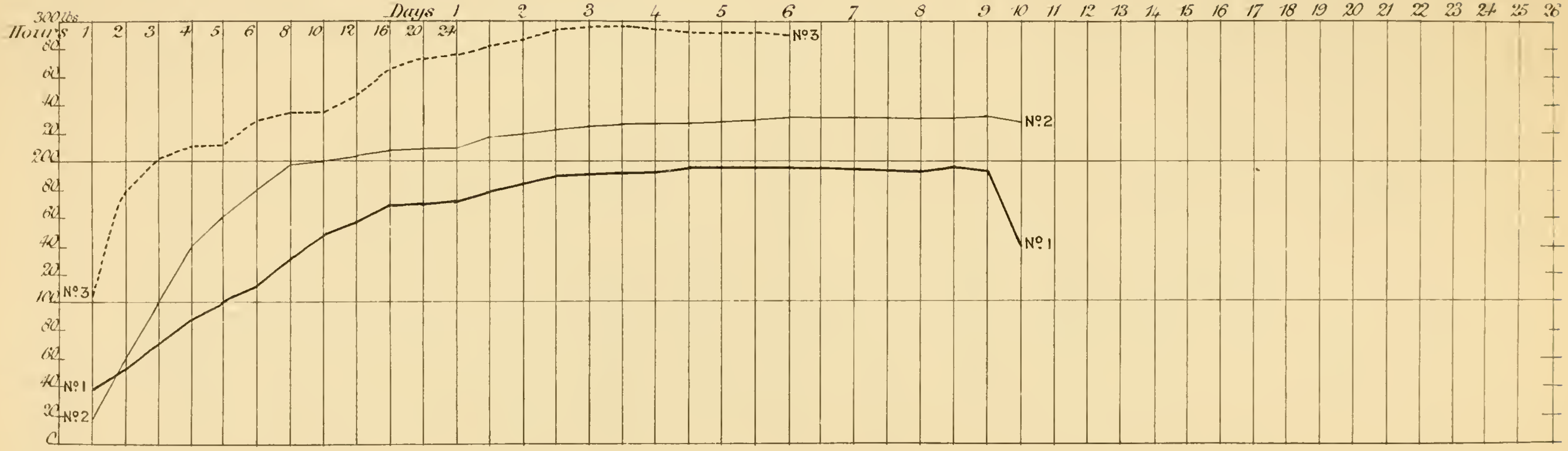
⁜ *During the interval the Gauge was off.*

§ *Gauge had been taken off and only replaced two hours previous to this reading*

⊙ *Fell back owing to leakage*

To illustrate Mr. L. Wood's paper on "Experiments made to ascertain the pressure and quantity of Gas in the solid Coal"

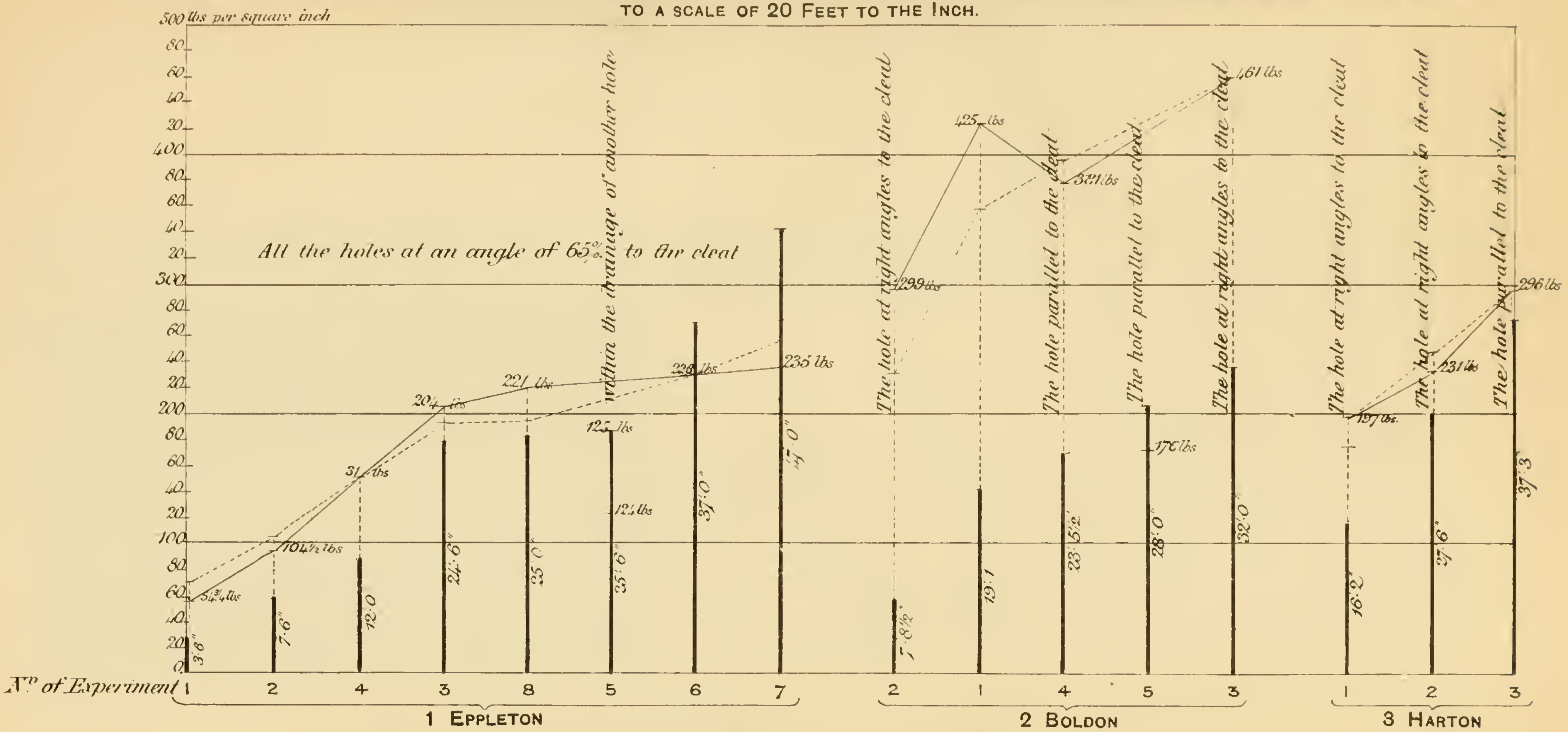
DIAGRAM SHEWING THE PRESSURES OF GAS AT THE SAME HOURS AND DAYS AFTER THE BORING OF THE HOLES IN NOS. 1, 2, AND 3 HARTON EXPERIMENTS.



Andw Reid Newcastle

To illustrate Mr. L. Woods paper on "Experiments made to ascertain the pressure and quantity of Gas in the solid Coal"

DIAGRAM SHEWING THE EXPERIMENTS ARRANGED ACCORDING TO THE DEPTH OF THE HOLES. THE DARK VERTICAL LINES REPRESENT THE HOLES TO A SCALE OF 20 FEET TO THE INCH.



The whole horizontal lines show the pressures actually exhibited

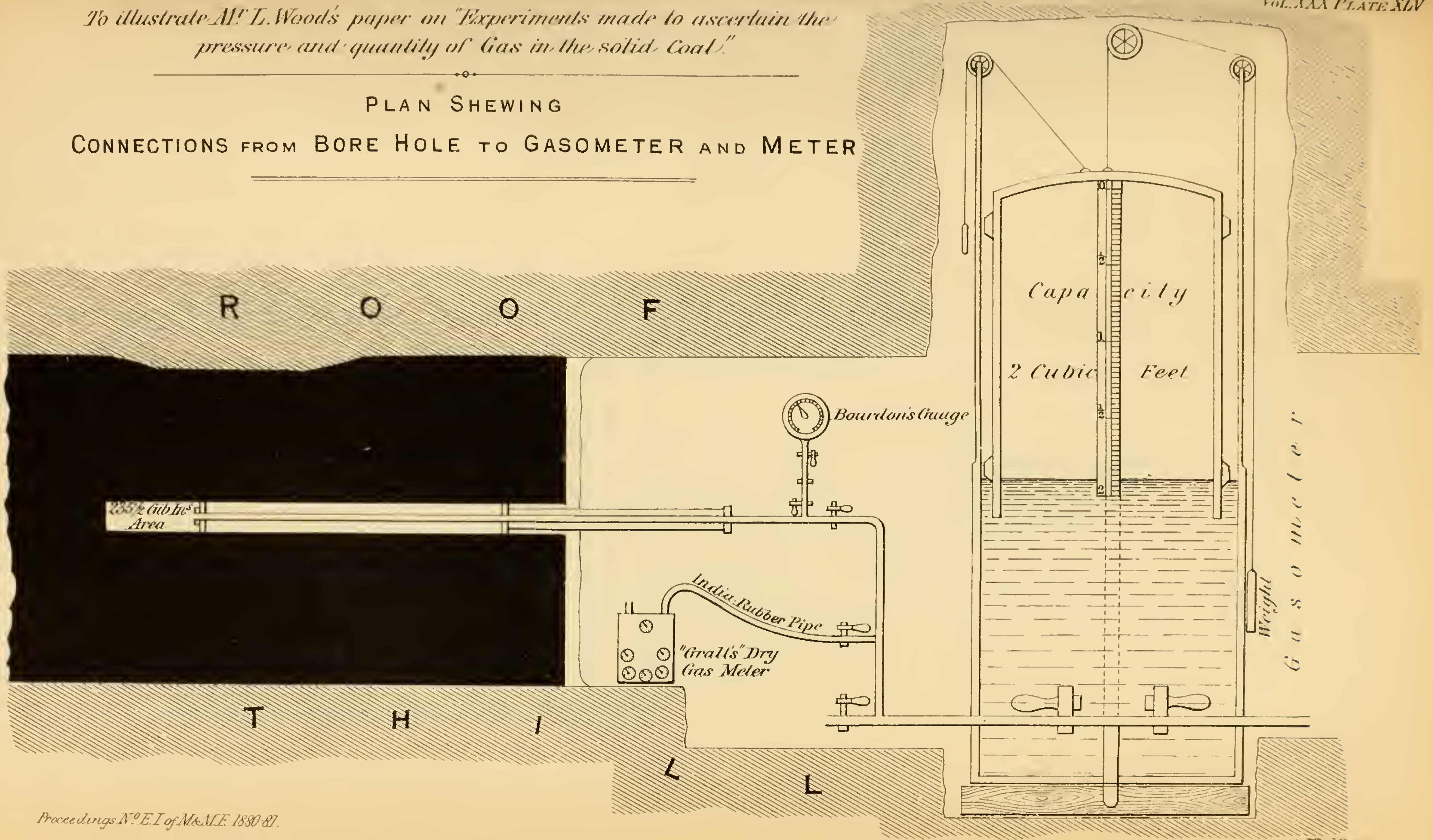
The dotted horizontal lines illustrate the formula pressure = √ of depth of hole

Andw Reid Newcastle

To illustrate Mr. L. Wood's paper on "Experiments made to ascertain the pressure and quantity of Gas in the solid Coal."

PLAN SHEWING

CONNECTIONS FROM BORE HOLE TO GASOMETER AND METER



The PRESIDENT said, he was sure every one of the members must be exceedingly obliged to Mr. Wood for having communicated these most elaborate and interesting experiments to the Institute. As there were so many figures to be mastered, the paper could hardly be discussed at the present time with any advantage; but if gentlemen had any observations to make he would be very glad to hear them.

Mr. A. L. STEAVENSON stated that he thought it would be in the recollection of many of the members that in the third volume of the Transactions of the Institute there was a paper which was read by Mr. P. S. Reid, and which spoke of pressures due to gas in coal even higher than those now given, and in order still further to illustrate the subject he hoped the experiments would be published with such information as to the depth of the superposed strata as would enable members to ascertain if the pressure of the gas in the coal bore any ratio to the pressure due from any defined column of water. In order to arrive at any satisfactory conclusion on this point it would be necessary to know from the nature of the strata what might be reasonably supposed to be the height of any column of water that would have access to the seam where the gas was. The pressures given fell very much short of those that would have resulted had they been formed under a column of water the whole depth of the strata; but there were many circumstances, for instance a portion of the upper strata being drained into other channels, which would prevent the actual column acting against the strata being represented by its depth from the surface.

Mr. D. P. MORISON said, he quite agreed that it would be highly desirable if the information suggested by Mr. Steavenson could be placed before the members. He thought one of the best proofs that water had something to do with the pressure was the fact of water issuing from the borehole.

Mr. COOKE said, he had seen a borehole in Strafford Main Colliery, from which the very large pressure of 120 lbs. to the square inch was obtained in twenty minutes, and no water came with the gas upon opening the top of the pipe, but as the hole dipped downwards it was not ascertained if any came into the hole.

Mr. R. L. GALLOWAY thought perhaps the water was due to the hydrogen in the gas combining with the oxygen of the atmosphere, and that water had not passed through the strata.

Mr. E. F. BOYD thought that there were certain difficulties with regard to the water pressure theory; for instance, he considered it more than probable that the coal seams are not subject to the superincumbent pressure due to water, seeing that there are many shale beds overlying the coal beds where these experiments had been made which are water-tight.

Mr. MORISON replied that these strata might be very much fissured, and allow the full pressure to come upon the gas in some portion of the seam and cause the pressure to accumulate.

Mr. LOGAN thought the experiments were extremely interesting, and he would be very glad if they could be extended a good deal further so that they might ascertain the conditions under which the gas presented itself. At present they had only dealt with it in its gaseous state; but he should like to be supplied with some data by which it could be ascertained if it existed naturally in a gaseous, a liquid, or a solid state. He never could understand how the enormous quantity of gas recorded in the volumes of the Institute as filling millions of cubic feet of space could come from a small borehole, or even from a trouble in so short a time.

Professor HERSCHEL said, it appeared to him that the gas pressure indicated in the way described had accumulated by being confined, and that the borehole had been sunk to a certain depth where the gas was confined, and had indicated the pressure. It might be a question as to where the gas came from and how it raised the pressure, but that it existed at the depth to which the borehole had been put, and had remained there till indicated and liberated, there could be no doubt. There were no deep fissures or cracks in the coal which permitted the passage of the gas; so that the pressure found was that which enabled the gas to make its escape through the varied thickness of coal contiguous to the hole. If the borehole was deeper a higher pressure would perhaps be found. The gas pressure was very likely due to its compression by the water pressure which holds it in; but it did not follow that water would find its way wherever gas would go, but the gas as it formed in the coal would balance the column of water which prevented its escape. If a hole could be put into the centre of the coal-field, away from the open workings where these boreholes were opened, the pressure of the water the gas was originally overcoming might be ascertained; as it was, the gas in the vicinity of the hole had escaped into the workings, and the question was, could the water follow it up so as to maintain the pressure? He thought not, and that the gas would gradually escape as the workings went on, and in no case in which a hole could practically be put would it indicate the full pressure due to the depth at which it had been tapped. A pressure indicated of 195 lbs. represented about 75 fathoms of water, which was of course a less depth than that at which the borehole was placed; but he supposed that this 75 fathoms of water thus indicated was not the pressure which the gas was actually overcoming in its generation in the coal, but the pressure which was found at the end of the borehole after the gas had partially liberated itself by escaping through the working face, for it had to be taken into account in these experiments that the coal was very permeable to gas, and would allow the escape of the gas through all the open parts of the mine where it might not allow the escape of water. He expected that the pressure of the gas in all cases had been that due to the pressure of the water which had confined it, but that before these experiments had been tried the gas had escaped into the workings, and that the pressures given at the various distances bored into the coal had all been more or less modified by this escape.

Mr. E. F. Boyd said, that with regard to Mr. Logan's observations he had a strong impression that gas prior to its being exposed to the action of the atmosphere might possibly exist in a state of solid matter. The action of taking off the pressure under which it existed *in sitû* by the penetration of the borehole might have produced the very effect which Mr. Logan premised; and he (Mr. B.) thought the experiments in future might very well be directed, first of all, to ascertaining the quality of the gases given off and what they consist of, whether they were pure carburetted hydrogen, the same as is met with in the ordinary driving of coal workings, or whether they consist of any other gases originating from that solid condition which Mr. Logan indicated. He (Mr. B.) thought that the latter supposition was very possibly the correct one.

Mr. Morison said, it would be very interesting if in any of the future experiments now in contemplation the pressure should be found in excess of that due to a column of water of the height of the superposed strata.

Mr. G. May (in answer to a member) said, that in the Bensham seam the holes were bored both in the line of the cleat and against it. In boring the holes the headways way they got a greater flow of gas by measurement; that is more gas was given off from the holes, but in boring the other way they got greater pressures. The experiments were going to be continued to test the question as to whether the different depths at which the seams were had anything to do with the pressure. Some experiments were being made in Wales, corresponding to those which proved that the temperature was guided entirely by the cover, about 100 fathoms down a pit, in a situation directly under a valley; and also in another place under a hill, 600 feet high—that is in situations covered by 100 and 200 fathoms of cover respectively; and so far as the experiments had gone they did not find the results were affected by depth. With regard to the water very little came from the holes in the experiments now described. The seams were almost perfectly dry; and when the taps were opened, after the pressures had been obtained, the gases came off very largely. The greatest difficulty which they had had to contend with had been to keep the holes tight. For instance, in the case of the one where 460 lbs. had been obtained, the pipes gave way and caused the pressure to fall. Of course a very little leakage took away the gas, and the pressure was immediately reduced.

The President thought they did not exactly know what the extreme pressure due to the situation might have been, inasmuch as the leakage had begun while the pressure was still increasing. He was sure that this paper would give them all much matter for consideration. When they had it before them they would be in a better position to gather their thoughts into some sort of form, so that the discussion might rise to a level worthy of the great importance of the subject. In the meantime he felt sure they would accord Mr. Lindsay Wood a cordial vote of thanks for the very valuable paper he had communicated to them.

This was unanimously responded to.

PROCEEDINGS.

ANNUAL GENERAL MEETING, SATURDAY, AUGUST 6TH, 1881, IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE.

G. C. GREENWELL, Esq., President, in the Chair.

Messrs. George May, J. G. Weeks, and William Armstrong, Jun., were appointed Scrutineers to examine the voting papers for the election of officers for the year 1881–82.

The Secretary read the minutes of the last meeting and reported the proceedings of the Council.

The Secretary also read the reports of the Council and Finance Committee, which were unanimously adopted.

The following gentleman was then elected :—

Ordinary Member—

Mr. John Grey Cranston, Consulting Mining and Mechanical Engineer, 22, Grey Street, Newcastle-upon-Tyne.

The following were nominated for election at the next meeting:—

Ordinary Member—

Mr. George H. Geddes, Mining Engineer, 112, Princes Street, Edinburgh.

Associate Member—

Mr. Frank Stobbs (Manager, Messrs. Thomas and William Smith), 1, Queen Street, Quay, Newcastle-upon-Tyne.

Students—

Mr. Arthur P. Wilson, Brancepeth, near Durham.

Mr. J. H. Nicholson, Cambois Colliery, Blyth, Northumberland.

The following paper on "Cranston's Deep Boring Machine" was read by the Secretary :—

CRANSTON'S DEEP BORING MACHINE, SUITABLE FOR SINKING ARTESIAN WELLS, SUB-MARINE BORING, AND BORING FOR MINERALS, &c.

By J. G. CRANSTON.

In comparing the operations and tools of Artesian well-borers, the various systems that have at different times been employed may be classified under three distinct heads, which may be described as follows :—

1.—A suspended tool, to which an up-and-down motion is communicated either by means of hand or steam power, the tool receiving between each drop, or from time to time a rotary motion communicated to it either by the apparatus itself or by the attendant.

2.—A rotating tool, either solid in the form of an augur, as in the old boring apparatus, or hollow in the form of a tube as in the Diamond boring instrument, the rotating motion being applied either direct by hand or by gearing.

3.—A stationary tool resting on the surface to be bored and having a series of blows imparted to it by hand, as in the ordinary drill, or by a body made to move up and down by machinery.

It would no doubt be most interesting to follow the separate history and career of each of these methods in all their several and numerous ramifications from the earliest to the present time, as each class in its turn has been brought to prominence by some important improvement or by some special case of notoriety to which it was more than usually adapted ; but the object of the present notice is to show the mode adopted for boring a series of deep bore-holes by a suspended tool for the Hartlepool Water Works Company.

The West Hartlepool Gas and Water Company is probably unique in having two distinct mains for supplying water to their district, one main supplying surface water to manufacturers and another supplying drinking water, obtained by boring through the magnesian limestone. The surface water is accumulated in reservoirs in the usual way ; one of these reservoirs is at Hurworth Burn and holds 160,000,000 gallons ; and one in the neighbourhood of Hartlepool holds 20,000,000 gallons—the total yearly supply of soft water delivered in the town being 130,000,000 gallons.

The drinking water was obtained till lately from five holes bored through the magnesian limestone, one 6 inches diameter; two 4½ inches diameter; and two 3 inches in diameter, and the supply from this source not being sufficient, it was determined to put down another hole. These five holes were placed at distances of from 400 feet to 600 feet apart, and tap the water-bearing strata at depths varying from 40 to 85 feet; the water rises up to within three feet of the surface, and is carried by brick culverts to one common well, from whence it is pumped into reservoirs 80 feet high, which is sufficient to allow it to gravitate to the highest parts of the district. This service is performed by two condensing engines, one having a 25-inch cylinder with a 5-feet stroke, and the other a 33-inch cylinder with a 6-feet stroke. These engines were put down at different times, but are so arranged that they can be made to work either separately or together as one compound engine. This permits of the service being continued whilst one engine is under repair.

The holes thus sunk through the magnesian limestone which abounds in the locality, were somewhat difficult to bore on account of the hard and peculiar nature of the rock.

The usual progress made in sinking these holes was from 8 to 9 inches per day, and the shallowest costing something over a hundred pounds for labour alone.

For sinking the sixth hole the boring arrangements employed were constructed with a view to simplicity combined with increased rapidity and economy, and consisted of a vertical steam engine *a*, with a 10-inch diameter of cylinder and a 12-inch stroke, making about 120 revolutions a minute ; the crank shaft carries a small drum *b*, which is geared into a larger one *c*, attached to the shaft *e* by means of a belt *d* ; on this shaft is a cam roller *f*, which lifts the wooden beam or lever *g* once to every three revolutions of the engine.

The bore rods, with an adjusting screw *h* attached, are suspended from the end *i* of the beam lever directly over the bore-hole. The boring tool *j* Fig. 2, Plate XLVI., is made of steel ; it is attached to the rods by a screw in the usual way, and is alternately raised and dropped with considerable force upon the face of the rock, while at the same time it is slightly rotated and fed forward as the hole deepens by the man in charge ; provision is also made to regulate the balance of the beam lever, which necessarily becomes heavier at one end in proportion to the additional weight of the rods which are gradually lengthened to suit the depth of hole required. K is a support to receive the beam, and is provided with India-rubber to break the shock of the blow.

The balance or force of the blow can be regulated by simply moving the fulcrum or trestle *l* which supports the beam arm further along nearer to the bore rods, when weights may be added to its opposite end *m* so as to maintain the desired equilibrium in this manner by the adjustment of the fulcrum and lever ; holes of various dimensions are bored to very great depths with a remarkable degree of simplicity and rapidity.

At the West Hartlepool Works water was taken from the Company's reservoirs by iron piping *n*, about half-inch in diameter, 320 feet long, down the 6-inch diameter bore-holes to a point close above the boring tool, so that the *debris* or mud accumulating at the bottom of the hole, as the rock is being pounded away, is washed or forced out through *o* by the regular flow of water ; it was found to be of great advantage, as over 100 feet could be bored at one time without it being necessary to withdraw the rods.

A crab winch *p* and derrick *q* being provided, the rods are readily withdrawn and re-inserted when desired.

The rods are made from $1\frac{1}{4}$ inch square wrought iron, varying in lengths from 1 foot 6 inches to 15 feet each. The boring tool *j*, an enlarged view of which is given, is made in shape similar to the letter *x*, and ensures a perfectly round hole, which is found to be a great advantage when tubing is required.

The apparatus has accomplished the work desired by the Water Company at West Hartlepool without requiring any repairs whatever, to their entire satisfaction.

The average cost for erecting the machine and boring a 6-inch diameter hole 103 feet deep, has not exceeded £15, including labour, fuel, oil, and stores. The progress was 10 feet a day, the whole depth being completed in ten days by two men at 3s. 6d. a day each, or for a total sum of £3 10s. The steam was taken from the boiler working the pumping engine, so that no additional fireman was required; the remaining cost being for the extra fuel and oil, and for the men's time erecting the machine ; whereas, 4-inch diameter holes had previously been bored 70 feet deep by hand, and they cost considerably more than 103 feet boring with machine.

The water has been tapped at this depth, each hole yielding an additional supply of pure water equal to 25,000 gallons per hour.

A somewhat similar apparatus is now being constructed and will shortly be employed by the River Tyne Commissioners on the Tyne for sub-marine boring; some modifications in the general arrangement are being made, but the principle is the same as the apparatus shown in the drawings, in order to suit the peculiar circumstances in having to work from a floating pontoon so as to be enabled to bore at any time during the varying rise and fall of the tides; but the whole is very simple and very inexpensive.

This machine has been got to work since the paper was read; at the first trial a hole 3 inches diameter was put down, 1 foot in two minutes and 14 feet in rather less than two hours, the average depth of water over the rock being 16 feet, and holes are now being bored 22 feet deep under 18 feet of water.

In reply to several questions the SECRETARY stated that the machine was suspended by a short chain, that a depth of one hundred feet was bored without changing the tool, even to sharpen it, as the water which entered at the small pipe N was carried down to the place where the tool worked and kept it sharp and free from *debris*. The sum of £15, mentioned as the cost of erecting the machine and boring a hole six inches in diameter, 103 feet deep, was the total expense incurred for labour, and did not of course include the value of the machinery.

The CHAIRMAN—It is not possible it could be that amount for the whole depth.

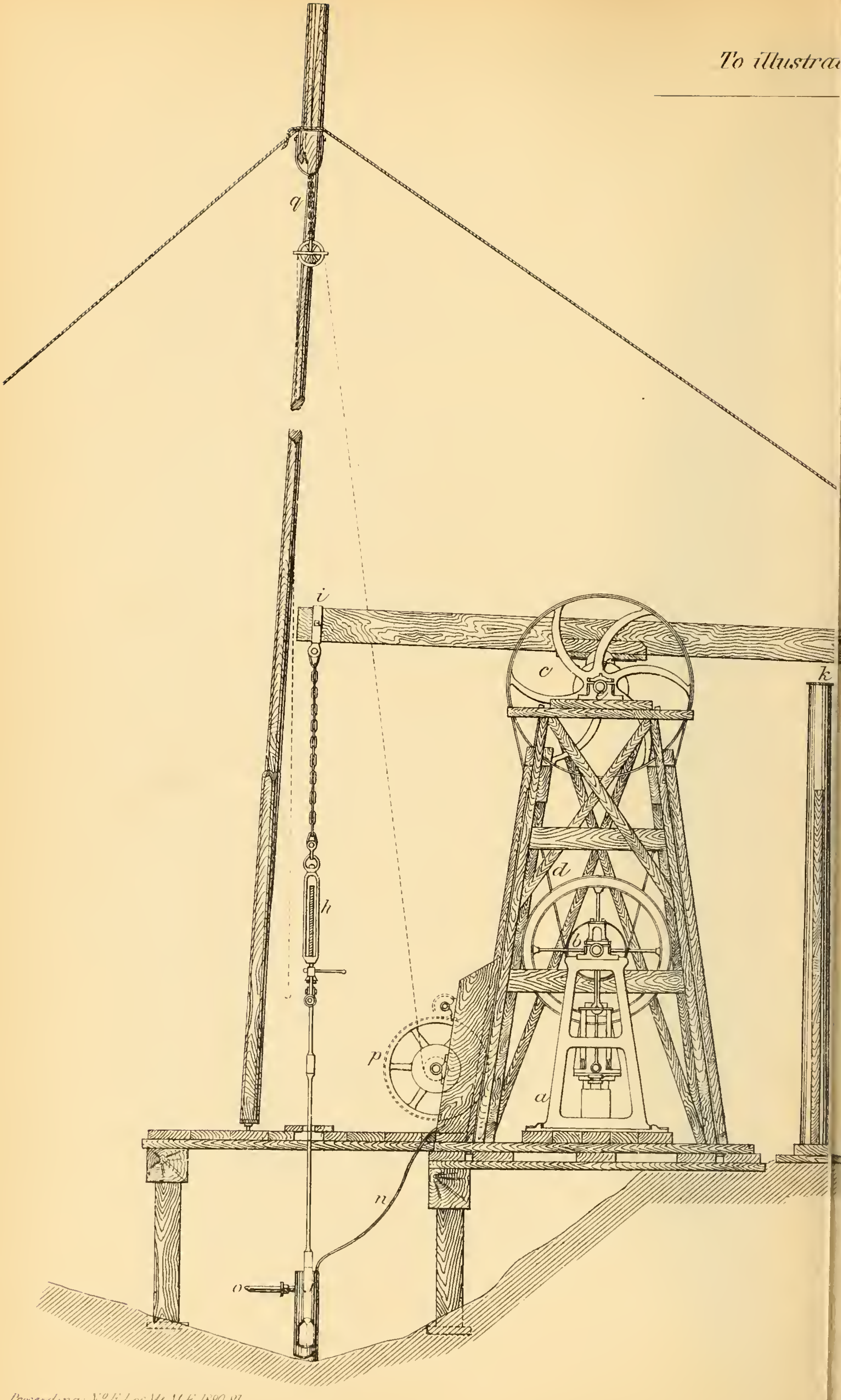
The SECRETARY—Mr. Mossman, the engineer of the West Hartlepool Water Works, supplied the details connected with the supply of water and the mode by which they obtained both the surface water and the hard water, and he perfectly agreed with this statement.

As Mr. Cranston had been unable to attend the meeting, the discussion was adjourned.

Mr. D. P. MORISON'S paper on "Boiler Accidents and their Prevention" was then discussed.

Mr. D. P. MORISON said, that since the first portion of his paper was published, much anxiety had been expressed with reference to the inspection of boilers by independent engineers; and he believed the subject would eventually take the shape of some legislative enactment. He thought the Government would either recommend, or to some extent compel, users of steam boilers to have them inspected by some impartial engineer, and would recommend that every boiler, working at a pressure, should be registered the same as ships. Although many seemed to object to Government inspection, he himself thought it very desirable, but the general feeling appeared to be that all boilers should be registered by the Govern-

To illustra



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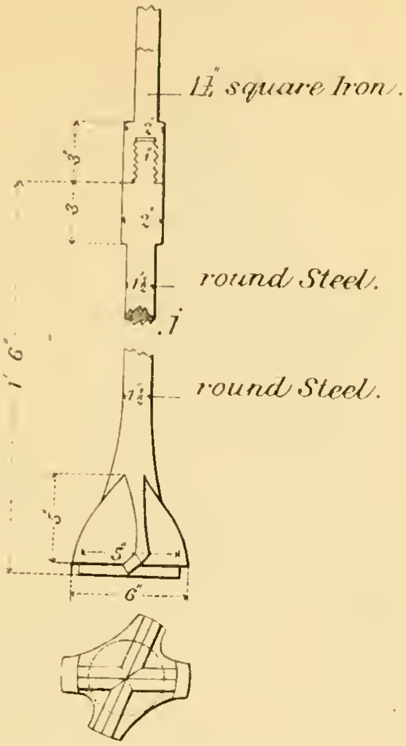
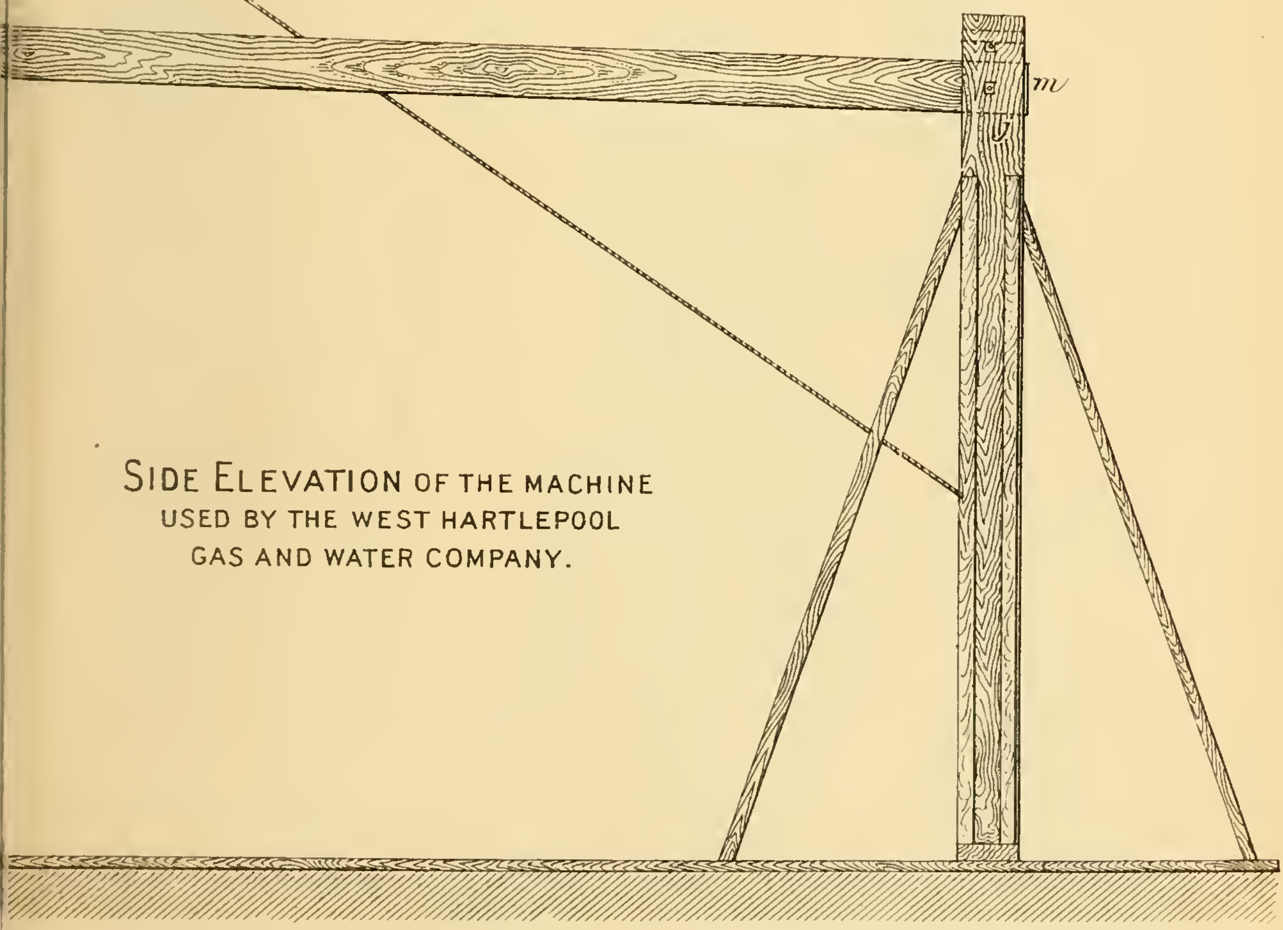
Mr. J. G Cranston's paper "On Deep Boring Machines."

FIG. 2.



Sketch of Drill bit used at the West Hartlepool Water Works.

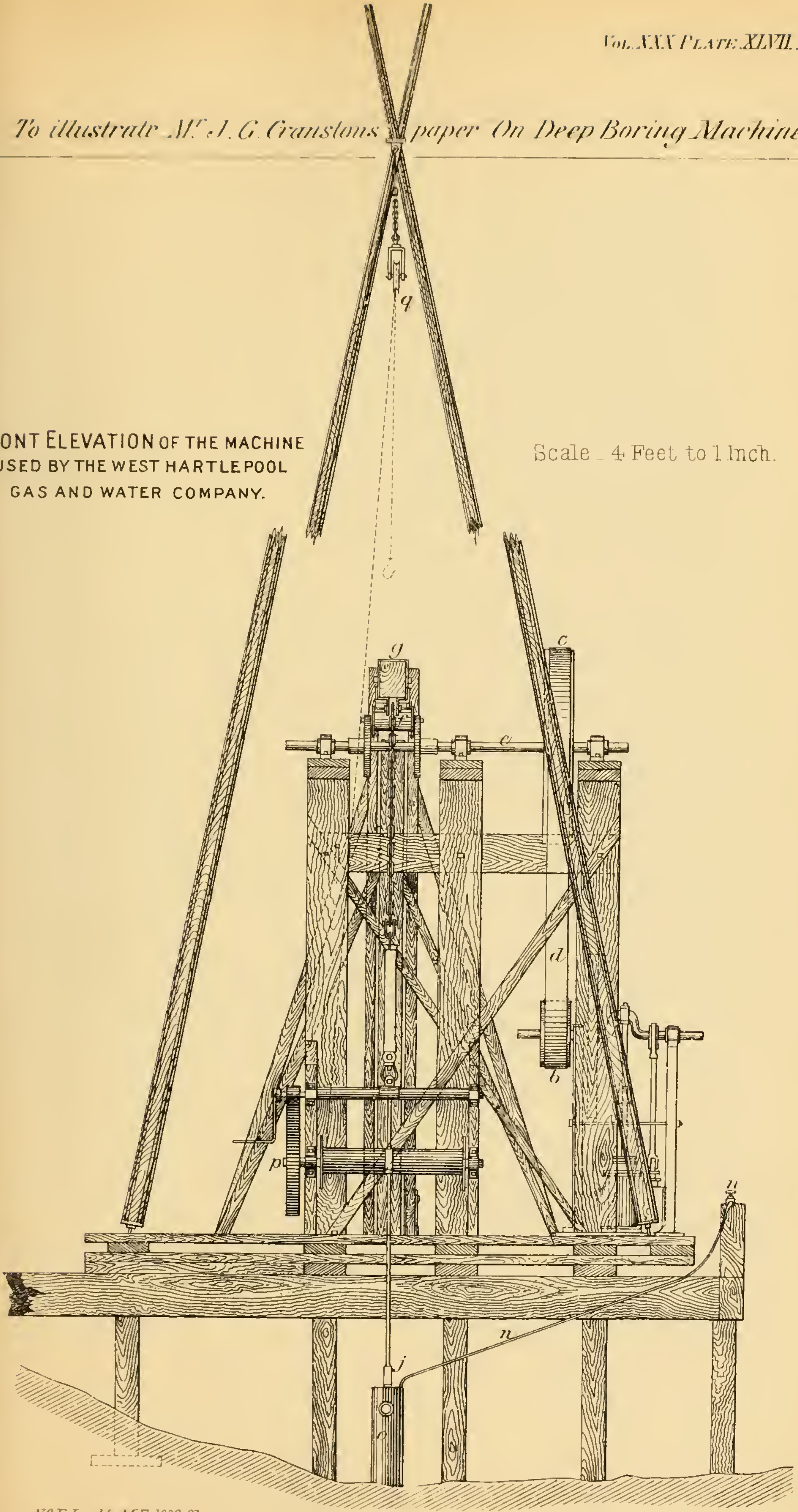


SIDE ELEVATION OF THE MACHINE USED BY THE WEST HARTLEPOOL GAS AND WATER COMPANY.

Scale _ 4 Feet to 1 Inch.

Vol. XXX Plate XLVII.

To illustrate Mr. J. G. Cranstons paper On Deep Boring Machines.



FRONT ELEVATION OF THE MACHINE
USED BY THE WEST HARTLEPOOL
GAS AND WATER COMPANY.

Scale _ 4 Feet to 1 Inch.

Proceedings No. E. I of M&M.E. 1880-81.

Andw Reid Newcastle

ment, and should be inspected by some impartial engineer. It was almost impossible to mention within the limits of a paper of this description all the different kinds of boilers in use, or all the improvements which had been made in late years; he had simply mentioned one or two of the types familiar to himself, and did not wish by any means to exclude other types that might be equally good. Since writing the paper he had had the opportunity of seeing Fox's corrugated flues, and he believed they were exceedingly good. He wished to qualify one statement in his paper, and that was where he rather condemned the use of steel plates for steam boilers. After what he had heard at a discussion, which took place at one of the meetings of the Mechanical Engineers during the week, he was inclined to modify the views which he had expressed, as it appeared that steel of a very much better quality was now being produced than had been made in past years.

Mr. A. L. Steavenson said, the remarks of Mr. Morison with respect to Government interference opened a very wide question. He had had boilers inspected by independent inspectors for twenty-five years, and recommended this course, but it was a very different thing to having a Government inspector reporting that the boiler was right, for were this done it might be assumed that, if an accident occurred, all responsibility would be removed from the owner of the boiler. That was the principal objection he saw to Government inspection; but otherwise he thought it would be an advantage.

Mr. Robert Thompson said, that he had had boilers with steel plates over the fire in use for six years, and they were as good now as when they were put in.

Mr. D. P. Morison said, he rather alluded to the use of boilers constructed entirely of steel and not so much to the use of steel plates over the fire. Some of the steel boilers put up in this neighbourhood had not by any means been a success, owing to the use of defective material; plates had scaled off, shrunk and split, and had to be replaced.

Mr. Newall said, there were good plates and bad plates. The boilers of the "Livadia" failed and had to be taken out. There were, on the other hand, good plates; and they had just heard mentioned an instance of steel plates being in use six years. Mr. Daniel Rowan, of Glasgow, had told him he had no more difficulty in using steel plates than in using iron plates, and found them answer well.

The President—Were the steel boilers apt to crack between the rivet holes?

Mr. MORISON—Yes; and that was one of the principal causes of failure, and they shelled very much.

Mr. A. L. STEAVENSON said, he could not see why there should be any more difficulty with boilers made of steel than there was with ropes made of steel.

Mr. S. C. CRONE said, steel ropes were used in the air, and the steel of boilers came in contact with water; and whether steel plates would be found more economical than iron plates would depend upon the action of water.

Mr. E. F. BOYD said, in the case of boilers the steel plates were subject to the action of both water and fire; whereas steel ropes were not subjected to the action of either of these elements.

Mr. R. THOMPSON said, he had nine boilers in use, which were cleaned out once in about three weeks. The water was moderately good, and the steel plates stood as well as iron plates.

The PRESIDENT said, the same prejudice existed against the use of steel wire ropes when they were first introduced. It did not follow, because the steel which was originally manufactured was not so good as that which was made at the present day, that the prejudice should extend to the use of steel boilers.

Mr. JOHN COOKE asked if Mr. Morison could give them any particulars as to the corrosion of steel?

Mr. D. P. MORISON said he could not. The advance which had been made up to a recent date in the manufacture of steel had been towards obtaining a uniform ductility, and if that was accomplished it would overcome the difficulty which he had raised.

Mr. T. W. BUNNING asked if Mr. Morison could give any reliable infortion as to the mode of inspecting boilers in France and Belgium?

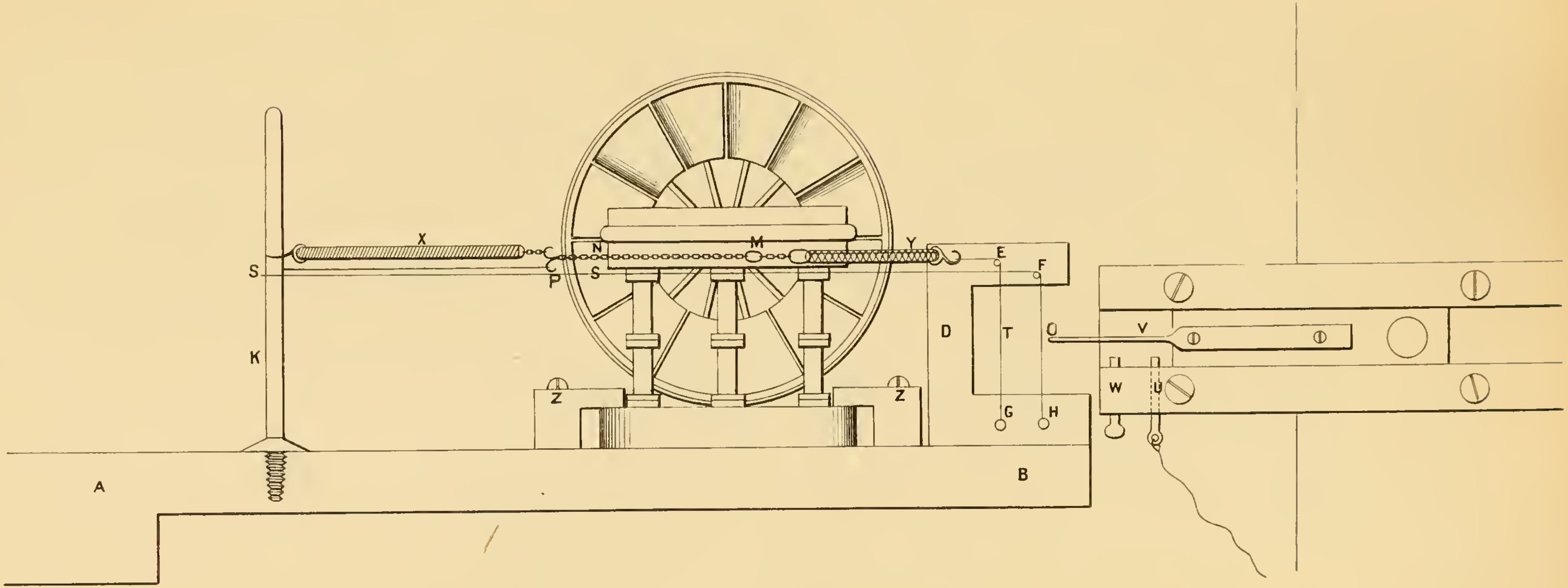
Mr. MORISON replied some results were given in his paper. He could not speak with certainty respecting France, but in Belgium, Germany, and Switzerland, the boilers were inspected by Societies connected with their respective Governments, and reports were made not only to the owners of the collieries and other places where the boilers were in use, but also to the Governments.

The PRESIDENT—Is it compulsory in Belgium to have boilers examined by these Societies?

Mr. MORISON—No. So far as the Government reports for that country were concerned the kingdom was divided into eleven districts, and, taking the districts one by one, it was proved that, in all the districts where

To illustrate the report of the Committee on "Mechanical Ventilators"

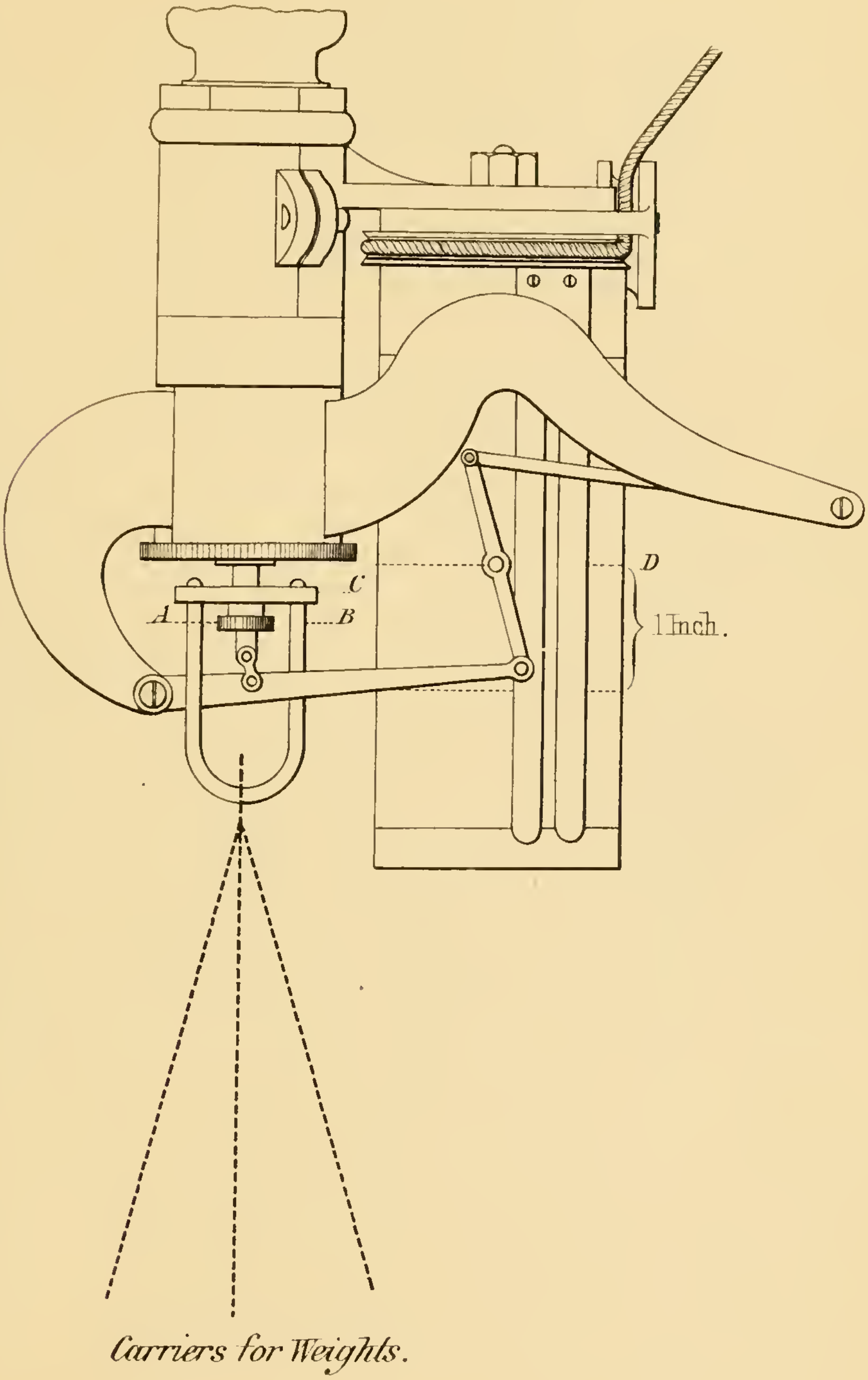
MACHINE FOR TESTING THE ANEMOMETERS, BY E.H.LIVEING.



Andrew Reid, Newcastle.

To illustrate the report of the Committee on "Mechanical Ventilators"

MODE OF TESTING THE INDICATOR SPRINGS.



Andw Reid Newcastle.

To illustrate the report of the Com

DRAWINGS OF VENTILATORS ALREA

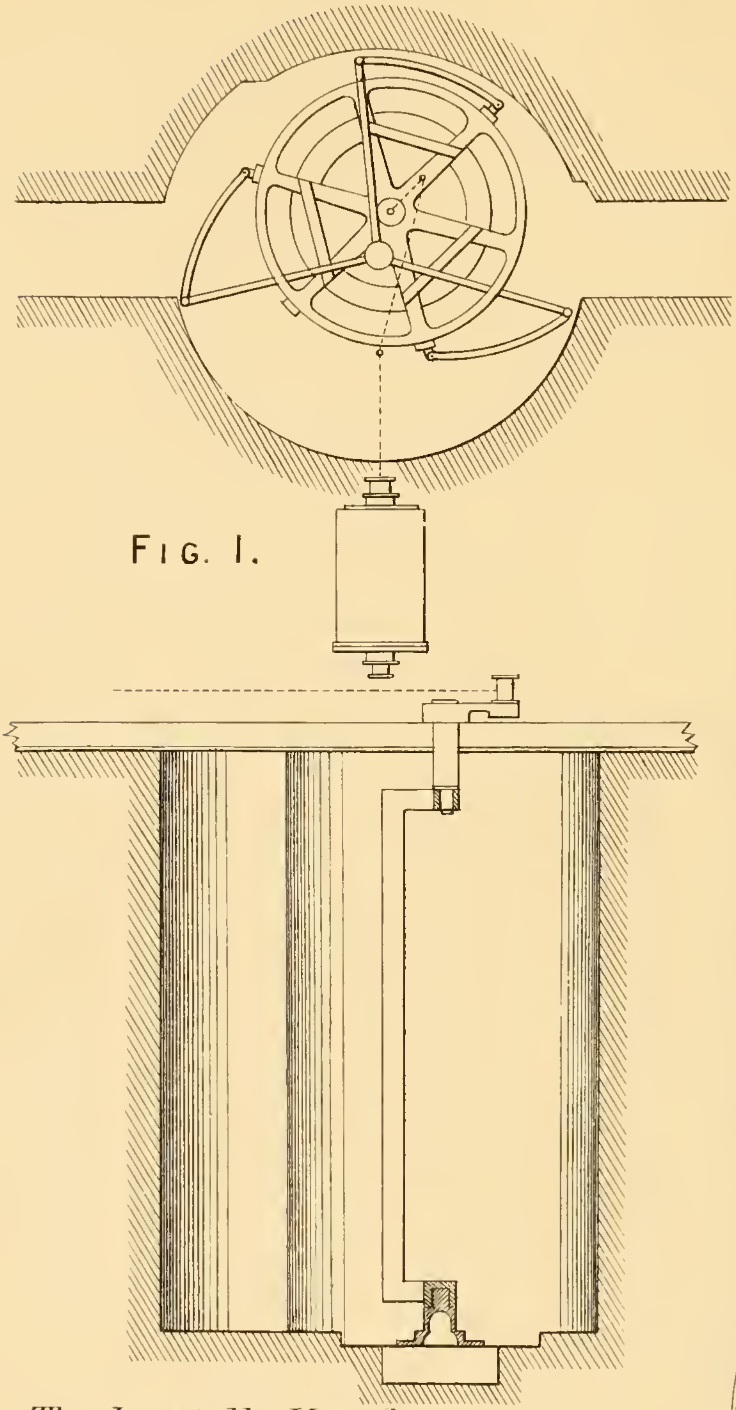
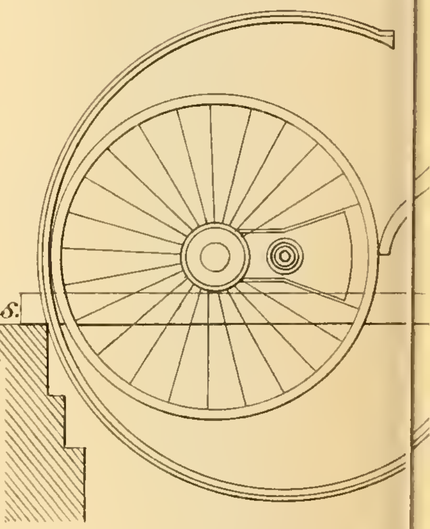


FIG. I.

The Lemielle Ventilator.
For details see Plates 7.8.9.10.11. Vol. 18 of Transactions.
Scale 1/160th

ELEVATION



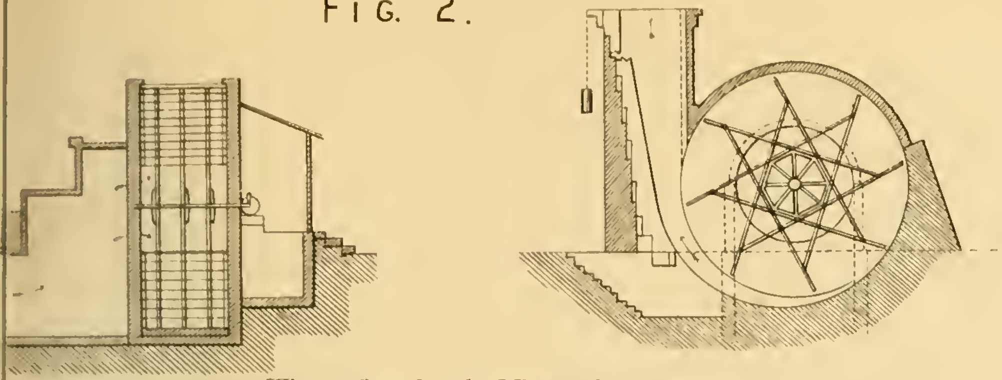
Proceedings N° E.I of M&M.E 1880 81.

For

ttee on "Mechanical Ventilators."

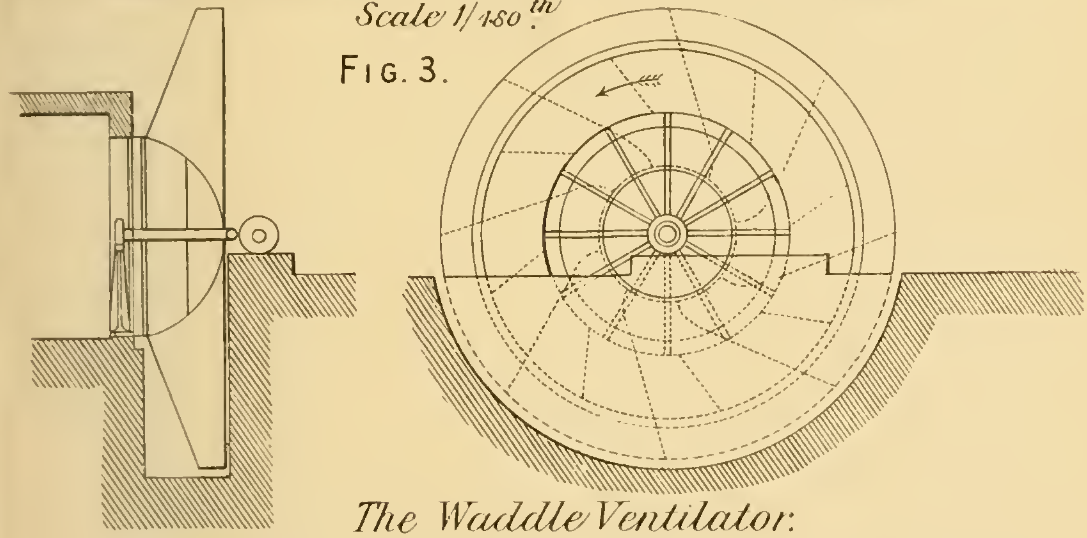
DESCRIBED IN TRANSACTIONS.

FIG. 2.



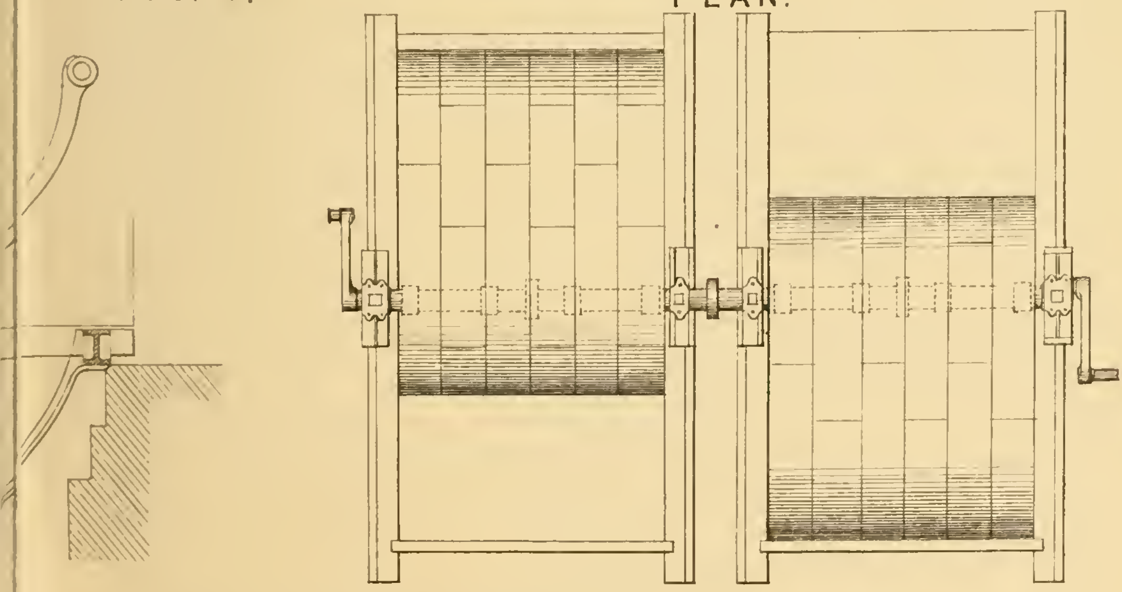
The Guibal Ventilator.
For details see Plates 69. 70. 71. Vol. 14 of Transactions.
Scale 1/180th.

FIG. 3.



The Waddle Ventilator.
For details see Plates 16 and 17 Vol 18 of Transactions.
Scale 1/240th.

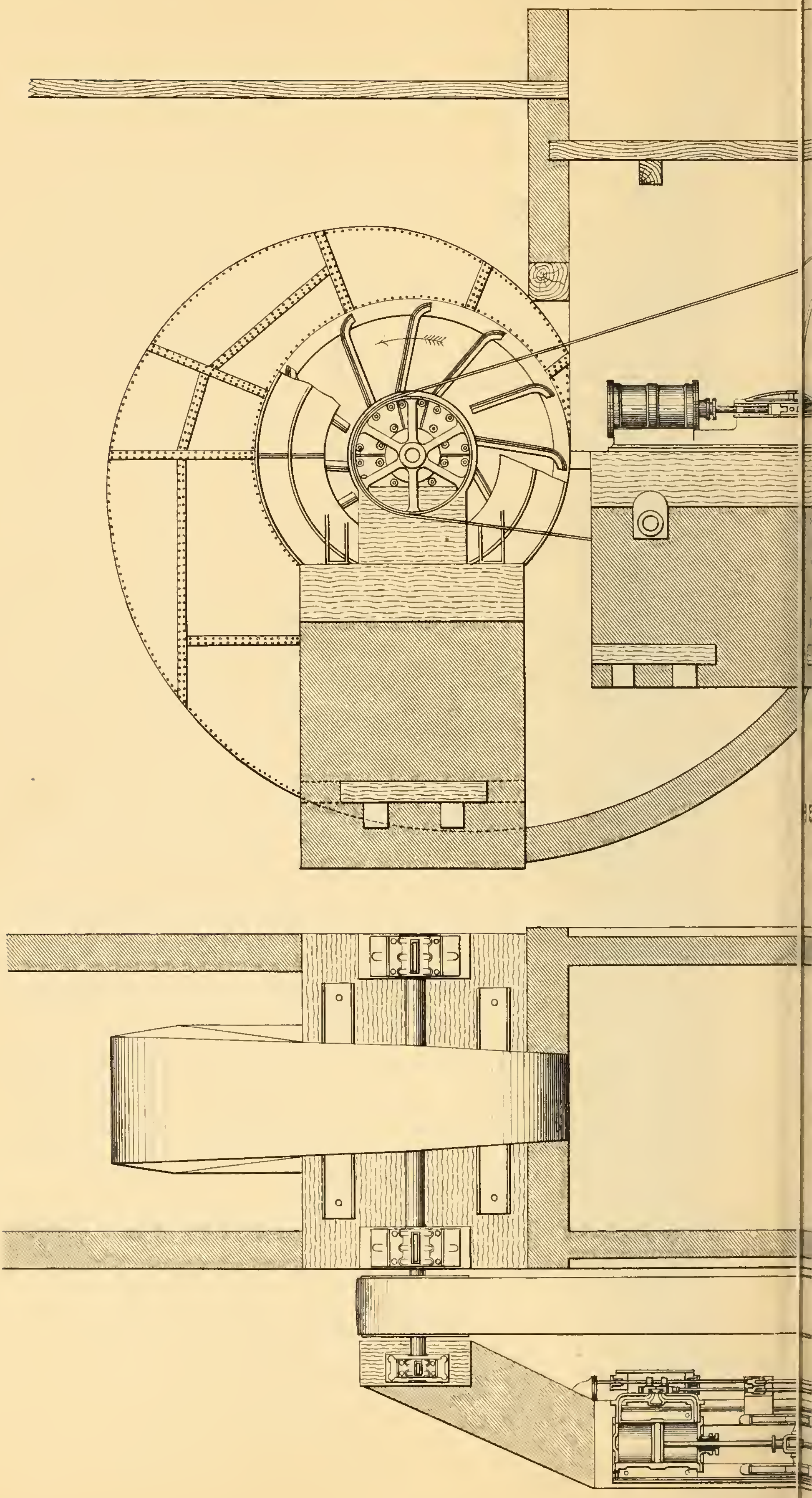
FIG. 4.



The Cooke Ventilator.
tails see Plates 23. 24. 25. Vol. 26 of Transactions.
Scale 1/117th.

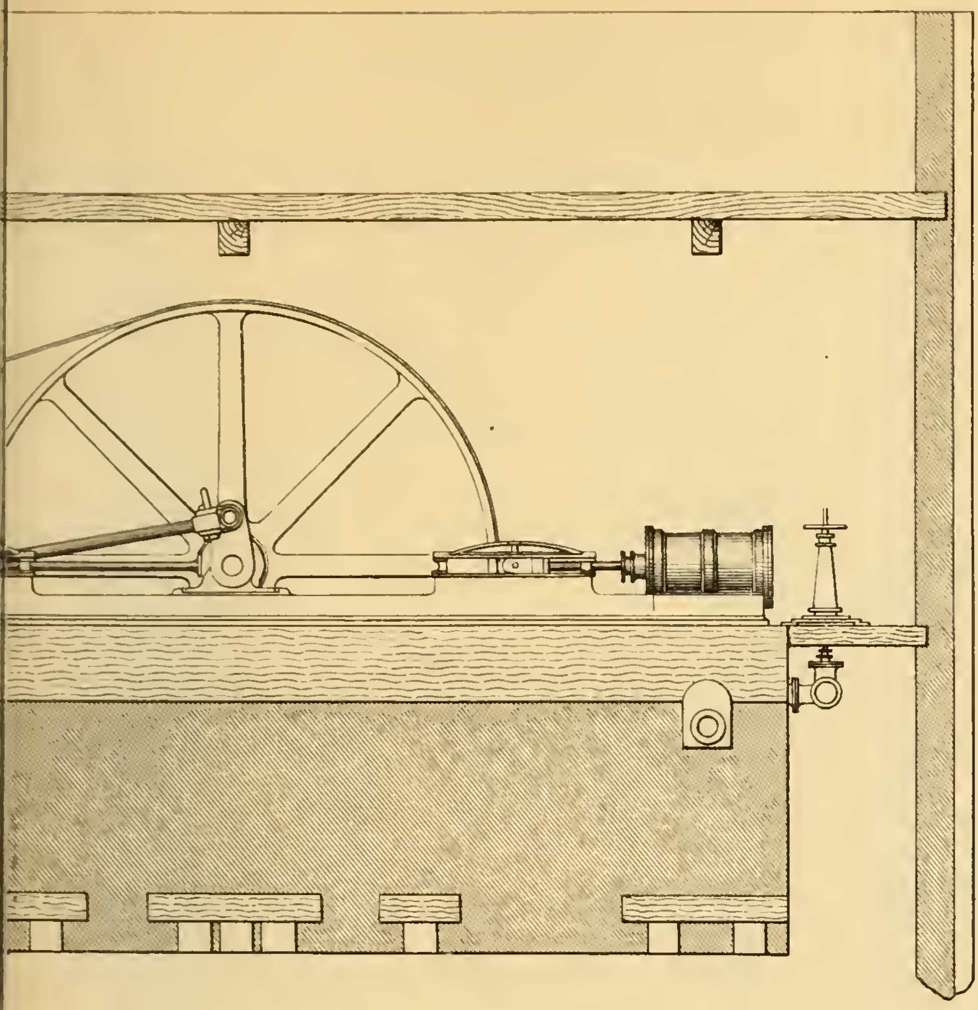
Andrew Reid, Newcastle

To illustrate the report of the C



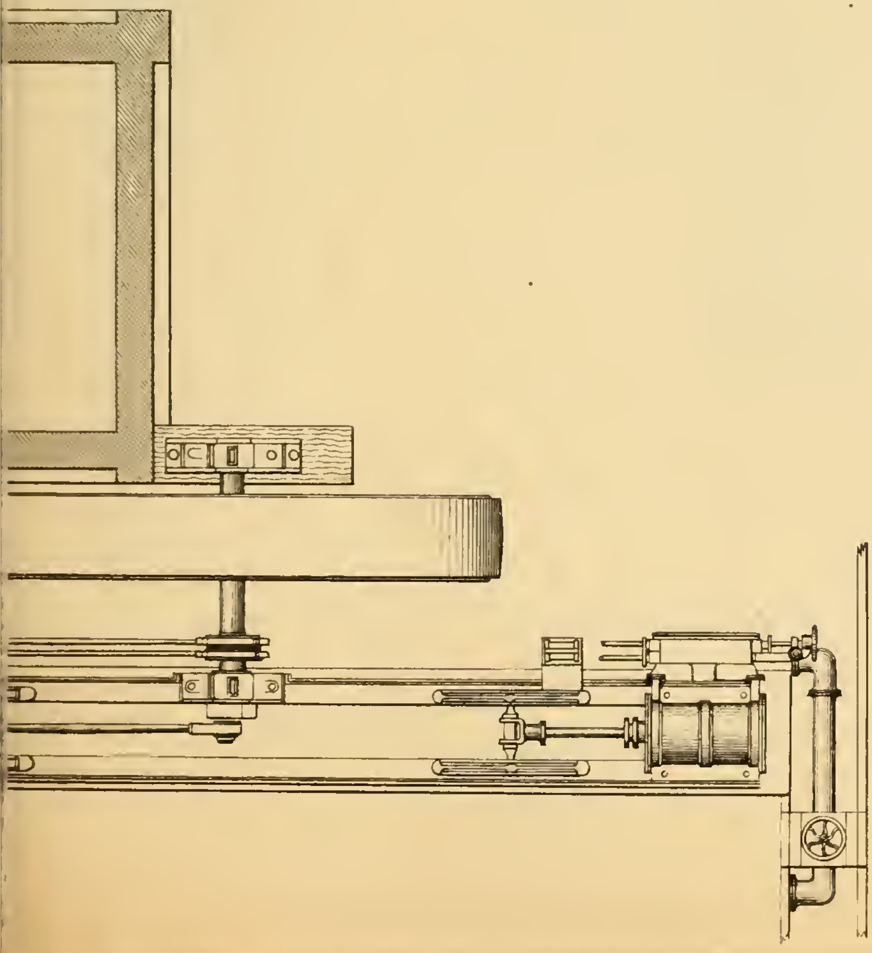
Proceedings N.º E. I of M&M.E. 1880 81.

mittee on "Mechanical Ventilators"



E SCHIELE VENTILATOR.

1/72 of Actual Size.

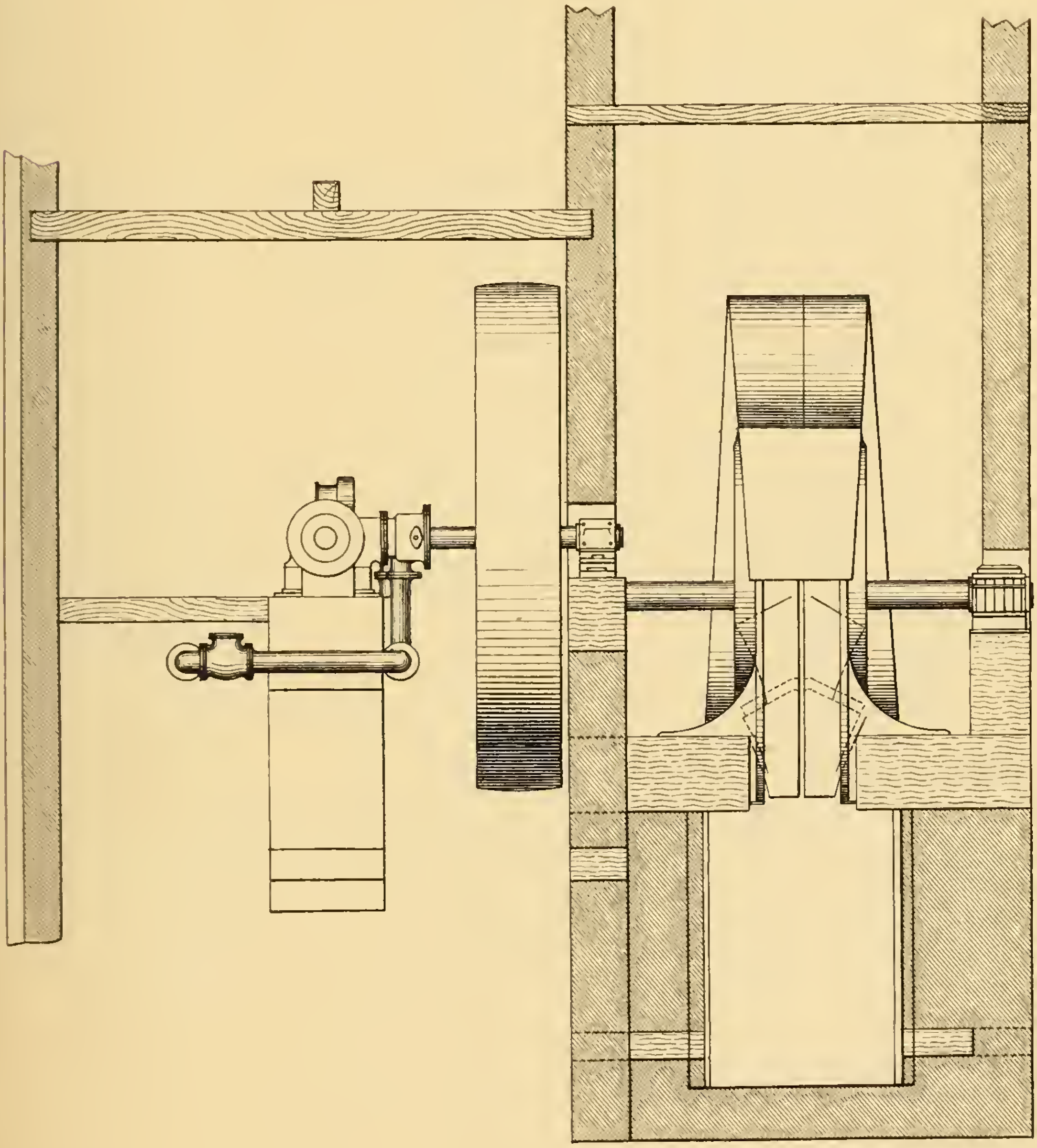


Andrew Reid Newcastle

To illustrate the report of the Committee on "Mechanical Ventilators"

THE SCHIELE VENTILATOR.

1/72 of Actual Size



Andrew Reid, Newcastle

To illustrate the report of the Committee on "Mechanical Ventilators."

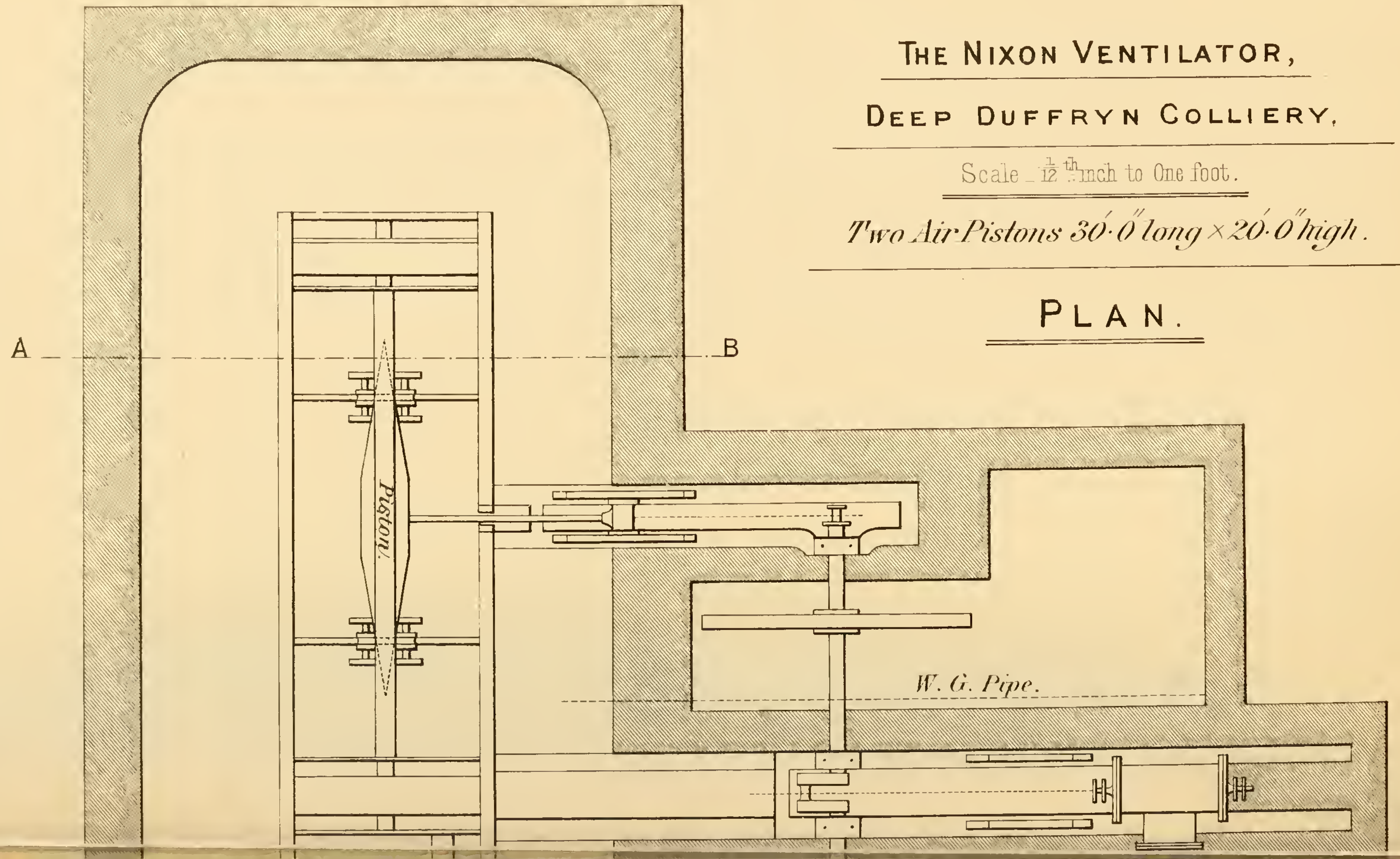
THE NIXON VENTILATOR,

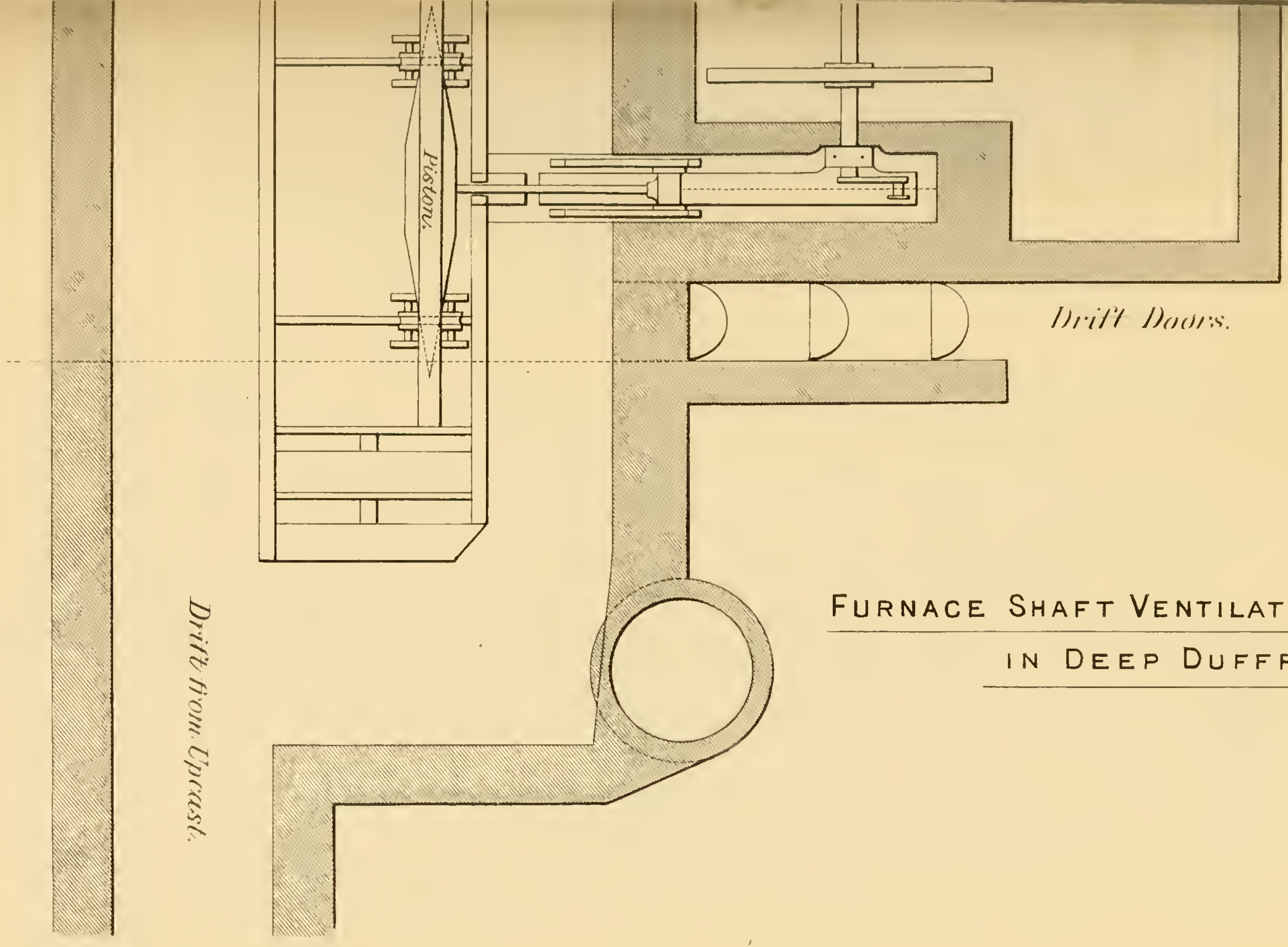
DEEP DUFFRYN COLLIERY,

Scale $\frac{1}{12}$th inch to One foot.

Two Air Pistons 30′·0″ long × 20′·0″ high.

PLAN.





FURNACE SHAFT VENTILATING WORKINGS.

IN DEEP DUFFRYN.

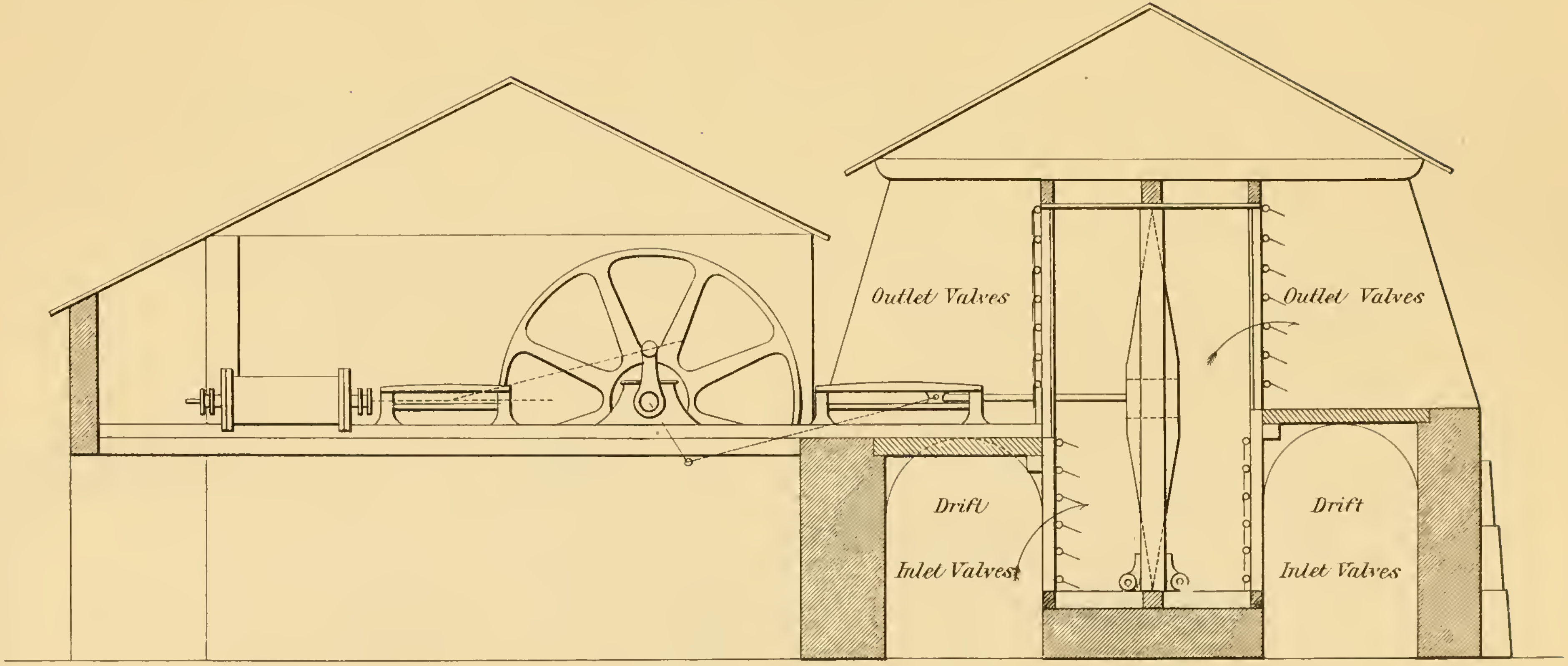
Proceedings Nº E I of M&M.E. 1880 81.

Reid Newcastle

To illustrate the report of the Committee on "Mechanical Ventilators"

THE NIXON VENTILATOR

CROSS SECTION THROUGH LINE A.B SEE PLAN.

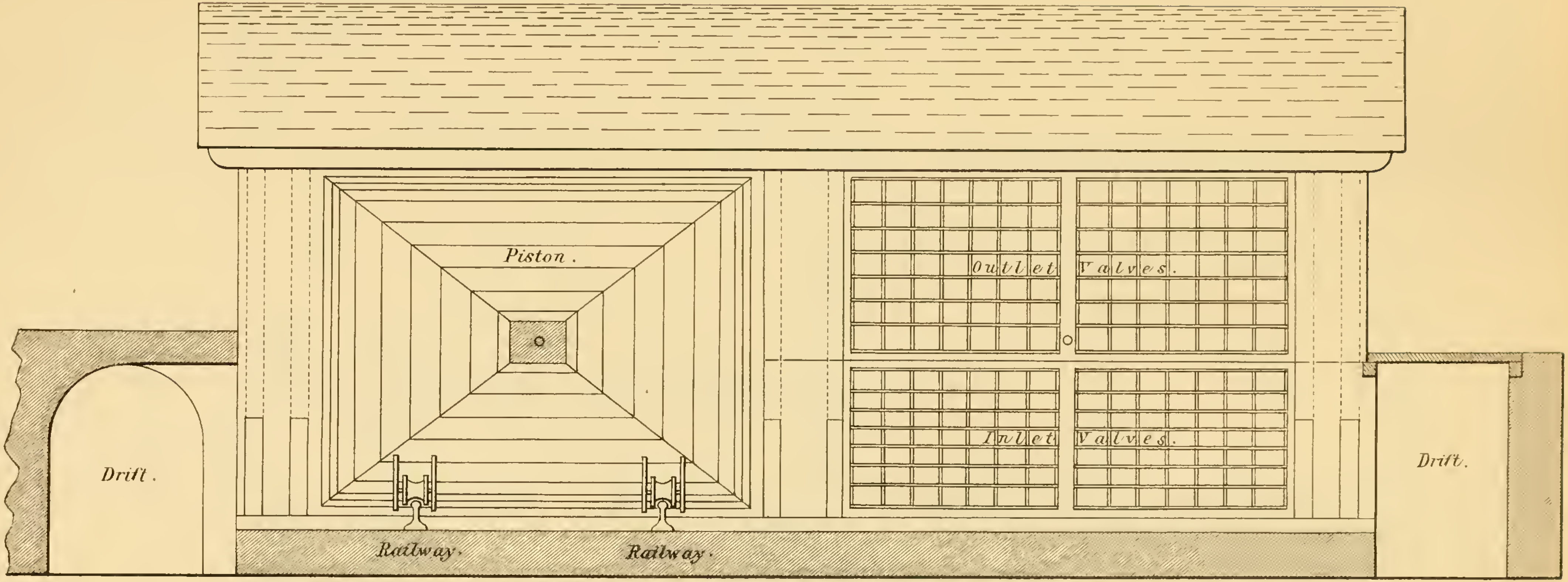


Andrew Reid Newcastle

To illustrate the report of the Committee on "Mechanical Ventilators."

THE NIXON VENTILATOR

SECTION AND ELEVATION OF CHAMBERS.

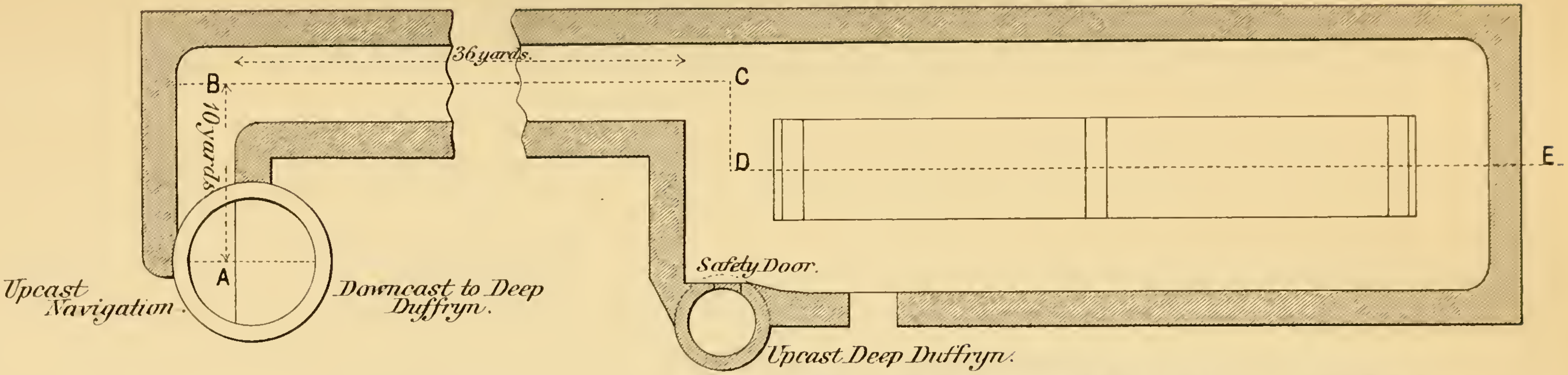


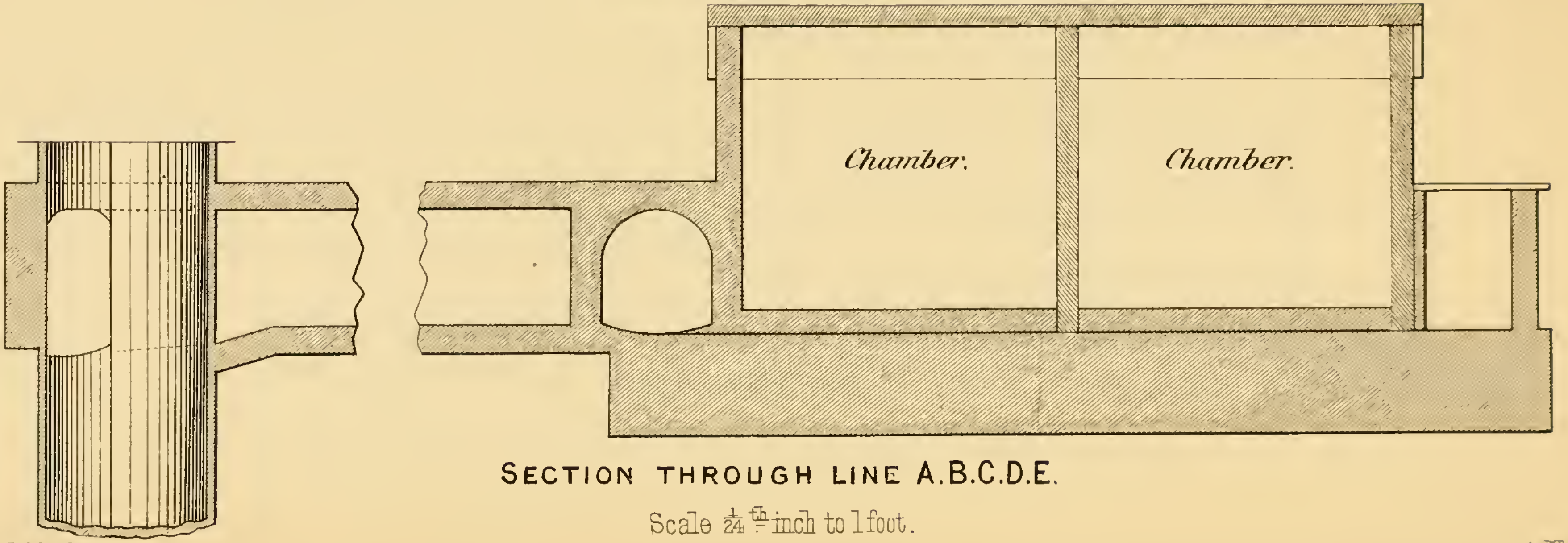
Scale $\frac{1}{12}$th Inch to 1 foot.

Andrew Reid, Newcastle

To illustrate the report of the Committee on "Mechanical Ventilators"

THE NIXON VENTILATOR PLAN OF VENTILATOR DRIFT.





SECTION THROUGH LINE A.B.C.D.E.

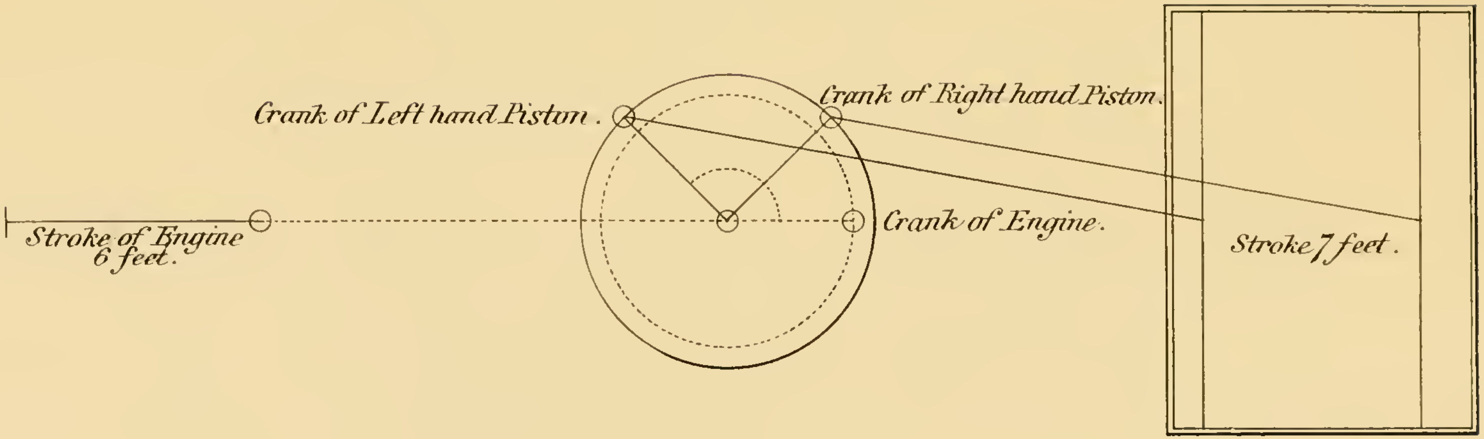
Scale $\frac{1}{24}$th inch to 1 foot.

Andw Reid Newcastle

To illustrate the report of the Committee on "Mechanical Ventilators."

THE NIXON VENTILATOR.

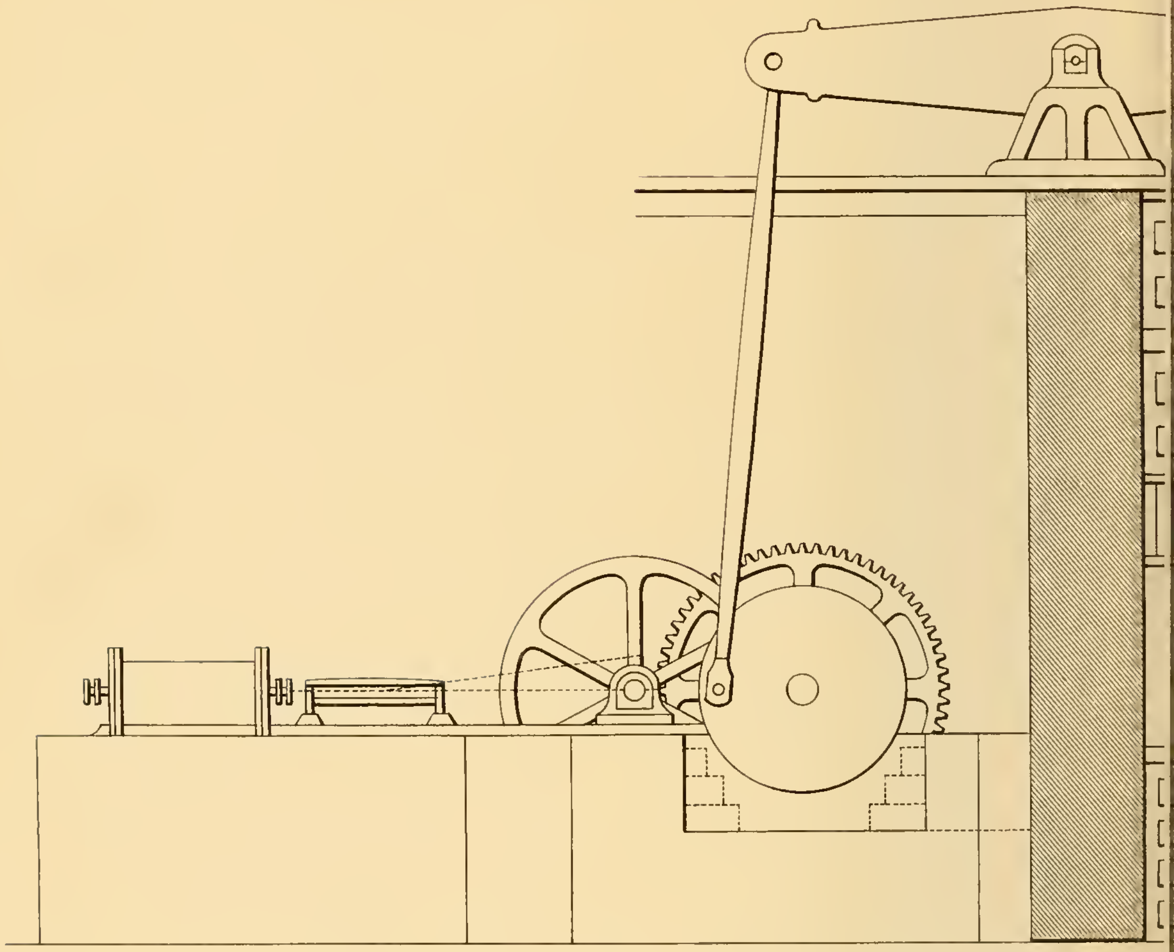
DIAGRAM SHEWING POSITION OF CRANKS OF ENGINE AND VENTILATOR.



Andw Reid Newcastle

To illustrate the report of the Com

THE STRUVE' VENTILATOR,



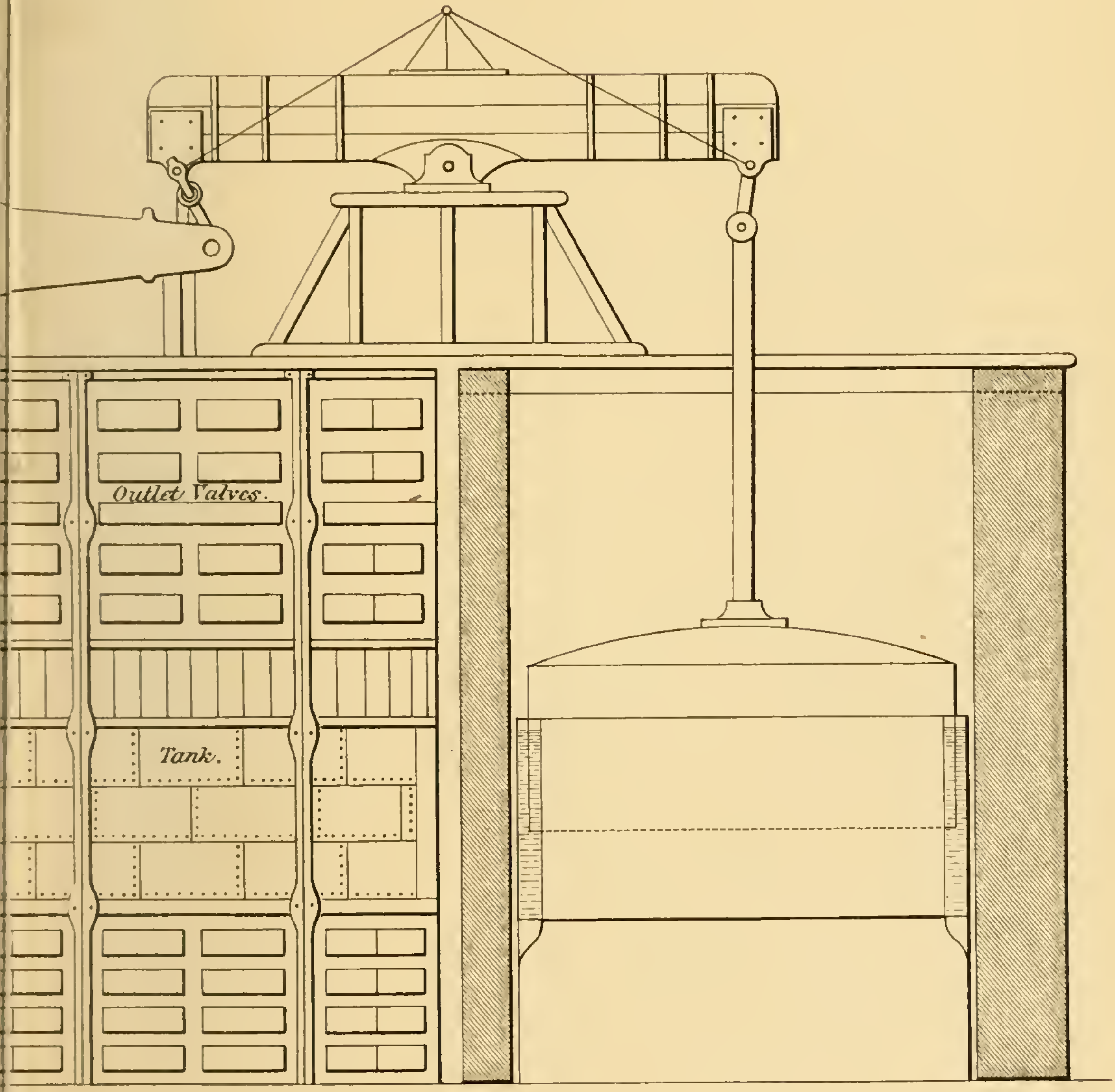
SIDE ELEVATION: C

Scale $\frac{1}{10}$ in

Proceedings N.º E.I of M&M.E 1880-81.

ittee on "Mechanical Ventilators."

YNSDAVID PIT, CWM AVON.



AMBER IN SECTION.

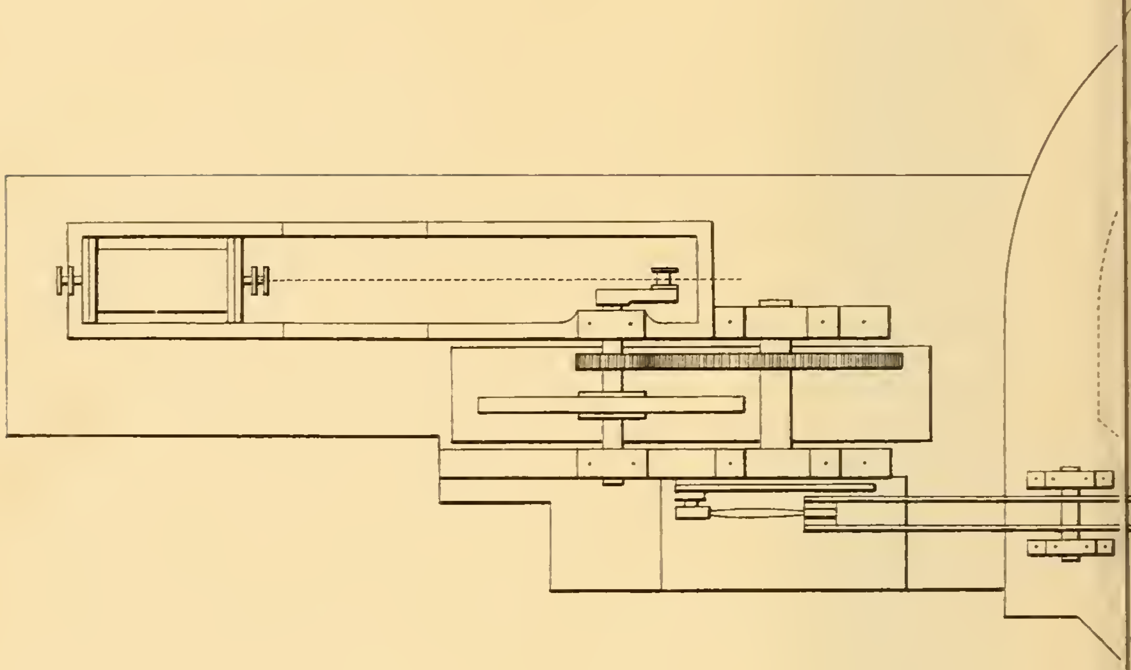
to 1 foot.

Andrew Reid Newcastle

To illustrate the report of the Co

THE STRUVÉ VENTILATO

P



Scale $\frac{1}{10}$th

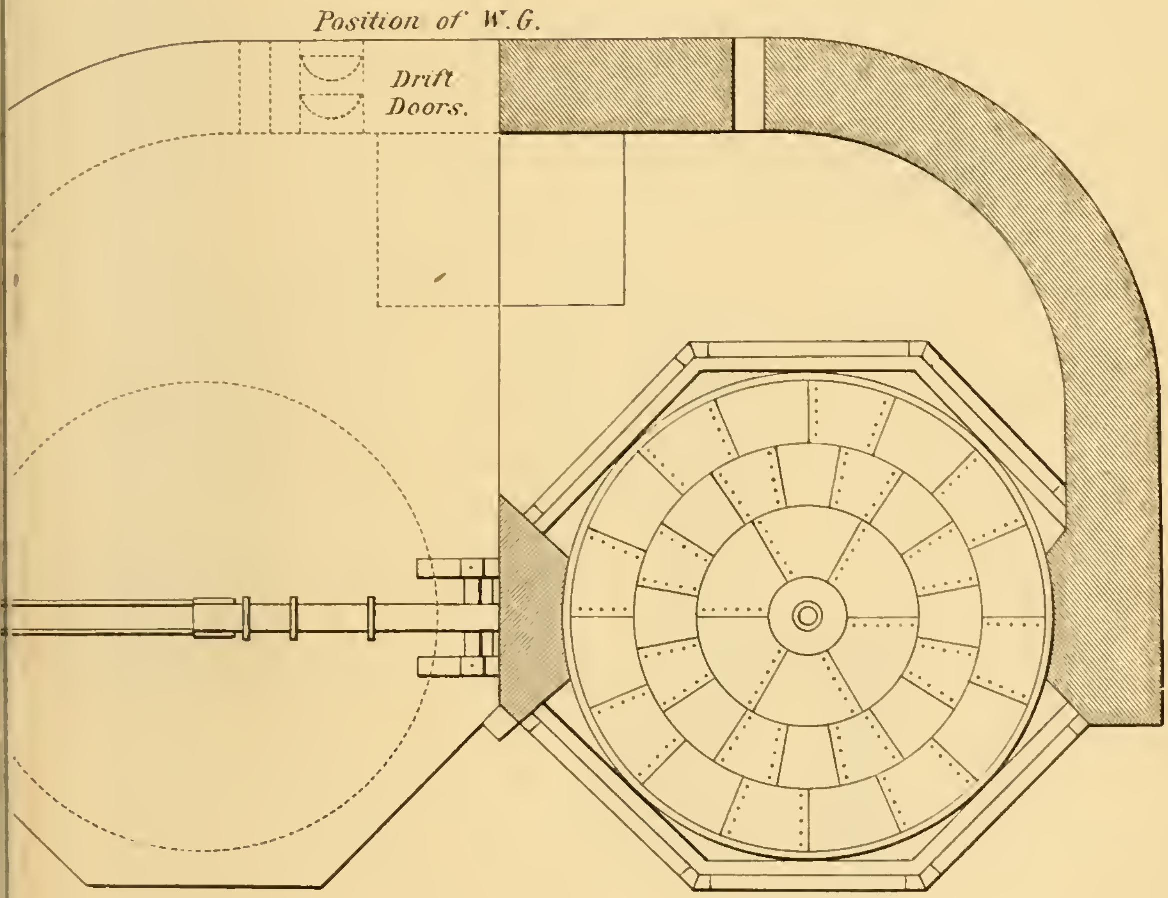
Proceedings Nº E.I of M&M.E 1880-81.

Vol. XXV Plate LIX.

nittee on "Mechanical Ventilators."

NYSDAVID PIT, CWM AVON.

AN.



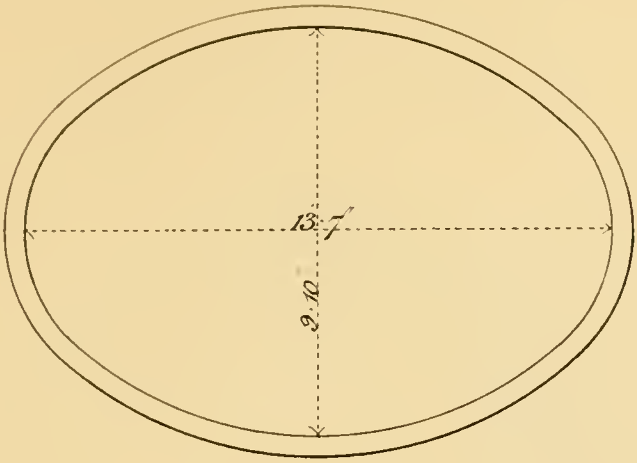
ch to 1 foot.

Andrew Reid, Newcastle

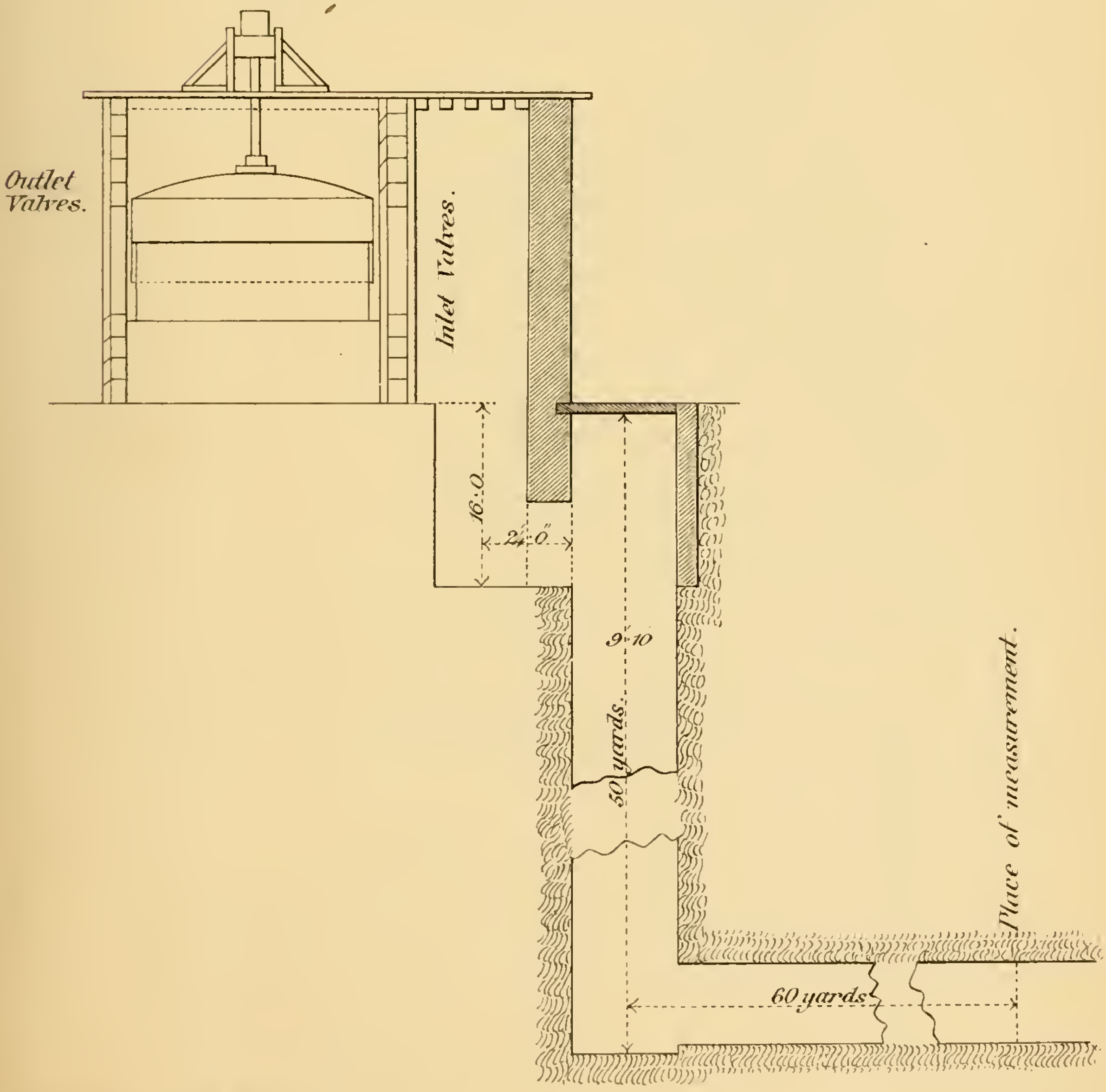
To illustrate the report of the Committee on "Mechanical Ventilators"

THE STRUVÉ VENTILATOR.

CROSS SECTION OF UPCAST SHAFT.



VERTICAL SECTION OF UPCAST SHAFT.



Proceedings No. V. I of N.&M.E 1880-81.

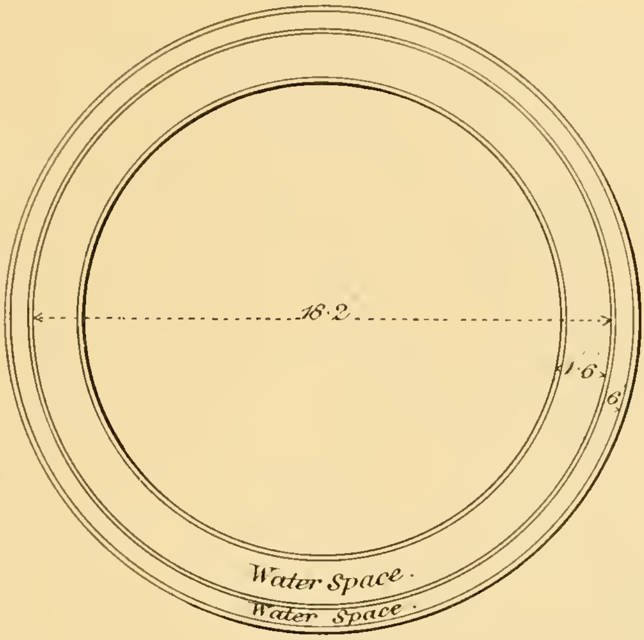
Andw Reid Newcastle

To illustrate the report of the Committee on "Mechanical Ventilators"

THE STRUVÉ VENTILATOR.

PLAN OF ANNULAR TANK.

FIG. I.

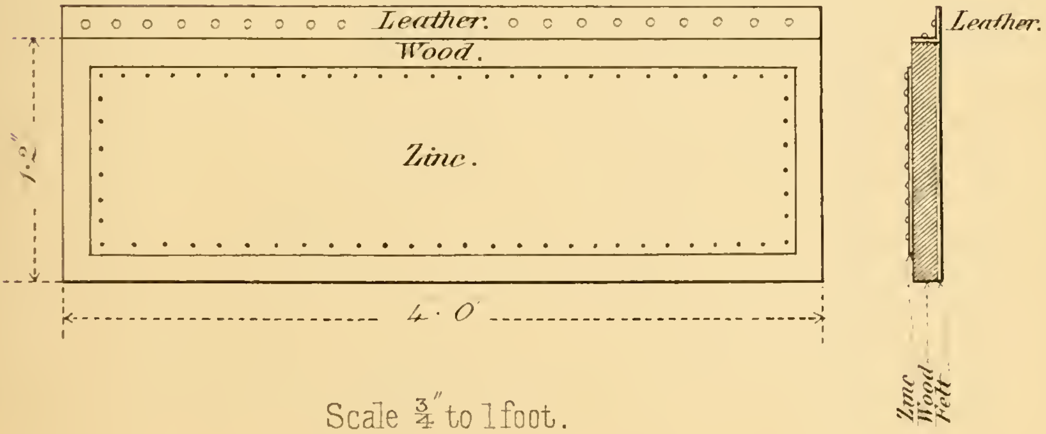


Scale $\frac{1}{8}''$ to 1 foot.

FIG. 2.

VALVES.

FRONT ELEVATION. SIDE ELEVATION.



Scale $\frac{3}{4}''$ to 1 foot.

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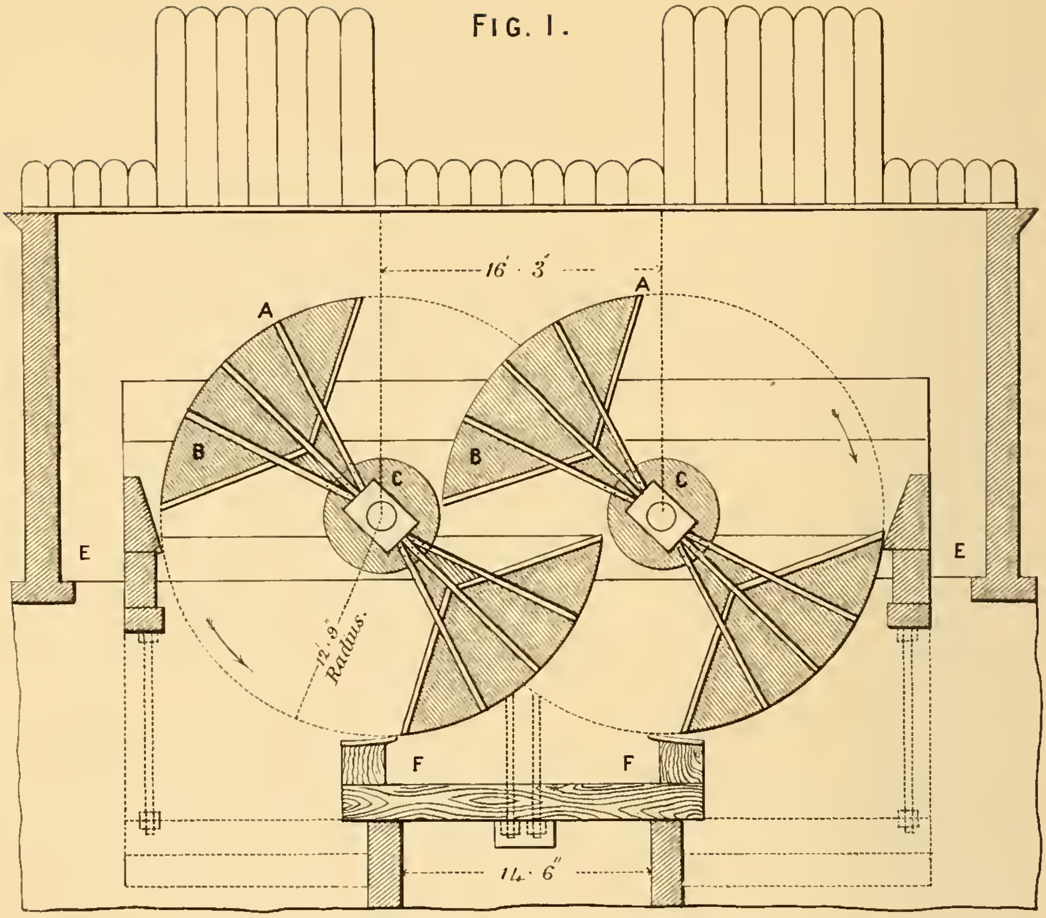
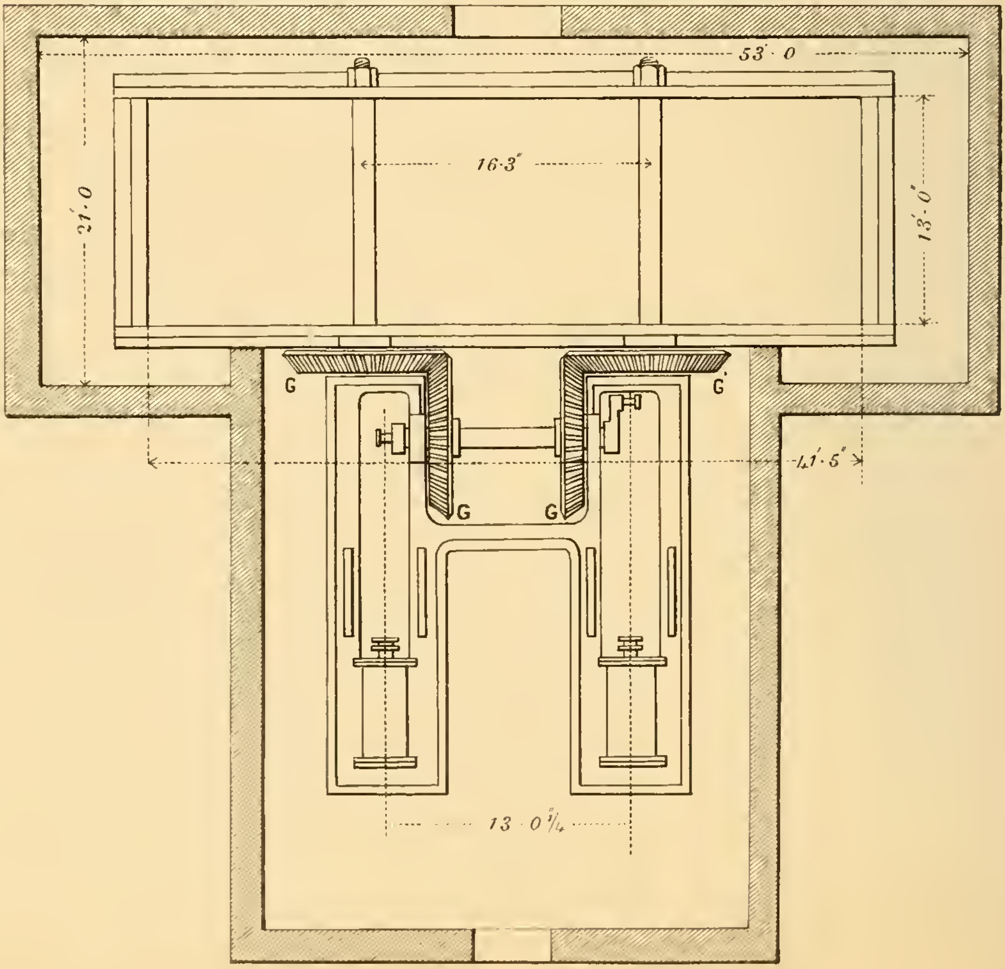
FIG. I.



CROSS SECTION OF VENTILATOR.

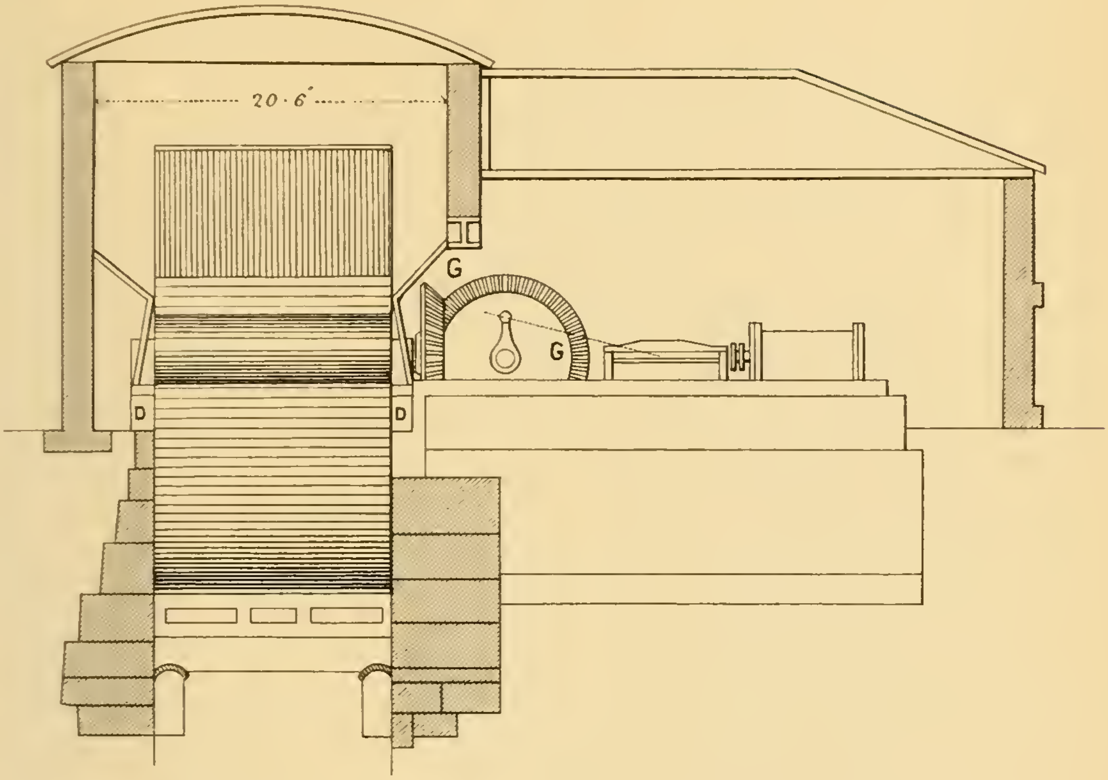
FIG. 3.



PLAN.

Proceedings N° 1 of M&M.F 1880 81.

Fig. 2.



CROSS SECTION OF VENTILATOR.

THE ROOTS VENTILATOR.

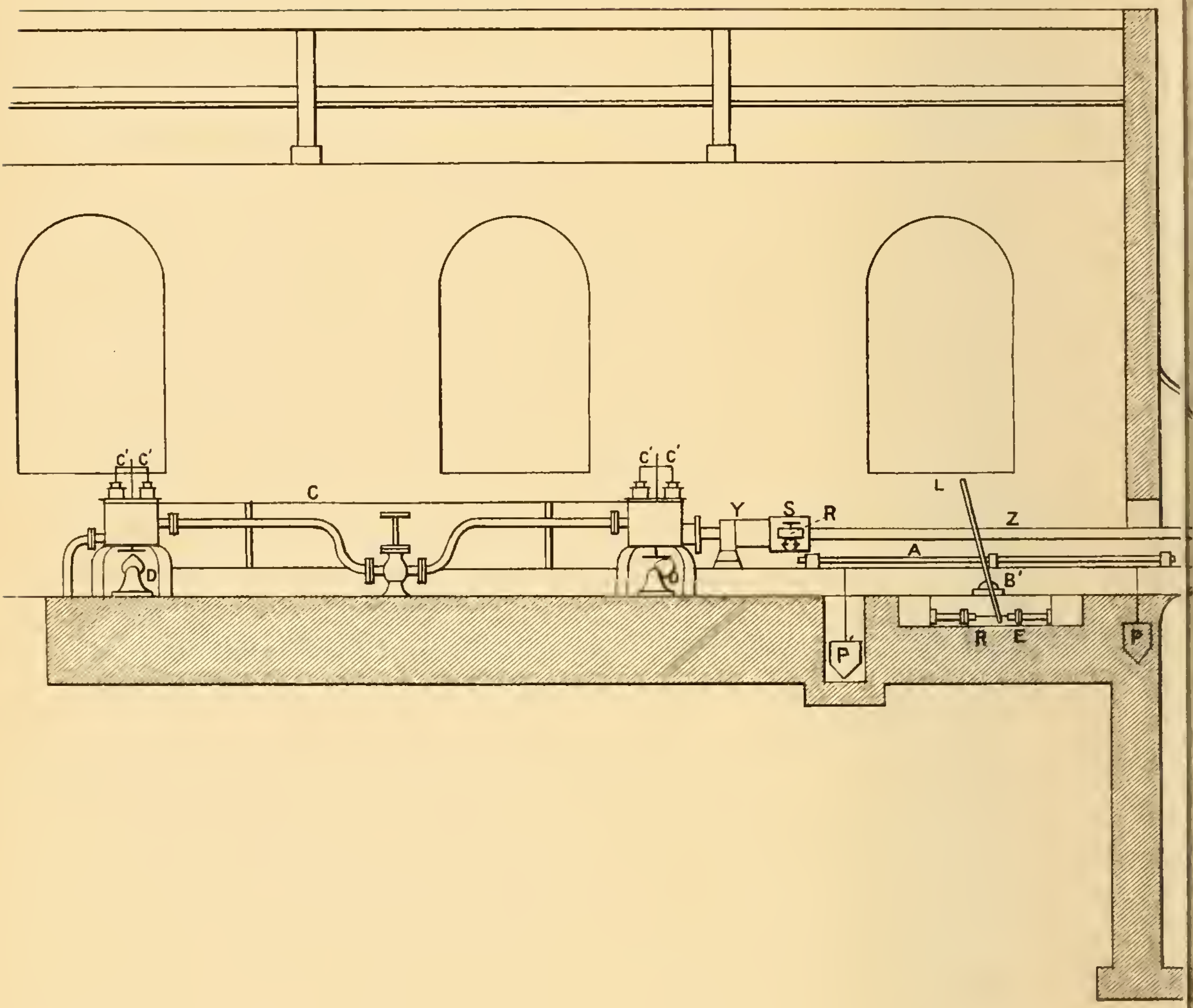
CHILTON COLLIERY.

Andrew Reid, Newcastle

To illustrate the report of the Com

THE GOFFINT

AT TILLEUR, LI



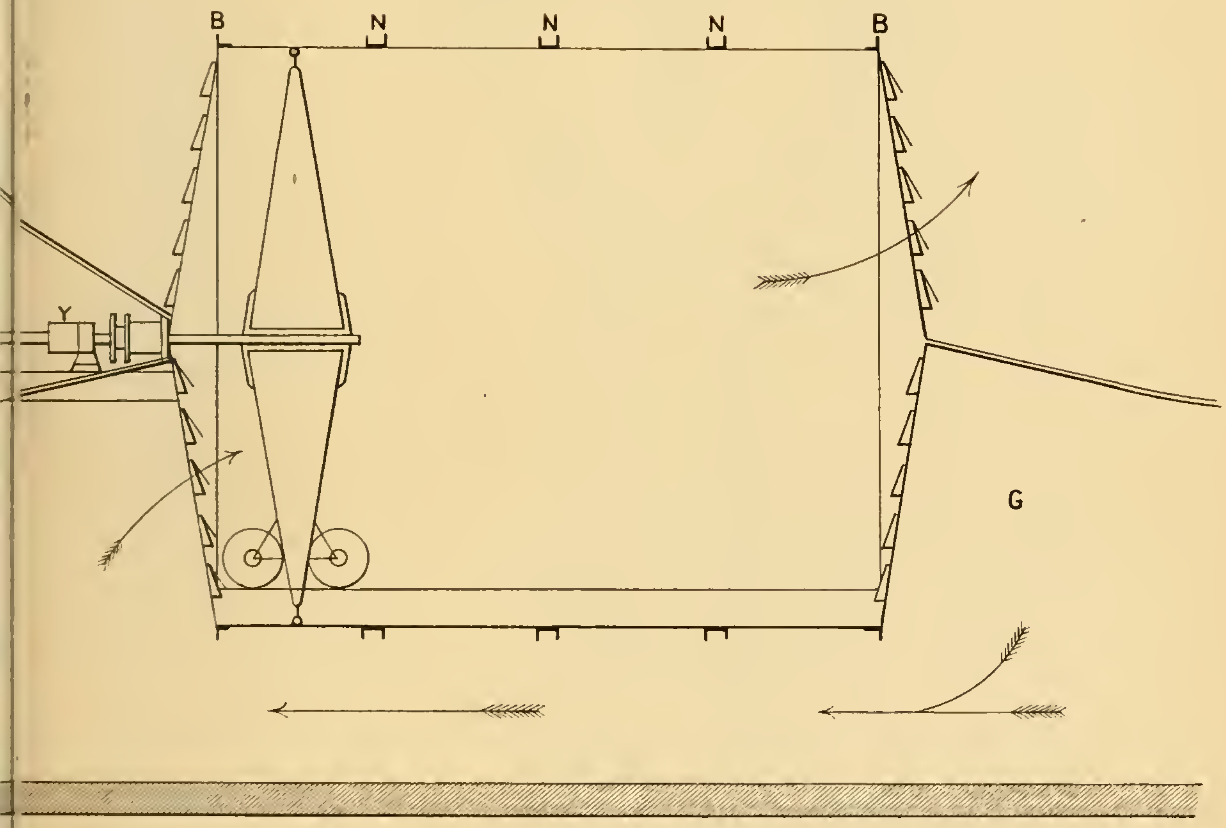
Scale $\frac{1}{200}$ of

Proceedings N.º E.I of M.&M.E. 1880 81.

ttee on "Mechanical Ventilators."

NTILATOR,

E, BELGIUM.



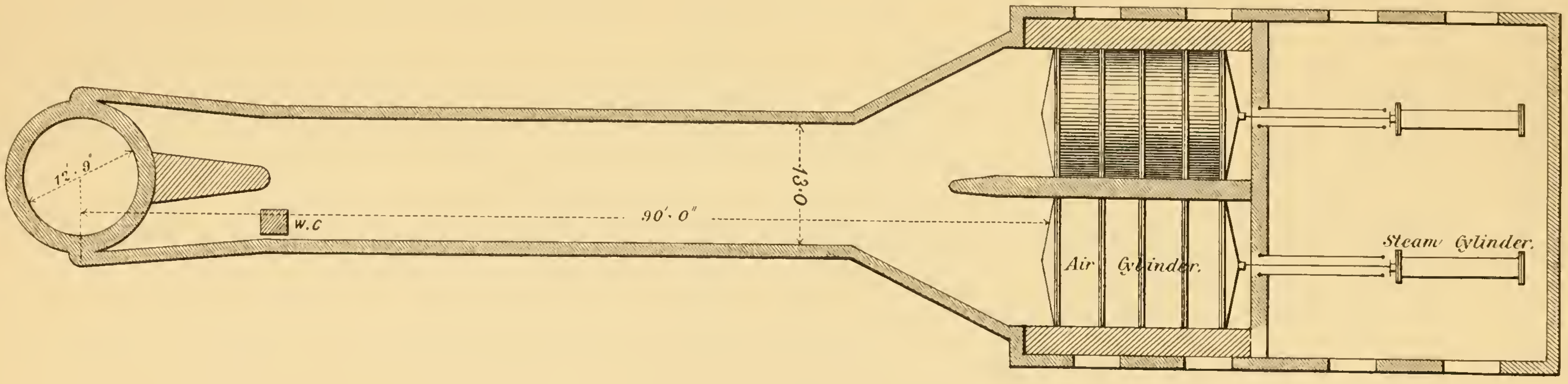
ctual Size

Andrew Reid Newcastle

To illustrate the report of the Committee on "Mechanical Ventilators."

THE GOFFINT VENTILATOR.

PLAN OF VENTILATOR DRIFT.



Proceedings N.º E. I. of M. & M. E. 1880-81.

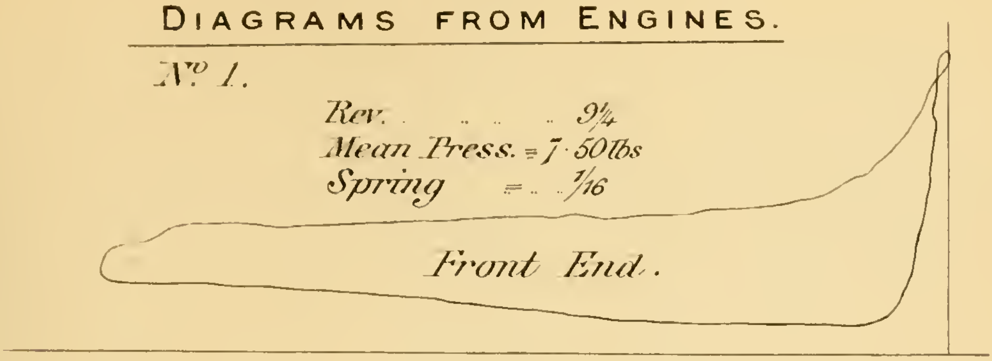
Andrew Reid, Newcastle.

To illustrate the report of the Committee on "Mechanical Ventilators"

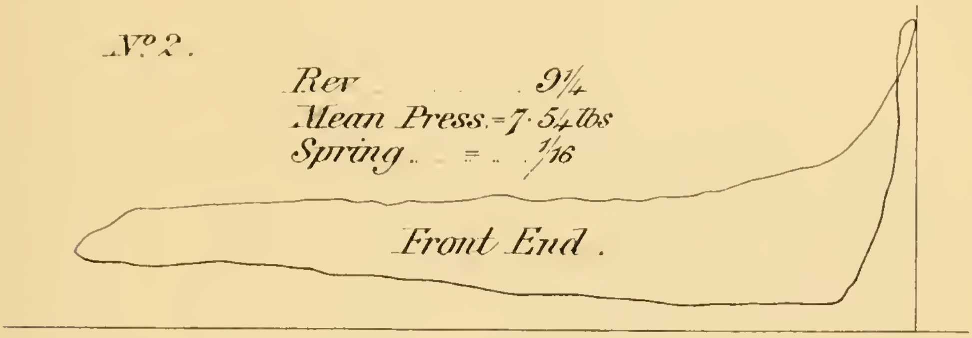
THE GOFFINT VENTILATOR.

DIAGRAMS FROM ENGINES.

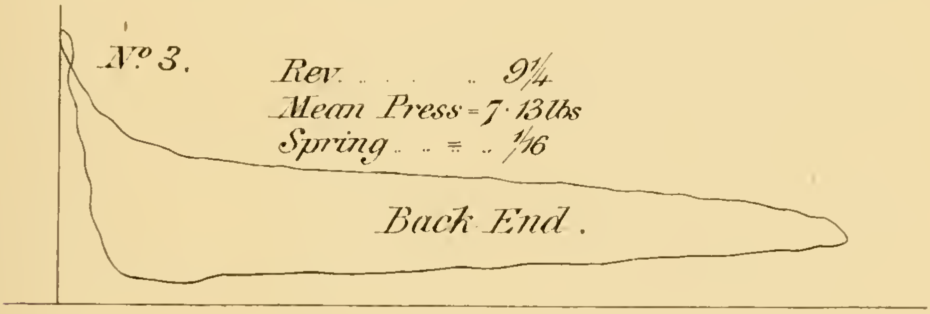
Nº 1.



Nº 2.



Nº 3.



DETAILS OF VALVES.

Front Elevation.

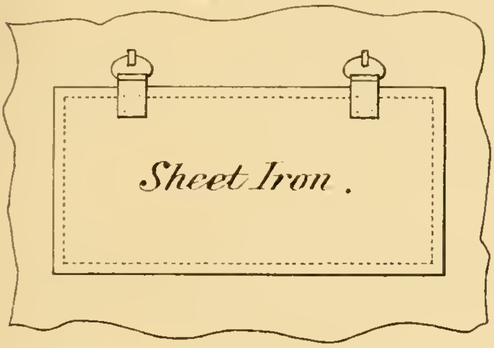


FIG. 1.

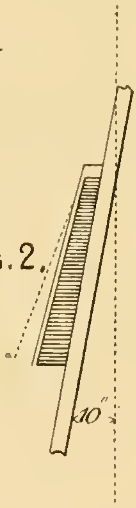


FIG. 2.

Cover Removed.

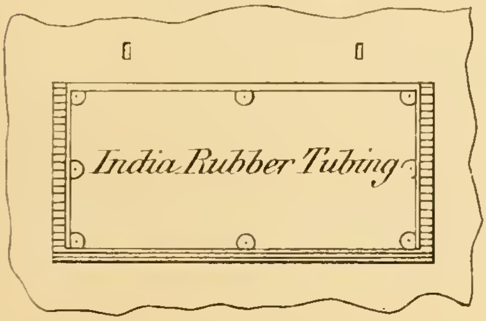


FIG. 3.

Scale ¾ inch to 1 foot.

Proceedings Nº E.I of M&M.E 1880 81.

Andw Reid, Newcastle

independent inspection was employed, the number of deaths from explosions was very much smaller than in those districts where no extraneous inspection took place. In Northumberland and Durham, where there was much independent inspection, there were only seven deaths in 1879, whilst in South Wales, where there was no inspection at all, there were sixty-three deaths.

VISIT TO CLEVELAND.

The President said, Mr. A. L. Steavenson had been kind enough to invite the members of the Institute to visit Cleveland on the 9th September, to see some matters of interest with respect to the sinking of a shaft, putting in tubbing, etc., and he (the President) thought it would not be unprofitable to some of the younger members, who probably had not had any experience in sinking, to witness what was being done there.

Mr. Steavenson said, his principal object in giving the invitation was to afford the younger members an opportunity of seeing the sinking operations in progress, as for several years there had been very little sinking done in this district. Two shafts of 100 fathoms each were being sunk; and the members could on the same day witness the operation of drilling in ironstone by machinery.

The Secretary then announced the result of the balloting for the election of officers for the ensuing year.

The President said—In leaving the Presidential chair after three years of office I cannot refrain from expressing my thanks for the great honour you have done me, and for the courtesy I have always received at the hands of the members.

An old member of the Institute, one who attended its opening meetings, I have watched its progress with the greatest satisfaction. I have seen with pride its proceedings quoted in all the leading scientific cyclopædias and other works devoted to scientific pursuits, translated into foreign languages and forming everywhere the starting point of all practical information on that most interesting subject—Mining. I have seen it grow in power and dignity, and its efforts to save life receive the acknowledgment of the Legislature. I have regarded with pleasure and satisfaction the advent to its ranks of that class of the profession to which mining is so much indebted—the Mechanical Engineers; and I have watched with gratified interest the increased accession to its ranks of Students; and I repeat, I feel proud that I have been permitted to participate in its councils and to hold that most coveted of all honours to the Mining Engineer, the position of its President.

Gentlemen, the only way to cause an Institute such as this to flourish is for its members to cherish it, to carry their love for it wherever they go, into foreign lands, into our colonies, and into those vast resources of mineral wealth yet unwrought in our imperial possessions; and it is with pleasure I note in the list of members many foreign addresses, and these, I trust, will increase with each new facility afforded by the Post-office for the interchange of correspondence.

I cannot conclude my observations without saying a few words respecting the Students who form so important a portion of our number; if you can once get them to become earnest and active members you will increase their chance of success in after life, and will give them, where successful, a respect and veneration for their *alma mater*, so to say, which will appear in the usefulness of their contributions to your pages.

A student of any profession, if he is worth anything, is naturally modest, and hesitates to utter his opinion in the presence of men whose knowledge he appreciates. There is much, however, of knowledge which he could elicit by participation in the discussions, but it is possible that he could obtain much more if he had more frequent opportunities of meeting his fellow-students and comparing notes with them. Nothing is so valuable to young men as visiting different districts and freely discussing with their equals in age and position subjects vital to all; and I trust the Council may find some way of giving the Students increased prominence and affording them greater opportunities of becoming directly interested in the success of the Institute. If this be done, depend upon it your labour will not be thrown away, and your country will thank you for the interest you have taken in a class who will in future be called upon to fulfil the important offices of Mining Engineers and be entrusted with the lives and property of their fellowmen.

Mr. E. F. Boyd said, they ought not to allow the meeting to conclude until they had returned their sincere thanks to Mr. Greenwell for the services he had rendered as President of the Institute. Having had the honour himself of filling the same position he was able to judge of the nature of the duties which Mr. Greenwell had had to perform. It was well known that an active Council was of inestimable value in encouraging the growth generally of a Society such as theirs, but over that Council there must be a ruling head; and he thought they would agree with him that Mr. Greenwell had filled the position of President in an able, dignified, and courteous manner. In the remarks which he had just made, Mr. Greenwell had used the word modesty; and he thought that that word was particularly applicable to Mr. Greenwell himself, a man of pre-eminent standing and experience in the profession. He (Mr. Boyd) had, like Mr. Greenwell, been a member of the Institute since its formation. He was present at the first meeting after the accident at Seaton, and he had experienced great satisfaction, and felt it an honour to have been one of its Presidents. He had much pleasure in proposing that a hearty and sincere vote of thanks be passed to Mr. Greenwell for the earnest interest he had taken during the three years of his Presidency in promoting the success of the Institute.

Mr. W. H. HEDLEY seconded the vote of thanks. He was sure they must all be satisfied that the Institute had very greatly benefited by the vast and varied experience and knowledge in all matters relating to Mining Engineering, which their retiring President was endowed with.

The vote was carried by acclamation.

Mr. GREENWELL thanked the members most sincerely and heartily for their kind expressions, and said he wished he could feel that he had merited them.

REPORT OF THE COMMITTEE ON MECHANICAL VENTILATORS, APPOINTED APRIL 13TH, 1878.

THE experiments were undertaken by your Committee with a view to place, as far as possible, on an impartial basis for comparison, the results of working, under ordinary conditions, of the principal Ventilators at present employed for the ventilation of mines, and the practical carrying out of such experiments was placed in the hands of two engineers, Messrs C. S. Lindsay and E. H. Liveing.

The following machines were selected, and the experiments were made in the order in which they appear in the annexed Table :—

No.	DESCRIPTION.	SITUATION.	System Described in Transactions.
1	Guibal Fan ...	Hilda Colliery, South Shields ...	Vol. XIV., p. 73.
2	Waddle „ ...	Celynen Colliery, Abercarne, So. Wales	Vol. XIX., p. 227.
3	Schiele „ ...	Car House Colliery, Rotherham ...	......
4	Schiele „ ...	Corton Wood Colliery, Barnsley ...	......
5	Guibal „ ...	Pemberton Colliery, Wigan	......
6	Guibal „ ...	Cannock Wood Colliery, Hednesford, Stafford	......
7	Lemielle Ventilator .	Page Bank Colliery, Durham ...	Vol. XVIII., p. 63.
8	Struvé „ ...	Cwm Avon Colliery, Taibach, South Wales	This Report.
9	Nixon „ ...	Navigation Colliery, Aberdare, South Wales	Do.
10	Roots „ ...	Chilton Colliery, Ferryhill, Durham...	Do.
11	Cooke „ ...	Hutton Henry Colliery Durham ...	Vol. XIX., p. 17.
12	Goffint „ ...	Horloz à Tilleur Colliery, Liége, Belgium	This Report.

One half the number of the above ventilators, viz., those numbered from 1 to 6 inclusive, are centrifugal, and the other half, numbered from 7 to 12, are varying capacity, or displacement machines.

The results of the experiments, together with the dimensions of the machines experimented on, are given in the annexed table, Pages 289 to 292.

Some ventilators are included which cannot fairly be said to show what the system they represent is capable of doing under more favourable conditions, and to these your Committee will briefly refer.

LEMIELLE VENTILATOR, PAGE BANK COLLIERY.

This ventilator was examined because, as far as could be ascertained, it was the only one of its class at work in this country. It will be seen on reference to the tabulated results that the re-entry was more than half the theoretical delivery of air with the present low water gauge. The engine is stated to be too large for the ventilator, the mean steam pressure in the cylinder being five pounds per square inch at the highest speed at which it can be worked with safety.

NIXON VENTILATOR, NAVIGATION COLLIERY.

This also is the only ventilator of its class at present working in this country. Considerable leakage, amounting to as much as 41 per cent. of the theoretical delivery of air, occurs at the air pistons, which prevents a high result being obtained.

MODE OF CONDUCTING THE EXPERIMENTS.

Measurement of Air in Ventilator Drift.—The first air measurement was made, when possible, in the ventilator drift. At the place of measurement strings or wires were fixed so as to divide the drift into divisions of nearly equal area.

The anemometer was allowed to run for one minute in each division; one minute interval was taken for reading the instrument and moving it to the next division.

The air measurement thus occupied twice as many minutes as there were divisions in the drift.

If it was not practicable to make the measurement in the drift, the returns were divided and the measurements made as in the drift.

Diagrams of Engine, Water Gauge, etc.—Simultaneously with the air measurement, diagrams were taken from the engine at intervals of three or five minutes. Each diagram was accompanied with an observation of the water gauge and revolutions of the engine per minute.

The usual working speed was in all cases that adopted for the experiment, and it was maintained as uniformly as possible throughout the trial.

In most instances diagrams were taken from each end of the cylinder on the same paper; when this could not be done, the diagrams were taken from one end of the cylinder only during the experiment, and subsequently a series of diagrams were taken from both ends of the cylinder, with the engine working at the same speed as during the experiment. A ratio was thus established between the pressures on both sides of the piston, which was used to determine the pressure at the end which could not be observed during the experiment.

CHECK AIR MEASUREMENTS.—After completing the drift measurement, a second air measurement was made either in the intakes or return air-ways to check in some degree the drift measurement.

These measurements were made by moving the anemometer uniformly over the whole area of the air-way for two minutes, and repeating the observation twice, to avoid error.

This method of measuring gives very trustworthy results.

An experiment was carefully made at Hilda Colliery in the Fan Drift, where the air current is very irregular, to compare these two methods of measuring, and the results obtained were practically the same.

DIAGRAMS OF ENGINE AND WATER GAUGE.—During the measurements, diagrams of engine, and observations of speed and water gauge, were taken in the same manner as in the first measurement.

CORRECTIONS OF UNDERGROUND AIR MEASUREMENTS TO THE CONDITIONS OF THE VENTILATOR DRIFT.—The laws of Mariotte and Gay Lussac were applied to correct the volume of air measured in the intake or return air-ways to the condition of the ventilator drift at the surface, viz., for pressure and temperature, after the following manner :—Supposing the volume of air measured in the intakes to be 100,000 cubic feet per minute, then the required volume it would occupy in the ventilator drift would be found by calculation to be 107,900 cubic feet, with the following conditions :—

	Barometer.	Temperature.
Ventilator drift	30·30 in. ...	60 degrees Fahr.
Intake, air-way	31·25 in. ...	37 „

and neglecting any small increase of volume due to evolution of gas or absorption of aqueous vapour in the mine, the conclusion would stand thus :—

$$100{,}000 \times \frac{31{\cdot}25'' \times (60^\circ + 461^\circ)}{30{\cdot}30'' \times (37^\circ + 461^\circ)} = 107{,}900 \text{ cubic feet}$$

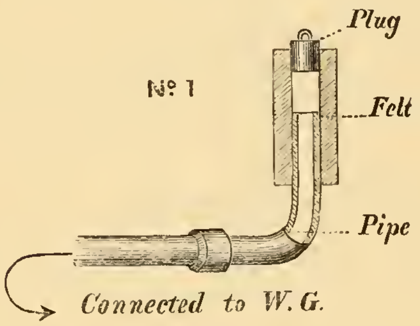
in the ventilator drift.

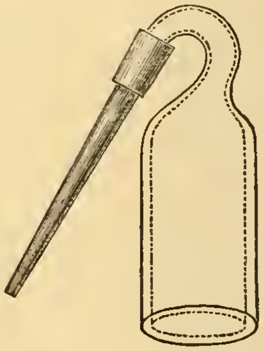
A second determination of useful effect was then made on this volume, with simultaneous diagrams and observations.

INSTRUMENTS.

Water Gauge.—The "Daglish" form of water gauge was used, and at the suggestion of Professor Herschel the end of the pipe connecting it to the drift was placed at right angles to the air current, and covered loosely with a roll of felt, plugged at the top with wood to cause the air to pass through the felt, as shown in woodcut No. 1.

Nº 1





Nº2

All observations of the water gauge in the inlet were made in the same manner.

To ascertain the water gauge of the varying capacity machines producing a pulsating pressure, the open end of the water gauge was closed by a capillary tube of glass, see woodcut No. 2, several of which were at hand, and one selected to reduce the pulsations within sufficiently narrow limits.

Anemometer.—The Casella anemometers employed were frequently tested on the circular whirling machine to ascertain the friction and a constant obtained from the straight lines by the formula $V = m R + a$.

Considerable accuracy was attained by means of an automatic arrangement on the whirling arm, contrived by Mr. Liveing, by which the anemometer stop could be set on and off when in motion.

This arrangement is shown in Plate XLVIII. A B represents the end of the arm of the whirling machine which should be made as thin as is consistent with rigidity, to this the anemometer is secured by two small wooden clamps Z Z tightened by screws. Beyond the anemometer is fixed a wooden frame D, in which are four pegs E F G H. On the other side of the anemometer a metal peg K is screwed into the arm. To the catch M of the anemometer is attached a piece of twisted wire of the form shown at N, which terminates in a loop at one end and in two hooks at the other; to one of these a weak India-rubber band X is secured, the other end of which is attached to the peg K, this band is of sufficient strength when acting alone to draw the catch on, and stop the index, to the other end of the twisted wire is fixed a second stronger India-rubber band Y, secured by a piece of thread T, passing over the peg E and attached to G; this second band is of sufficient strength to pull the catch off in opposition to the band X, and lastly a thread S is attached to the hook P and passing round the peg K and over F is secured to H; this being drawn tight keeps the catch on in opposition to the band Y. There is a small knife V attached to a slide and fixed to the wall or other support in such a manner that by its movement in the slide it can be made to cut first one thread, and then the other. On cutting the first thread the index is released, and on cutting the second it is stopped.

Before commencing an experiment the threads are arranged as shown in the drawing, and before starting the machine the reading of the anemometer is of course noted, the arm is then permitted to make ten revolutions in order to acquire a uniform speed; between the ninth and tenth revolution the knife is moved up against a small stop on the slide, and as the tenth revolution is completed the thread is cut at O, and the time noted by a watch, the sound produced by the cutting of the thread rendering this easy. Nineteen revolutions are then counted, and between the nineteenth and twentieth the knife is moved up against a second stop on the slide so that it severs the second thread at the completion of the twentieth revolution, the time being again noted by the watch, the arm is then allowed to come to rest and the reading of the anemometer recorded.

The following table shows an example of the results obtained from the Casella anemometer, No. 572, which was used during the experiments when tested on a circular whirling machine provided with E. H. Liveing's automatic arrangement, 3rd June, 1880. The circumference of the circle of motion was 25 feet, and 20 revolutions were therefore equal to 500 feet.

No. of experiment.		Seconds by Watch.	Mean Do.	Difference of Anemometer reading in feet.	Mean Do.	Obs. Velocity per minute. Feet.	True Velocity per minute.	Difference.	Velocity per formula ·995 R + 31·5.	Error. Feet.
1	*a*	$60\frac{1}{2}$	59·1	$469\frac{1}{2}$	471·2	478·4	507·6	29·2	507·5	—0·1
2		59		472						
3		58		472						
4	*b*	43	42·6	$479\frac{1}{2}$	480·4	676·6	704·2	27·6	704·7	+0·5
5		43		480						
6		$41\frac{1}{2}$		$479\frac{1}{2}$						
7		43		$482\frac{1}{2}$						
8	*c*	29	29·0	$487\frac{1}{2}$	487·2	1008·0	1034·5	26·5	1034·1	—0·4
9		29		487						
10		29		$485\frac{1}{2}$						
11		29		488						

Taking the mean results of *a* and *c* a straight line formula of the type is obtained, $V = m\,R + a$ in which

$$m = \frac{1034·5 - 507·6}{1008 - 478·4} = \frac{526·9}{529·6} = ·9994$$

and $a = 507·6 - m\ 478·4 = 31·7$, therefore $V = ·9949\ R + 31·7$ or $·995\ R + 31\frac{1}{2}$ (very nearly is obtained) and this figure agrees with great exactness with all the above observations. It will be seen from these figures that the arrangement described gives very satisfactory results, and is a great improvement upon the primitive method hitherto employed of suddenly stopping the arm at full speed, and reading the instrument, for the sudden shock this occasioned was liable to materially alter the co-efficient of correction.

Steam Indicator.—Richard's indicator was used, and the springs were tested and compared with their corresponding scales in the following manner, Plate XLIX. .—

The spring to be examined was placed in the indicator cylinder in the usual way, but, before the milled nut A was attached to the piston rod a perforated metal disc, C, with a wire loop, B, was arranged, so as to rest upon the milled nut.

The indicator was fixed in an inverted position with a diagram paper on the drum, and an atmospheric line, D, drawn. Known weights were then suspended to the wire loop, and corresponding lines drawn on the drum after each addition. The diagram thus obtained was subsequently measured with the corresponding scale, and the readings compared with the weights employed, then as the area of the piston was half a square inch, every half pound suspended should indicate one pound on the scale; if it did not do so to any appreciable extent the spring was rejected.

In order to render this report to some extent complete in itself a small drawing of the Guibal, Waddle, Lemielle, and Cooke ventilators, already fully described in the Transactions, is given in Plate L., and those ventilators only which have not been previously alluded to are more particularly described.

SCHIELE VENTILATOR.

CAR HOUSE COLLIERY, ROTHERHAM.

This ventilator has been at work for some years. It ventilates the Barnsley Bed Seam, which has at this pit been worked a considerable length of time: large areas of goaf surround the shaft; indeed the goaf has for the most part to act as the return air-way. This, together with the high inclination of the seams (from 12 to 16 in. per yard) renders the ventilation of this colliery a matter of considerable difficulty. This fan replaced a furnace, and gave a very great increase in the ventilating current.

Description.—The Schiele Ventilator (Plates LI. and LII.) is a centrifugal machine of the closed type. The moving part of the fan is small in diameter, and constructed wholly in wrought iron, the heaviest portions being disposed round the centre. The disc or blades of the fan taper from the tip, widening towards the centre. This disc revolves between two cast-iron side walls of a section following the taper of the blades. The air enters at each side of the fan in equal quantities. The casing of the fan is in wrought iron, and takes the form of a gradually increasing volute air-chamber surrounding the periphery of the blades, and culminating in the exit which forms the widest point of the air-chamber.

The engines are usually of a horizontal type, with broad-faced fly-wheel, from which the power is given off by suitable belt to a driving drum on the fan shaft. Some of the Schiele Fans are driven direct from the crank-shaft of the engine.

NIXON VENTILATOR.

DEEP DUFFRYN COLLIERY, MOUNTAIN ASH, SOUTH WALES.

This ventilator was the first and is at present the only one of its kind working.

It was erected in 1859, and has worked without any considerable stoppage since that period, requiring very little repair. Plates LIII., LIV., LV., LVI., and LVII.

The workings ventilated are the east and west workings in the four-feet seam; these extend over 450 acres; the downcast shaft (Navigation) is situated 1,000 yards from the upcast shaft at Deep Duffryn; the effective area of each shaft is 122·28 square feet and 66 square feet respectively.

Description.—The Nixon Ventilator is a horizontal double-acting air pump; two rectangular pistons, each 30 feet wide and 20 feet high, reciprocate to and fro on a railway fixed in the chambers; the back and front of these chambers consist of wood framing, on which a number of wood valves or "flaps" are hung; the lower half of each chamber is in connection with the pit when the inlet valves are open; on the upper half of the chamber the outlet valves are hung, and communicate with the atmosphere.

The Chambers.—There are two chambers, Plates LIV., LV., and LVI., built chiefly of wood (red pine), and strengthened with masonry buttresses, one at the centre and one at each end. Each chamber is 30 feet wide, 20 feet high, and 7 feet long. These are erected on stone foundations; half their depth, about 10 feet, is below the top of the engine pillar. The chambers are surrounded at the sides and ends by drifts which communicate with the main drift (36 yards long and 93·25 square feet area) to the top of the upcast shaft—Plate LIII. Over the casing of the chambers is a slate roofing to protect it from the weather.

Theoretical Capacity.—The loss arising from leakage (41 per cent.) is very high; it is improbable that all this occurs at the valves, no doubt some portion of it takes place at the pistons, for on observing a free water gauge connected with the chamber (right hand) a sudden fall was observable at half-stroke. It is stated that there is no packing inserted between the edge of the piston and the sides of the chamber.

THEORETICAL CAPACITY.

Wide.		High.		Stroke.		Double Strokes.		Strokes p. min.		
30 ft.	×	20 ft.	×	7 ft.	×	4	×	7·19	=	120,790 cub. ft. p. min.

Measured quantity at 7·19 Strokes. p. min. = 71,215 „ „

Difference ... ... 49,575 „ „

Equal to a loss of 41 per cent.

In the piston of a new ventilator of this class it is proposed to make the edge of the piston, where it meets the sides of the chamber, about 3 feet wide.

PISTONS.—There are two rectangular pistons, their dimensions corresponding with the chambers. They form a "casing" or "shell;" the sides are covered with sheet iron plates 3·75 inch thick near the centre, and ·25 inch thick at the outer edge; the middle plates are riveted to a cast-iron centre-piece 3 feet by 2 feet 9 inches by a projecting flange 3 inches all round; the piston is connected to the crank shaft by a piston rod and connecting rod; the piston rod is attached to the centre-piece by a taper head and key.

Each piston is carried on four rollers, two on either side, which are placed in carriages fixed at the bottom, and travel on a rail secured to the floor; the diameter of each roller is such that in one stroke of the piston it makes exactly one revolution, so that the wear may be uniform. This wear is found to be rather excessive, and wheels of puddled steel are adopted. There is a flange to prevent any lateral movement; and each roller is further fitted with adjustable set bolts to set the piston up when required.

In the piston of the new ventilator these rollers have been done away with and a double-headed girder 25 feet long substituted; this is secured to the piston two feet above the centre in such a way as to travel with the piston over wheels placed on the outside of the chambers.

OUTLET VALVES.—The outlet valves, 336 in number, occupy the top half of both sides of the chambers; these are suspended by a hook attached to the framework, and are made so as to cover the opening by the space of one inch all round; no packing is attached to the faces, as experience has shown that additional back pressure is caused by inserting a strip of felt. The resistance of the valves with planed faces as at present is ·5 inch water gauge.

The size of each valve is 24 inches long by 16 inches high; and the amount of opening at the lower edges varies from 2½ inches to 3 inches.

Inlet Valves.—These occupy the lower half of the front and back sides of the chambers, and number 392, or 56 more than the outlet valves, and are similar in construction and dimensions.

Engine.—Cylinder (single) 36 inches diameter and 6 feet stroke. It is placed in front of the ventilator, Plate LIII., and works direct on to the crank shaft, on which are placed two fly-wheels 20 feet diameter, weighing 15 tons each.

The ventilator cranks at the end of the shaft are placed at right angles to each other, and the engine crank 45° in front of the right-hand chamber, and 135° from the left; this is shown in Plate LVII.

STRUVÉ VENTILATOR.

CWM AVON COLLIERY, TAIBACH, SOUTH WALES.

This ventilator is situated at the Ynysdavid Pit. It is one of the largest of its kind erected, and is now one of the few remaining at present working.

The workings which it ventilates are very irregular, the dip varying from 45 degrees to 90 degrees, the average inclination being about 50 degrees.

A slant driven in the dip of the seam is used as a downcast, and splits of air are taken from it along the different levels in the Finery Seam.

Description.—This ventilator consists of two air pistons, or "aerometers," Plates LVIII., LIX., LX., and LXI., each 18 feet 3 inches diameter, made of sheet iron ·25 inch thick, which reciprocate vertically in an annular tank or reservoir filled with water. The length of stroke of each piston is 7 feet, the motion is communicated to them by a beam above the chambers (Plate LVIII.), and the pistons are connected to it by a parallel motion.

Chambers.—There are two chambers to each piston, viz., one above and one below it. The sides are formed of hexagonal wood framing, on which the valves are hung. The outlet valves are hung on the front, and the inlet on the inner or back half, Plate LX.

Valves.—There are ninety-two outlet valves, including four double valves used as manholes. Each valve is 4 feet long, and 1 foot 2 inches high, extending 1½ inches over the framing. They are made of zinc (about 7 ounces per foot), carried on a light frame of wood, and suspended to the chamber frame by a leather band, Plate LXI., Fig 2). The face of the valve is covered with a strip of canvas. The maximum amount of opening at the bottom edge is 4 inches, and the resistance due to opening the outlet valves ·3 inch water gauge.

Plate LX. shows a section of the shaft and ventilator. It is connected to the upcast by a short rectangular drift 8 yards long and 16 feet below the surface level.

Engine.—The engine is a single cylinder; diameter, 24 inches; length of stroke, 4·37 feet. It is connected to the ventilator by spur gear 4 to 1. The first motion shaft carries a fly-wheel 12 feet diameter. A disc crank, 3 feet 6 inches throw, is fitted on the second motion shaft, to which the beam on the top of the chamber is attached by a wood connecting rod 25 feet long.

There are two observations worth recording, namely: On entering the ventilator drift the rapid variation in atmospheric pressure, viz., from 5·89 to 2·00 inches, had a painful effect upon the drum of the ear; and the sudden relief of pressure on the saturated return air caused a momentary precipitation of moisture, the air in the chamber becoming quite opaque at one instant, and transparent at the next. This was noticed also with the Nixon ventilator, though to a less extent.

Theoretical Capacity and Leakage.—The diameter of the cylinders of this ventilator, as near as could be ascertained by measurement, was 18 feet 3 inches. The length of stroke was 7 feet. Leaving out of consideration the small error due to oscillation in the level of the water in the annular reservoirs of the water joint, a theoretical capacity is obtained of 18·25 diameter = 261·58 area × 7 × 4 = 7,324 cubic feet per revolution of the ventilator crank. If this figure be multiplied by the mean revolutions of the ventilator crank during the two air measurements, it gives for the first 7,324 × 6·53 = 47,825 cubic feet as the quantity that should have been delivered had there been no leakage, and during the second experiment 7,324 × 6·255 = 45,811 cubic feet, showing leakages of about 4,000 cubic feet and 3,000 cubic feet respectively, or about 7½ per cent.

This leakage of course occurs at the valves, as the water joint admits of none, and appears to cause very little inconvenience from splashing.

ROOTS VENTILATOR.

CHILTON COLLIERY, DURHAM.

This ventilator commenced working in 1877, and is at present ventilating the workings in the Five-quarter and Main Coal Seams.

Description.—It is a rotary displacement machine, discharging the air in four distinct volumes during each revolution. It consists of two rotary pistons A A, Plate LXII., Fig. 1, each 25 feet diameter and 13 feet wide, revolving in a casing, the lower part of which is connected with the pit, the upper part being open to the atmosphere. The periphery of each piston B is in the form of a sector, and revolves closely with a centre drum 7 feet 6 inches diameter on the opposite piston C, their relative positions being maintained by spur-gearing. The sectors are supported by three wrought-iron arms on either side of the centre, the pistons, and the centre drums are covered on their peripheries with sheet iron ·25 inch thick, and the insides are covered with wood.

The shaft carrying the piston revolves in bearings fixed on a girder D, Fig. 2, at either side, 13 feet ·25 inch apart; this allows ·125 inch clearance.

There are two adjustable packing blocks of wood E, Fig. 1, fixed at each end of the ventilator chamber, and two F on either side of the inlet from the shaft; these are attached to hinged frames, and made so as to be adjusted, by set screws, close to the periphery of the pistons.

Engine.—The engines are placed at right angles to the ventilator, Fig. 2. There are two cylinders 28 inches diameter and 4 feet stroke, with adjustable cut-off valves, which were set to cut-off at ·3 of the stroke during the experiment. The motion is communicated to the rotary pistons of the ventilator by two bevel wheels G G′, Fig. 2, each 9 feet 3 inches diameter.

GOFFINT VENTILATOR.

HORLOZ À TILLEUR, LIÉGE, BELGIUM.

Both ventilator and engine are the design of M. Goffint, formerly Director of the Meuse Iron Works.

Description of Ventilator.—Plate LXIII. is a sectional elevation of the apparatus. It will be seen that it is a horizontal piston ventilator, like Nixon's, but differing in construction from that machine. Plate LXIV. shows the drift connecting the ventilator with the up-cast shaft.

Air Cylinders.—The air chambers, two in number, are of sheet iron, circular in section, and 13·2 feet in diameter; they are strengthened by iron rings N, Plate LXIII., and the ends, which are of cast metal, are secured to them by a flange of angle iron B.

Valves.—The ends of the cylinders are not flat, but are made with a slight bevel extending outwards, so that the exit valves hung on the outside of the upper half, and the inlet valves on the inside of the lower half are retained by gravity against their seatings, and their immediate closing at the end of the stroke is insured.

The details of the valves and seats are shown in Plate LXV, Fig. 1, 2, 3. The seats are made of India-rubber tubing covered with canvas, and, when new, are very efficient, but they appear to suffer from long wear. The valves are of sheet iron. There are 48 at each end of the cylinder, the lower 24 of which are inlet valves communicating by the drift G (Plate LXIII.) with the upcast shaft, and the other 24 are outlet valves opening to the atmosphere.

Air Pistons.—The pistons are of sheet iron in the form of a convex lens, with a central boss of cast iron, by which they are secured to the piston rods; they are supported by small wheels travelling on rails placed within the cylinders; the periphery of the pistons is of wood, and the packing formed by a flexible India-rubber tube covered with leather; this, judging from M. Stévart's experiments, would appear, when in good condition, to permit very little re-entry.

Dimensions of Engine.—The engine consists of a pair of horizontal steam cylinders which act directly upon the air pistons without crank or fly-wheel; they are 15¾ inches in diameter and have a maximum stroke of 11·6 feet; the length of the stroke is adjustable, being determined by the movement of the steam valves.

The steam and air piston rods are in a continuous line and are joined in a cross-head, S, Plate LXIII. travelling between cylindrical guides Z, at either end of which are placed powerful buffers of India-rubber, Y, to resist the shocks which are liable to be produced if the stroke of the engine becomes excessive.

The steam is admitted by crown valves C′ C′; which are lifted by cams D D keyed on to shafts which have a reciprocating movement communicated to them by a rod and levers (not shown in the plate, but which connect them with the spindle B′ and the cataract E.

The action of the single engine may be thus explained:—

Beneath each guide Z is placed a shaft A capable of turning in bearings and carrying by means of a lever on one side a counterpoise P P′, and on the other a long inclined lever cam (not shown). The cross-head S is provided with small rollers R on both sides; one of these, whilst the out stroke is being made, travels along the lever-cam, turns the shaft A, and raises the counterpoise P′; when this reaches a certain height it is secured by a catch, and is retained though the roller passes off the cam, and it is the fall of this counterpoise that is made use of at the requisite moment to move the valves for the next out stroke.

The shaft A is connected by levers with the spindle B and with the valve cams D D.

Supposing the machine to be in the position shown, the counterpoise P raised, the counterpoise P′ just fallen, and the out stroke commenced: the roller R first comes in contact with the cam lever belonging to the counterpoise P′, and travelling along it gradually raises it till it is secured by a catch; then, as the piston approaches the end of the stroke, the roller strikes the catch, and releases the counterpoise P which in its fall turns the spindle B and cataract E from right to left, and this movement transmitted to the valve cams D D closes the admission of the steam on the left and opens the exhaust on that side, then closes the exhaust on the right, and admits the steam for the return stroke, during which a similar course of action takes place.

ACTION OF THE TWO ENGINES COMBINED.—In this manner each machine may be worked singly if desired, or one driven at a different speed from the other.

When, however, the two are worked together, the first is made to control the admission of the steam to the second in such a manner that it must have passed through part of its course before the second commences.

The action is then as follows:—

Suppose the piston of the first machine moving from left to right, detaching the catch; the counterpoise P in falling moves the valve cams through two-thirds of their course; this counterpoise is then arrested in its fall by a catch or detent (not shown) on the starting lever L, which prevents it falling the last third.

The form of the valve cams and their setting is such that during the first third they close the admission on the left, during the second they close the exhaust on the right and open that of the left, and it is only during the last third of their movement that they cause the admission of the steam on the right, and this last cannot be completed until the counterpoise P is released from the second detent, and it is the second machine that is made to do this.

In connection with this detent are two levers of peculiar construction, one of which (L) is shown, so arranged that when the second machine has passed through two-thirds of its back stroke the roller on its cross-head strikes this lever and releases the detent; the counterpoise P of the first machine then falls through the last third of its course, and the steam being admitted, the machine commences its back stroke. The levers L L are made with hinged heads so that the rollers can pass them in one direction without effect; whilst in the other they cause them to release the detent of the opposite machine.

Diagrams.—The diagrams taken from the engine, Plate LXV., Figs. 1, 2, and 3, show that a considerable amount of cushioning is required to stop the piston at the end of the stroke before reversing the motion.

RESULTS OF THE EXPERIMENTS.

The results obtained by the experiments are placed side by side for comparison in the following Table :—

TABULATED RESULTS

OF

EXPERIMENTS.

TABULATED RESULTS OF EXPERIMENTS.

No.	Description of Ventilator.	Situation.	Date of Experiment.	No. of Experiments.
1	Guibal ...	Hilda Colliery, South Shields ...	July 11, 1879	1
2	Waddle ...	Celynen Colliery, South Wales ...	Oct. 30, 1879	1
...	Do. ...	Do. Do. ...	...	2
3	Schiele ...	Car House Colliery, Rotherham ...	Jan. 23, 1880	1
4	Do. ...	Corton Wood Colliery, Barnsley ...	Jan. 24, 1880	1
...	Do. ...	Do. Do. ...	...	2
5	Guibal ...	Pemberton Colliery, Wigan ...	Jan. 27, 1880	1
...	Do. ...	Do. Do. ...	...	2
6	Do. ...	Cannock Wood Colliery, Staffordshire	Jan. 29, 1880	1
...	Do. ...	Do. Do. ...	...	2
7	Lemielle ...	Page Bank Colliery, Durham ...	Mar. 11, 1880	1
...	Do. ...	Do. Do. ...	...	2
8	Struvé ...	Cwm Avon Colliery, South Wales ...	April 7, 1880	1
...	Do. ...	Do. Do. ...	...	2
9	Nixon ...	Navigation Colliery, South Wales ...	April 9, 1880	1
...	Do. ...	Do. Do. ...	...	2
10	Roots ...	Chilton Colliery, Durham ...	May 29, 1880	1
...	Do. ...	Do. Do. ...	...	2
11	Cooke ...	Hutton Henry Colliery, Durham ...	June 5, 1880	1
...	Do. ...	Do. Do. ...	...	2
12	Goffint ...	Horloz Colliery, Liége, Belgium ...	June 23, 1880	1
...	Do. ...	Do. Do. ...	...	2

No.	DIMENSIONS OF VENTILATORS AND GENERAL RESULTS.											
	DIMENSIONS OF VENTILATOR.					DIMENSIONS OF ENGINES.				GENERAL RESULTS.		
	Diameter.	Width.	Theoretical Capacity.	Diam. of Inlet.	Weight.	No. of Cylinders.	Diam. of Cylinders.	Length of Stroke.	Direct-acting or otherwise.	Volume of Air.	Mean W.G. Drift Door	Useful Effect Drift W.G.
	Ft. In.	Ft. In.	Cubic Feet per Min.	Ft. In.	Tons.		Inches	Ft. In.			Inches	%
1	50 0	12 0	...	15 0	50	1	42	3 6	Direct	108,422	3·30	·10
2	45 0	Inlet 6 6 Periphery 1 5	...	15 0	...	1	32	4 0	Direct	163,312	3·08	52·79
	...	...	...	...	...	...	...	...	...	...	...	...
3	9 6	Inlet 3 2 Periphery 1 8	...	8 0	...	1	20	1 8	2½ to 1	106,570	2·03	49·27
4	12 0	2 1	...	...	...	1	25	2 0	2·57 to 1	157,176	1·91	46·12
	...	...	...	...	...	...	...	...	...	...	...	...
5	46 0	14 10	...	13 0	...	1	36	3 6	Direct	246,509	1·85	52·95
	...	...	...	...	...	...	...	...	...	...	...	...
6	40 0	12 0	...	14 0	24	1	36	3 0	Direct	170,581	1·46	47·95
	...	...	...	...	...	...	...	...	...	...	...	...
7	Chamber 22 6	Height 32 0	At 9·9 strokes 108,900	...	...	1	55	6 0	Direct	47,307	1·37	23·40
	Drum 15 0	...	...	...	...	...	...	...	...	...	...	...
8	2 Pistons 18 3	Stroke 7 0	At 6¼ strokes 47,827	...	...	1	24	4·37	4 to 1	43,793	5·11	57·80
	...	...	...	...	...	...	...	...	...	...	...	...
9	2 Pistons, 30 ft. long, 20 „ high.	Stroke 7 0	At 7·19 strokes 120,790	...	...	1	36	6 0	Direct	...	...	...
	...	...	...	...	...	...	...	...	...	72,595	2·74	45·91
10	2 Drums 25 0	13 0	At 16·71 rev. 96,918	...	...	2	28	4 0	Direct	...	...	...
	...	...	...	...	...	...	...	...	...	89,772	3·29	47·84
11	2 Drms. 15′ Casing 22′	...	At 17·92 rev. 80,640	...	...	1	25	3 6	Direct	54,190	1·12	37·33
	...	...	...	...	...	...	...	...	...	...	...	
12	2 Pistons 13 2	Stroke 10 7¼	At 9¼ strokes 63,020	...	...	2	15¼	10 7¼	Direct	36,286	0·71	25·79
	...	...	...	...	...	...	...	...	...	...	...	...

OBSERVATIONS.													
Duration of Experiment.	AREA OF VENTILATOR DRIFT AND SEAMS.				AIR MEASUREMENT AND OBSERVATIONS.								No.
	Ventilator Drift.	No. of Divisions.	Place of Measurement Underground.	Area.	Ventilator Drift.		Returns.	Intakes.	Equivalent Volume in Drift.	W.G. Drift Door.	W.G. Inlet.	H.P. in Air calculated on W.G. at Drift Door.	
					Mean Velocity.	Volume of Air.							
H. M.	Sq. Ft.			Sq. Ft	Ft. p. Min	Cub. Ft. per Min.	Cub. Ft per Min.	Cub. Ft. per Min.	Cub. Ft. per Min.	Inches	Inches		
0 52	143	26	...	...	758·2	108,422	...	...	...	3·30	3·40	53·5	1
1 12	216	...	2 main retorns 4 small returns 2 main returns where divided.	...	...	...	157,180	...	163,312	3·08	3·08	79·26	2
...	...	...	2 main intakes scales.	...	...	...	...	144,690	153,500	2·80	2·80	67·72	
1 6	75·2	...	2 main retrns, 4 scales, retrns, divided	...	...	...	105,415	...	106,570	2·03	2·38	34·14	3
1 46	300	...	2 returns divided.	...	...	...	152,354	...	157,176	1·91	...	47·30	4
...	...	...	...	...	...	...	...	149,351	160,090	1·85	...	46·67	
0 46	167·5	21	...	...	1471·7	246,509	...	...	...	1·85	2·06	72·10	5
...	...	...	10 returns	...	...	..	217,366	...	235,729	...	...		
0 45	209·2	23	...	...	810·54	170,581	...	...	...	1·46	1·50	39·40	6
...	...	...	8 returns	...	...	...	159,223	...	163,209	...	...		
0 24	69·97	12	...	...	676·1	47,307	...	...	..	1·37	...	10·26	7
...	...	...	3 returns	...	...	...	44,378	...	45,946	...	...	...	
0 24	...	...	1 return, 12 divisions	45·41	964·4	...	43,793	...	43,793	5·11	...	35·23	8
...	...	...	...	...	...	...	42,824	...	42,824	4·8	...	32·39	
0 22	93·25	12	...	...	763·7	71,215	...	...	...	2·82	...	31·64	9
...	...	...	...	...	...	72,595	...	...	...	2·74	...	31·34	
0 35	136·25	17	...	...	614·1	83,662	...	...	...	3·24	...	42·71	10
0 34	...	...	...	...	...	89,772	...	...	...	3·29	...	46·54	
0 38	120·63	20	...	...	449·2	54,190	...	49,838	51,998	1·12	...	9·60	11
1 15	...	...	6 intakes	...	...	...	...	...	...	1·12	...	9·21	
0 29	84·88	15	...	...	427·5	36,286	...	...	...	0·71	...	4·06	12
0 15	...	...	...	...	...	36,710	...	...	...	0·72	...	4·18	

APPENDIX.

BAROMETER AND THERMOMETER READINGS FOR 1880.

By the SECRETARY.

These readings have been obtained from the observatories of Kew and Glasgow, and will give a very fair idea of the variations of temperature and atmospheric pressure in the intervening country, in which most of the mining operations in this country are carried on.

The Kew barometer is 34 feet, and the Glasgow barometer 180 feet above the sea level. The latter readings have been reduced to 32 feet above the sea level, by the addition of ·150 of an inch to each reading, and both readings are reduced to 32 degrees Fahrenheit.

The fatal accidents have been obtained from the Inspectors' reports, and are printed across the lines, showing the various readings. The name of the colliery at which the explosion took place is given first, then the number of deaths, followed by the district in which it happened.

At the request of the Council the exact readings at both Kew and Glasgow have been published in figures.

BAROMETER READINGS, &c.

JANUARY, 1880.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·788	29·934	29·973	30·035	55·0	50·5	1	29·339	29·397	29·407	29·303	53·9	48·8
2	30·017	30·081	30·191	30·268	50·8	40·3	2	29·445	29·613	29·607	29·690	50·0	37·3
3	30·311	30·434	30·447	30·469	47·7	37·2	3	29·931	30·128	30·154	30·096	45·8	40·1
4	30·468	30·472	30·412	30·425	43·6	32·0	4	30·117	30·168	30·178	30·168	46·9	43·8
5	30·424	30·475	30·464	30·512	41·8	32·9	5	30·162	30·179	30·167	30·210	47·9	46·2
6	30·528	30·578	30·565	30·607	36·7	34·1	6	30·252	30·321	30·368	30·439	47·9	46·0
7	30·603	30·647	30·623	30·629	37·2	34·0	7	30·478	30·528	30·528	30·542	47·5	43·4
8	30·581	30·569	30·522	30·522	34·1	30·1	8	30·522	30·496	30·421	30·427	43·9	38·9
9	30·520	30·532	30·505	30·504	33·8	30·6	9	30·391	30·384	30·344	30·366	39·5	37·0
10	30·510	30·539	30·524	30·533	40·0	33·0	10	30·388	30·457	30·478	30·519	40·9	34·9
11	30·507	30·539	30·531	30·548	39·0	33·0	11	30·526	30·560	30·540	30·566	37·2	30·9
12	30·538	30·590	30·550	30·572	36·5	31·3	12	30·549	30·574	30·554	30·562	32·7	29·6
13	30·536	30·492	30·382	30·345	34·4	29·8	13	30·512	30·475	30·402	30·360	34·4	27·7
14	30·315	30·321	30·311	30·329	34·7	30·0	14	30·295	30·345	30·345	30·346	36·2	26·5
15	30·317	30·299	30·222	30·122	34·9	32·0	15	30·292	30·156	30·076	30·041	44·0	26·1
16	30·070	30·034	29·943	29·953	39·1	34·3	16	29·886	29·846	30·008	30·122	38·4	33·4
17	29·985	30·053	30·009	29·977	37·8	30·8	17	30·119	30·076	29·913	29·822	37·9	28·7
18	29·939	29·977	30·000	30·112	37·3	25·7	18	29·856	29·941	30·007	30·199	36·8	30·3
19	30·226	30·376	30·486	30·578	34·6	21·8	19	30·312	30·432	30·476	30·525	32·3	24·9
20	30·604	30·626	30·589	30·607	32·1	19·5	20	30·534	30·516	30·504	30·533	34·9	23·9
21	30·599	30·619	30·570	30·524	32·5	20·3	21	30·566	30·585	30·525	30·461	32·1	23·6
22	30·444	30·358	30·306	30·322	37·4	24·6	22	30·418	30·407	30·371	30·403	37·1	25·5
23	30·366	30·446	30·441	30·473	37·9	34·0	23	30·417	30·424	30·395	30·380	37·3	24·2
24	30·448	30·438	30·343	30·277	35·8	31·0	24	30·335	30·289	30·165	30·070	37·4	28·9
25	30·179	30·165	30·137	30·213	35·0	25·2	25	29·990	30·030	30·063	30·151	35·0	32·4
26	30·245	30·309	30·283	30·331	31·0	18·9	26	30·143	30·175	30·127	30·106	38·2	32·7
27	30·315	30·364	30·301	30·327	25·0	18·5	27	30·082	30·092	30·016	30·013	42·2	35·0
28	30·303	30·315	30·237	30·208	25·1	18·5	28	29·984	29·940	29·834	29·800	45·2	41·2
29	—	30·195	30·168	30·173	29·8	21·0	29	29·762	29·803	29·781	29·733	45·6	42·7
30	30·133	30·172	30·190	30·255	47·7	23·0	30	29·669	29·659	29·787	29·901	48·9	43·5
31	—	30·351	30·318	30·347	47·8	24·6	31	29·940	30·020	30·001	30·015	47·5	43·6

FEBRUARY, 1880.

1	30·320	30·328	30·273	30·299	44·9	26·0	1	30·021	30·014	29·990	30·002	48·9	43·3
2	30·293	30·309	30·320	30·376	44·0	25·0	2	29·961	29·963	30·066	30·152	48·1	44·0
3	30·402	30·440	30·392	30·394	43·8	36·7	3	30·178	30·193	30·151	30·134	46·5	42·0
4	30·374	30·386	30·296	30·259	41·0	28·4	4	30·076	30·072	29·984	29·885	52·3	44·3
5	30·154	30·112	30·009	29·983	43·2	27·3	5	29·681	29·724	29·812	29·830	46·7	40·0
6	29·936	29·891	29·796	29·711	46·2	40·6	6	29·726	29·596	29·348	28·984	46·7	37·9
7	29·640	29·682	29·553	29·419	48·3	45·5	7	29·076	29·321	29·330	29·204	46·5	40·5
8	29·363	29·473	29·556	29·621	47·0	33·9	8	29·111	29·290	29·365	29·417	44·0	33·9
9	29·510	29·355	29·177	29·155	47·9	34·2	9	29·393	29·310	29·160	29·146	39·5	31·6
10	29·371	29·441	29·438	29·514	46·7	36·4	10	29·185	29·289	29·376	29·526	45·0	35·7
11	29·602	29·722	29·781	29·809	43·1	33·0	11	29·622	29·677	29·627	29·539	43·5	33·0
12	29·759	29·767	29·861	29·991	50·0	31·0	12	29·407	29·503	29·559	29·677	44·0	37·6
13	30·099	30·207	30·161	30·201	46·5	34·3	13	29·836	29·953	29·953	29·837	44·2	34·9
14	29·925	29·838	29·807	29·835	43·8	37·6	14	29·563	29·446	29·505	29·633	49·2	37·9
15	29·817	29·763	29·563	29·419	47·8	41·5	15	29·641	29·595	29·407	29·219	45·8	37·8
16	29·287	29·023	28·937	29·005	52·0	45·2	16	29·110	29·013	28·657	28·543	46·7	40·9
17	28·803	29·059	29·216	29·268	50·8	40·0	17	28·640	28·797	28·848	28·910	48·9	40·8
18	29·248	29·306	29·406	29·333	52·9	45·0	18	28·880	28·957	28·976	28·788	47·9	41·2
19	29·248	29·287	29·283	29·289	51·5	49·1	19	28·766	28·776	28·763	28·753	50·0	44·5
20	29·335	29·393	29·423	29·511	53·0	45·5	20	28·824	28·924	29·043	29·216	47·7	43·6
21	29·628	29·769	29·715	29·761	51·1	39·0	21	29·338	29·451	29·525	29·621	45·9	41·0
22	29·747	29·774	29·763	29·829	45·8	32·2	22	29·699	29·815	29·860	29·948	46·4	40·6
23	29·881	29·959	29·973	30·077	41·1	35·0	23	29·989	29·998	30·060	30·118	47·1	40·0
24	30·146	30·237	30·293	30·408	40·4	36·9	24	30·170	30·242	30·235	30·287	47·2	38·0
25	30·413	30·436	30·306	30·203	48·0	32·0	25	30·230	30·141	29·971	29·748	46·9	43·1
26	29·983	29·864	29·910	29·914	50·2	38·0	26	29·544	29·685	29·721	29·777	46·1	35·0
27	29·888	29·879	29·761	29·663	47·5	36·0	27	29·721	29·592	29·349	29·169	46·7	34·9
28	29·509	29·500	29·537	29·631	52·4	42·2	28	29·065	29·221	29·243	29·178	48·0	42·8
29	29·610	29·654	29·588	29·572	51·6	42·7	29	29·137	29·178	29·135	29·006	51·0	46·0

BAROMETER READINGS, &c.

MARCH, 1880.

	KEW.							GLASGOW.					
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·428	29·412	29·374	29·369	51·5	37·6	1	28·708	28·783	28·798	28·759	47·1	34·5
2	29·468	29·371	29·341	29·307	51·1	47·5	2	28·871	28·911	28·869	28·749	42·1	34·0
3	29·219	29·335	29·371	29·400	52·8	48·8	3	28·628	28·964	29·022	29·083	44·4	35·0
4	29·557	29·803	29·905	29·968	54·0	46·0	4	29·232	29·443	29·593	29·679	47·1	37·5
5	29·971	30·024	30·080	30·138	51·7	50·0	5	29·620	29·657	29·665	29·747	51·5	36·5
6	30·154	30·160	30·066	30·025	53·1	46·0	6	29·763	29·744	29·671	29·678	51·2	46·9
7	29·980	30·081	30·130	30·272	53·0	46.4	7	29·776	30·016	30·166	30·321	50·6	38·5
8	30·373	30·474	30·412	30·414	49·1	40·7	8	30·392	30·465	30·423	30·405	52·1	35·0
9	30·296	30·255	30·195	30·183	57·1	41·0	9	30·339	30·241	30·122	30·129	42·9	30·8
10	30·091	30·137	30·160	30·256	55·0	39·0	10	30·099	30·138	30·136	30·222	45·7	35·1
11	30·302	30·370	30·362	30·404	54·4	33·9	11	30·278	30·328	30·310	30·322	48·9	39·1
12	30·376	30·330	30·242	30·265	52·0	40·8	12	30·263	30·247	30·183	30·118	42·3	39·1
13	30·268	30·293	30·263	30·291	57·5	38·7	13	30·133	30·201	30·209	30·245	49·9	38·1
14	30·265	30·258	30·204	30·232	48·2	37·4	14	30·233	30·251	30·220	30·270	47·0	38·8
15	30·236	30·240	30·182	30·172	46·6	39·5	15	30·271	30·262	30·212	30·209	44·9	38·4
16	30·108	30·076	30·015	30·029	47·0	36·7	16	30·192	30·121	30·070	30·066	41·6	34·5
17	30·035	30·105	30·114	30·198	49·2	38·5	17	30·061	30·122	30·123	30·214	50·3	33·5
18	30·248	30·301	30·303	30·335	51·0	36·0	18	30·265	30·331	30·317	30·357	51·1	32·9
19	30·341	30·355	30·275	30·281	54·0	37·0	19	30·365	30·331	30·240	30·253	54·6	30·8
20	30·267	30·267	30·214	30·264	47·9	32·9	20	30·248	30·290	30·270	30·347	47·3	31·6
21	30·258	30·278	30·227	30·257	48·1	35·3	21	30·329	30·315	30·243	30·269	48·9	34·0
22	30·289	30·315	30·277	30·305	43·1	33·9	22	30·297	30·315	30·259	30·303	46·6	31·1
23	30·303	30·313	30·265	30·297	45·0	33·5	23	30·304	30·332	30·299	30·332	43·6	32·8
24	30·249	30·247	30·196	30·180	54·1	33·1	24	30·329	30·338	30·250	30·232	46·3	31·2
25	30·114	30·094	30·017	30·028	60·6	36·7	25	30·177	30·140	30·071	30·121	46·9	34·1
26	30·000	30·018	29·993	30·067	59·6	38·0	26	30·119	30·147	30·114	30·174	42·9	35·6
27	30·091	30·133	30·105	30·169	47·6	33·7	27	30·174	30·203	30·150	30·178	44·1	34·2
28	30·177	30·194	30·108	30·100	47·0	30·2	28	30·134	30·111	30·019	29·993	50·6	29·9
29	30·058	30·048	29·953	29·969	58·0	27·7	29	29·940	29·937	29·911	29·938	53·9	40·5
30	29·961	29·972	29·886	29·838	59·1	37·8	30	29·923	29·881	29·736	29·571	56·2	41·9
31	29·698	29·554	29·408	29·248	53·3	33·5	31	29·313	29·171	29·153	29·230	51·7	40·2

APRIL, 1880.

1	29·362	29·548	29·607	29·714	53·6	41·5	1	29·285	29·392	29·477	29·525	50·5	36·5
2	29·633	29·512	29·406	29·483	53·0	40·6	2	29·334	29·154	29·152	29·244	50·5	38·5
3	29·513	29·551	29·539	29·526	59·0	46·1	3	29·212	29·213	29·192	29·181	52·9	39·5
4	29·388	29·263	29·289	29·458	55·5	43·6	4	29·132	29·093	29·062	29·058	51·0	39·0
5	29·494	29·446	29·356	29·322	52·6	40·5	5	29·053	29·142	29·026	29·031	49·8	40·3
6	29·238	29·274	29·287	29·372	54·9	39·2	6	29·024	29·080	29·109	29·139	51·6	41·5
7	29·427	29·501	29·520	29·626	54·5	36·9	7	29·224	29·421	29·571	29·752	49·1	41·3
8	29·723	29·862	29·931	30·089	53·9	34·7	8	29·866	29·998	30·126	30·274	52·5	38·9
9	30·163	30·219	30·211	30·231	47·7	40·0	9	30·355	30·486	30·383	30·378	50·0	34·9
10	30·189	30·180	30·076	30·076	46·8	39·2	10	30·236	30·309	30·205	30·140	49·9	41·9
11	29·982	29·960	29·893	29·909	47·0	37·7	11	30·014	29·983	29·977	30·022	51·0	38·8
12	29·881	29·887	29·816	29·864	49·1	37·7	12	30·022	30·012	29·950	29·932	48·7	36·9
13	29·860	29·860	29·826	29·843	56·7	39·5	13	29·932	29·944	29·865	29·799	47·4	38·7
14	29·736	29·678	29·614	29·666	47·4	44·6	14	29·729	29·732	29·734	29·791	52·3	37·8
15	29·662	29·658	29·607	29·657	49·1	39·9	15	28·815	29·868	29·834	29·775	46·0	38·7
16	29·675	29·945	29·796	29·873	55·0	38·8	16	29·666	29·575	29·457	29·557	50·1	37·1
17	29·824	29·820	29·793	29·909	61·5	35·9	17	29·595	29·627	29·592	29·670	56·5	42·7
18	29·967	30·006	29·995	29·995	57·8	42·4	18	29·681	29·611	29·551	29·519	52·0	42·6
19	29·939	29·913	29·830	29·800	64·6	50·3	19	29·575	29·576	29·567	29·613	56·8	47·2
20	29·774	29·828	29·873	29·987	58·9	46·0	20	29·618	29·650	29·667	29·746	56·3	43·5
21	30·021	30·019	29·925	29·825	56·0	42·9	21	29·611	29·349	29·392	29·363	51·2	40·8
22	29·737	29·809	29·816	29·896	57·9	43·6	22	29·352	29·566	29·669	29·754	53·9	39·9
23	29·962	30·054	30·038	30·090	60·6	40·0	23	29·772	29·822	29·818	29·838	52·0	43·5
24	30·062	30·032	29·951	29·941	58·0	43·7	24	29·793	29·705	29·742	29·792	52·0	40·9
25	29·917	29·948	29·928	29·962	57·0	42·0	25	29·836	29·886	29·901	30·003	53·9	39·1
26	29·950	29·984	30·003	30·135	50·2	38·0	26	30·016	30·117	30·151	30·250	51·3	37·3
27	30·145	30·165	30·120	30·137	48·9	35·8	27	30·268	30·283	30·226	30·230	55·9	33·6
28	——	30·048	30·008	30·096	50·5	41·6	28	30·226	30·222	30·202	30·254	56·9	38·0
29	30·114	30·212	30·278	30·388	51·9	39·6	29	30·330	30·414	30·444	30·489	50·8	40·9
30	30·392	30·400	30·297	30·324	55·6	38·2	30	30·440	30·403	30·306	30·278	57·6	39·3

BAROMETER READINGS, &c.

MAY, 1880.

	KEW.							GLASGOW.					
	BAROMETER.				TEMPERATURE.			BAROMETER.				TEMPERATURE.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·281	30·217	30·081	30·015	55·9	33·8	1	30·192	30·118	29·952	29·862	58·2	41·0
2	29·903	29·859	29·767	29·779	60·1	32·2	2	29·784	29·842	29·816	29·839	55·9	42·6
3	29·707	29·693	29·653	29·745	58·0	34·0	3	29·751	29·801	29·834	29·959	49·1	39·3
4	29·717	29·911	29·935	30·000	55·0	45·1	4	29·999	30·185	30·046	30·079	56·6	36·0
5	29·977	30·015	29·999	30·007	49·1	44·9	5	30·078	30·088	30·042	30·047	62·3	37·6
6	29·973	30·005	29·996	30·037	57·7	44·4	6	30·040	30·042	30·023	30·103	58·1	39·8
7	30·056	30·103	30·082	30·094	5[illegible]·9	40·0	7	30·115	30·105	30·039	30·050	53·1	40·9
8	30·082	30·104	30·098	30·201	55·0	39·4	8	30·054	30·099	30·113	30·268	60·9	38·1
9	30·234	30·279	30·221	30·223	52·2	37·1	9	30·218	30·326	30·259	30·211	59·7	35·7
10	30·153	30·097	30·000	29·979	49·8	35·7	10	30·127	30·108	30·091	30·126	55·3	44·3
11	29·920	29·907	29·879	29·917	57·9	43·8	11	30·111	30·101	30·088	30·134	53·4	41·3
12	29·943	29·979	29·983	30·081	49·0	43·9	12	30·144	30·109	30·195	30·252	54·0	40·9
13	30·087	30·113	30·079	30·139	64·5	42·5	13	30·236	30·266	30·250	30·278	53·0	43·9
14	30·101	30·095	30·021	30·063	71·0	44·0	14	30·267	30·260	30·234	30·286	55·7	41·1
15	30·067	30·063	29·990	30·101	71·0	47·1	15	30·281	30·294	30·263	30·291	55·1	41·1
16	30·099	30·104	30·070	30·168	63·7	43·6	16	30·273	30·274	30·248	30·263	55·5	40·1
17	30·184	30·205	30·161	30·229	58·0	42·1	17	30·276	30·270	30·240	30·209	62·0	39·5
18	30·219	30·241	30·202	30·258	56·3	38·8	18	30·198	30·276	30·204	30·198	63·3	45·7
19	30·254	30·230	30·076	30·072	59·6	35·9	19	30·134	30·089	30·054	30·111	69·2	51·5
20	30·114	30·160	30·165	30·269	60·1	49·1	20	30·118	30·172	30·197	30·204	63·7	50·6
21	30·233	30·189	30·082	30·054	73·5	48·9	21	30·122	30·089	30·002	29·842	58·6	49·2
22	29·906	29·820	29·762	29·852	61·7	49·9	22	29·625	29·566	29·651	29·732	59·0	46·8
23	29·907	29·908	29·869	29·849	60·6	46·4	23	29·644	29·521	29·431	29·397	56·0	46·9
24	29·817	29·845	29·920	29·997	63·6	51·9	24	29·318	29·455	29·611	29·711	52·9	43·9
25	30·007	30·048	30·007	29·988	70·6	51·0	25	29·720	29·784	29·803	29·723	57·9	44·7
26	29·927	29·925	29·891	29·811	81·0	46·2	26	29·583	29·640	29·682	29·749	59·0	47·8
27	29·658	29·707	29·818	30·019	66·7	49·6	27	29·738	29·733	29·763	29·847	58·3	45·7
28	30·086	30·184	30·267	30·365	62·0	46·0	28	29·894	29·994	30·057	30·151	54·3	42·8
29	30·411	30·439	30·403	30·408	62·5	40·8	29	30·263	30·3[illegible]8	30·301	30·278	59·2	39·3
30	30·377	30·319	30·205	30·197	65·0	39·0	30	30·169	30·096	29·990	29·956	53·0	47·0
31	30·131	30·111	30·071	30·076	52·3	46·5	31	29·938	30·004	30·096	30·244	53·7	46·7

JUNE, 1880.

1	30·073	30·109	30·074	30·064	60·8	46·2	1	30·324	30·374	30·359	30·388	62·0	45·8
2	30·018	30·010	29·969	29·965	62·0	50·6	2	30·362	30·327	30·234	30·222	66·9	45·1
3	29·885	29·871	29·846	29·858	55·7	48·6	3	30·152	30·062	29·939	30·004	71·0	46·3
4	29·806	29·864	29·900	29·972	56·3	42·3	4	30·026	30·024	29·984	29·982	57·8	42·7
5	29·966	29·988	29·963	29·973	59·5	37·4	5	29·932	29·877	29·819	29·773	55·1	42·2
6	29·885	29·871	29·822	29·865	63·3	50·8	6	29·673	29·668	29·647	29·640	56·0	46·9
7	29·760	29·582	29·647	29·793	64·2	48·8	7	29·480	29·341	29·444	29·521	56·2	43·3
8	29·787	29·741	29·659	29·760	60·1	46·9	8	29·531	29·525	29·524	29·618	58·3	42·8
9	29·786	29·781	29·753	29·777	58·0	44·0	9	29·630	29·648	29·650	29·684	59·7	37·5
10	29·775	29·813	29·798	29·830	65·3	41·6	10	29·731	29·772	29·775	29·813	60·0	40·0
11	29·828	29·856	29·868	29·922	63·0	47·2	11	29·839	29·851	29·817	29·851	66·8	38·9
12	29·940	29·992	29·949	29·999	70·1	42·5	12	29·840	29·833	29·805	29·826	63·1	44·4
13	29·989	29·989	29·957	30·000	70·5	45·9	13	29·825	29·842	29·880	29·969	58·1	48·1
14	30·000	30·014	30·026	30·071	70·6	50·2	14	29·998	30·086	30·[illegible]80	30·176	67·1	45·3
15	30·061	30·052	29·997	29·945	56·6	52·3	15	30·202	30·206	30·192	30·242	69·0	50·0
16	29·884	29·884	29·955	30·084	61·0	53·0	16	30·199	30·228	30·221	30·292	70·2	54·0
17	30·107	30·103	30·040	30·059	65·0	53·5	17	30·285	30·293	30·223	30·267	68·5	51·9
18	30·014	29·953	29·849	29·811	71·0	54·6	18	30·213	30·105	29·946	29·886	69·3	49·9
19	29·715	29·695	29·653	29·637	70·7	56·5	19	29·728	29·776	29·676	29·650	68·0	51·3
20	29·587	29·583	29·577	29·619	68·8	57·4	20	29·634	29·615	29·555	29·550	63·3	53·8
21	29·635	29·649	29·633	29·669	70·5	53·0	21	29·531	29·541	29·555	29·599	65·2	54·0
22	29·657	29·709	29·737	29·757	62·5	54·6	22	29·673	29·704	29·671	29·710	71·5	53·8
23	29·737	29·739	29·695	29·706	67·1	53·9	23	29·692	29·675	29·621	29·656	64·0	51·2
24	29·676	29·717	29·721	29·783	70·1	52·8	24	29·654	29·681	29·657	29·739	69·2	50·0
25	29·791	29·809	29·749	29·789	73·0	52·2	25	29·735	29·745	29·710	29·749	68·4	48·5
26	29·787	29·849	29·901	30·027	69·7	52·2	26	29·748	29·806	29·851	29·940	62·8	48·9
27	30·105	30·175	30·162	30·202	73·0	52·1	27	29·966	29·935	29·833	29·804	61·9	50·6
28	30·174	30·196	30·159	30·151	73·5	58·1	28	29·817	29·854	29·865	29·862	61·8	50·7
29	30·107	30·045	29·935	29·893	70·6	57·9	29	29·803	29·779	29·732	29·685	66·8	57·5
30	29·817	29·783	29·690	29·692	75·5	53·6	30	29·602	29·577	29·556	29·556	66·3	53·7

BAROMETER READINGS, &c.

JULY, 1880.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	29·656	29·650	29·661	29·719	67·0	56·0	1	29·515	29·532	29·520	29·558	63·0	50·3
2	29·755	29·772	29·758	29·762	64·5	51·0	2	29·531	29·517	29·474	29·481	64·9	46·7
3	29·702	29·666	29·631	29·659	65·0	55·0	3	29·461	29·504	29·583	29·773	63·1	54·8
4	29·724	29·855	29·980	30·101	65·1	54·3	4	29·883	29·975	30·002	30·049	65·8	49·6
5	30·121	30·146	30·100	30·106	70·0	49·9	5	30·039	30·022	29·967	29·920	62·8	49·1
6	30·057	30·018	29·963	29·906	67·1	53·4	6	29·810	29·677	29·644	29·626	66·1	52·9
7	29·780	29·659	29·604	29·616	64·0	53·0	7	29·536	29·508	29·440	29·427	63·7	51·1
8	29·578	29·616	29·624	29·677	65·1	51·8	8	29·381	29·382	29·388	29·460	61·9	50·9
9	29·691	29·735	29·746	29·794	66·5	53·0	9	29·506	29·572	29·594	29·648	66·0	47·5
10	29·798	29·839	29·876	29·976	65·1	50·9	10	29·662	29·705	29·736	29·813	66·3	50·1
11	30·028	30·078	30·069	30·102	69·0	53·6	11	29·852	29·911	29·933	29·997	63·9	47·8
12	30·108	30·137	30·123	30·145	68·2	55·0	12	30·006	30·036	30·023	30·090	68·0	45·3
13	30·123	30·114	30·075	30·095	67·1	55·5	13	30·109	30·123	30·114	30·152	63·3	52·8
14	30·074	30·039	29·989	29·975	71·0	55·2	14	30·144	30·164	30·156	30·152	63·3	52·9
15	29·897	29·899	29·931	30·016	75·8	57·0	15	30·110	30·093	30·063	30·093	59·1	52·4
16	30·015	30·054	30·009	30·021	74·0	54·8	16	30·069	30·112	30·077	30·061	67·1	54·5
17	30·015	30·010	29·931	29·931	73·0	57·4	17	30·020	29·969	29·878	29·849	73·2	51·5
18	29·899	29·920	29·940	29·960	70·5	57·8	18	29·794	29·769	29·767	29·767	60·0	55·0
19	29·960	29·980	29·980	30·010	71·1	57·0	19	29·780	29·840	29·875	29·923	62·6	53·9
20	30·040	30·069	30·053	30·075	72·5	54·9	20	29·951	30·015	30·018	30·035	66·8	50·7
21	30·049	30·045	29·968	29·978	73·9	56·4	21	30·043	30·042	30·008	30·010	65·7	47·4
22	29·932	29·972	29·950	29·984	70·6	55·3	22	29·990	29·968	29·917	29·924	67·4	52·3
23	29·970	29·967	29·927	29·932	73·6	54·3	23	29·889	29·870	29·817	29·797	69·2	52·0
24	29·902	29·880	29·818	29·844	72·1	56·5	24	29·736	29·718	29·677	29·704	66·7	55·3
25	29·872	29·909	29·843	29·817	73·8	53·5	25	29·815	29·811	29·735	29·728	70·6	55·2
26	29·645	29·535	29·420	29·522	70·4	57·0	26	29·659	29·599	29·548	29·597	63·9	53·0
27	29·640	29·735	29·782	29·824	72·2	59·0	27	29·597	29·615	29·637	29·642	55·1	52·6
28	29·762	29·724	29·674	29·640	67·5	61·0	28	29·528	29·391	29·306	29·308	63·9	52·7
29	29·542	29·496	29·565	29·663	66·9	56·8	29	29·311	29·316	29·360	29·420	61·9	49·1
30	29·648	29·595	29·634	29·667	67·5	51·9	30	29·420	29·443	29·453	29·538	61·5	46·7
31	29·712	29·780	29·743	29·721	66·7	48·6	31	29·558	29·571	29·554	29·568	62·0	47·0

AUGUST, 1880.

1	29·617	29·589	29·596	29·649	69·0	52·1	1	29·545	29·557	29·543	29·567	62·2	44·0
2	29·620	29·638	29·660	29·768	66·0	50·7	2	29·555	29·605	29·616	29·698	63·5	49·0
3	29·813	29·873	29·877	29·913	70·8	47·9	3	29·722	29·768	29·776	29·764	62·5	46·8
4	29·898	29·909	29·869	29·879	72·0	57·9	4	29·693	29·685	29·653	29·631	66·5	55·0
5	29·846	29·824	29·751	29·737	75·6	59·0	5	29·553	29·529	29·497	29·407	65·5	57·7
6	29·653	29·612	29·558	29·572	69·2	57·0	6	29·347	29·457	29·465	29·495	64·8	51·4
7	29·606	29·680	29·362	29·200	65·0	51·8	7	29·443	29·381	29·319	29·356	61·7	50·9
8	29·454	29·602	29·691	29·821	67·2	53·4	8	29·386	29·489	29·565	29·701	64·6	51·7
9	29·890	29·993	30·056	30·160	72·2	50·3	9	29·758	29·890	29·958	29·999	67·0	50·0
10	30·226	30·277	30·234	30·242	76·0	50·9	10	30·053	30·140	30·179	30·224	72·3	55·8
11	30·228	30·222	30·162	30·194	75·6	59·3	11	30·234	30·251	30·252	30·270	74·8	61·1
12	30·184	30·180	30·131	30·125	73·0	57·8	12	30·271	30·265	30·243	30·259	75·6	58·6
13	30·101	30·101	30·057	30·083	74·5	59·7	13	30·239	30·233	30·203	30·220	71·7	53·3
14	30·070	30·075	30·042	30·070	71·9	59·4	14	30·186	30·182	30·101	30·144	76·4	54·3
15	30·068	30·072	30·063	30·075	66·4	59·0	15	30·129	30·138	30·119	30·136	63·2	44·6
16	30·051	30·057	30·023	30·062	65·5	57·0	16	30·123	30·141	30·135	30·188	61·8	55·0
17	30·055	30·085	30·054	30·122	72·0	59·1	17	30·199	30·244	30·232	30·243	63·3	55·1
18	30·115	30·118	30·072	30·076	67·0	58·0	18	30·231	30·222	30·158	30·140	61·1	54·6
19	30·033	30·043	29·966	30·004	72·8	58·0	19	30·089	30·085	30·042	30·040	64·0	53·8
20	29·994	30·026	30·022	30·068	67·8	60·8	20	30·024	30·053	30·053	30·109	66·9	54·0
21	30·078	30·088	30·024	30·056	73·3	59·0	21	30·132	30·154	30·124	30·149	71·7	49·3
22	30·032	30·042	30·008	30·050	69·8	55·7	22	30·140	30·144	30·105	30·114	67·3	54·3
23	30·017	30·019	29·984	30·020	67·0	53·9	23	30·086	30·097	30·072	30·115	65·0	56·4
24	30·012	30·022	29·990	30·009	68·5	54·1	24	30·112	30·113	30·079	30·087	61·0	55·0
25	29·973	29·977	29·939	29·938	64·8	57·0	25	30·046	30·040	30·083	29·979	60·8	54·4
26	29·898	29·878	29·877	29·944	71·0	59·8	26	29·959	29·952	29·958	29·999	61·8	53·3
27	29·987	30·093	30·114	30·166	68·8	60·1	27	30·018	30·109	30·121	30·190	68·3	57·6
28	30·164	30·192	30·129	30·136	77·6	60·5	28	30·233	30·249	30·197	30·229	72·2	50·2
29	30·078	30·034	29·943	29·941	71·5	58·3	29	30·202	30·177	30·190	30·094	69·9	56·5
30	29·905	29·925	29·929	29·959	68·1	56·0	30	30·027	30·003	29·959	30·024	74·1	55·8
31	29·961	30·021	30·032	30·108	75·0	54·8	31	30·011	30·020	29·947	29·982	73·4	55·0

BAROMETER READINGS, &c.

SEPTEMBER, 1880.

KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·142	30·229	30·234	30·295	71·0	51·9	1	29·944	29·993	30·062	30·176	64·9	50·6
2	30·315	30·327	30·265	30·293	77·5	59·5	2	30·214	30·222	30·134	30·110	66·7	44·9
3	30·265	30·235	30·156	30·126	80·2	56·1	3	30·180	30·111	30·072	30·047	71·4	56·7
4	30·028	29·985	29·940	29·983	84·0	58·0	4	29·976	29·918	29·812	29·793	77·6	53·2
5	29·991	30·050	30·044	30·066	73·1	62·0	5	29·750	29·810	29·813	29·843	65·7	56·0
6	30·121	30·135	30·038	29·994	71·0	53·7	6	29·824	29·811	29·780	29·797	62·3	53·5
7	29·920	30·006	30·022	30·059	70·0	51·4	7	29·804	29·880	29·923	30·011	62·1	51·6
8	30·035	30·019	29·929	29·917	67·1	48·5	8	30·014	30·071	30·026	30·021	60·6	45·4
9	29·858	29·847	29·804	29·796	65·1	55·7	9	29·966	29·906	29·769	29·723	64·2	45·6
10	29·748	29·720	29·688	29·706	78·0	55·1	10	29·607	29·517	29·463	29·435	63·0	53·3
11	29·656	29·656	29·625	29·535	68·0	54·5	11	29·442	29·507	29·554	29·601	62·6	49·7
12	29·603	29·665	29·637	29·595	67·9	52·1	12	29·540	29·466	29·423	29·450	61·2	49·1
13	29·547	29·639	29·720	29·808	63·0	48·4	13	29·442	29·478	29·501	29·558	59·7	47·4
14	29·730	29·566	29·372	29·224	63·3	47·7	14	29·515	29·520	29·479	29·472	54·3	45·7
15	29·111	29·276	29·306	29·312	61·7	53·9	15	29·467	29·429	29·584	29·703	55·8	50·5
16	29·270	29·494	29·607	29·723	64·7	51·9	16	29·742	29·829	29·815	28·829	63·1	49·7
17	29·763	29·832	29·864	29·878	63·9	52·2	17	29·756	29·712	29·612	29·494	59·9	44·0
18	29·776	29·679	29·676	29·757	62·5	48·5	18	29·436	29·441	29·443	29·479	54·8	45·5
19	29·744	29·706	29·653	29·733	57·9	45·9	19	29·459	29·480	29·497	29·506	54·9	42·3
20	29·767	29·831	29·872	29·924	60·7	44·0	20	29·627	29·701	29·704	29·711	54·3	40·1
21	29·909	29·887	29·906	29·975	59·6	48·0	21	29·680	29·700	29·734	29·740	58·3	45·1
22	29·955	29·969	29·970	30·032	68·8	50·6	22	29·677	29·755	29·818	29·933	59·3	47·5
23	30·049	30·113	30·099	30·099	67·3	59·9	23	29·983	30·031	30·004	29·979	55·0	47·5
24	30·081	30·103	30·066	30·079	68·9	52·0	24	29·954	29·961	29·934	29·937	62·3	54·6
25	30·063	30·070	30·057	30·093	66·0	55·0	25	29·896	29·898	29·909	29·952	61·9	53·8
26	30·095	30·147	30·160	30·212	69·1	53·3	26	29·967	30·028	30·059	30·132	63·2	54·6
27	30·230	30·286	30·286	30·348	71·0	54·4	27	30·146	30·183	30·171	30·223	63·0	51·8
28	30·372	30·439	30·405	30·446	67·0	51·2	28	30·295	30·388	30·402	30·429	62·9	50·1
29	30·446	30·473	30·420	30·420	63·0	46·5	29	30·394	30·393	30·353	30·337	57·5	48·5
30	30·368	30·378	30·320	30·318	62·0	45·9	30	30·274	30·298	30·237	30·234	61·9	50·9

OCTOBER, 1880.

1	30·267	30·251	30·127	30·057	62·5	52·0	1	30·150	30·090	29·951	29·859	60·0	51·3
2	29·950	29·901	29·840	29·939	63·7	40·5	2	29·857	29·917	29·908	29·897	52·3	37·9
3	29·943	29·909	29·858	29·874	52·4	34·5	3	29·835	29·809	29·827	29·849	52·0	36·0
4	29·824	29·740	29·630	29·479	46·6	37·0	4	29·811	29·770	29·698	29·708	49·0	32·5
5	29·292	29·214	29·213	29·299	63·8	46·5	5	29·633	29·566	29·461	29·453	49·5	37·0
6	29.333	29·345	29·338	29·413	52·9	50·0	6	29·438	29·512	29·548	29·667	52·6	45·5
7	29·457	29·560	29·610	29·668	64·1	50·0	7	29·689	29·774	29·804	29·866	51·6	44·2
8	29·662	29·724	29·719	29·758	57·0	49·2	8	29·857	29·894	29·887	29·954	52·5	41·2
9	29·714	29·677	29·659	29·686	55·5	48·4	9	29·987	30·068	30·095	30·171	53·9	42·8
10	29·728	29·913	30·029	30·165	54·0	51·2	10	30·164	30·231	30·238	30·306	52·2	38·0
11	30·204	30·255	30·198	30·238	56·8	45·0	11	30·334	30·389	30·357	30·392	50·9	31·8
12	30·203	30·137	30·081	30·138	52·7	44·0	12	30·362	30·344	30·264	30·281	50·6	30·8
13	30·161	30·252	30·268	30·341	55·5	46·6	13	30·270	30·306	30·281	30·297	53·0	43·1
14	30·358	30·395	30·346	30·356	52·1	36·8	14	30·290	30·306	30·279	30·281	57·0	44·1
15	30·314	30·286	30·186	30·160	51·0	32·7	15	30·230	30·213	30·133	30·110	54·0	46·3
16	30·062	30·058	30·026	30·048	52·7	45·4	16	30·055	30·045	30·006	30·010	53·5	45·6
17	30·033	30·082	30·068	30·092	56·3	41·5	17	29·984	30·005	29·974	29·975	54·9	45·1
18	30·062	30·062	29·993	29·979	55·8	43·9	18	29·883	29·808	29·802	30·018	55·2	37·9
19	29·970	30·044	29·982	29·906	47·5	40·0	19	30·085	30·090	29·986	29·916	40·5	30·4
20	29·766	29·628	29·531	29·630	40·0	33·2	20	29·826	29·752	29·677	29·750	39·8	24·1
21	29·717	29·807	29·837	29·849	46·7	31·6	21	29·844	29·908	29·888	29·861	44·7	31·3
22	29·760	29·722	29·635	29·613	46·0	39·0	22	29·828	29·895	29·878	29·940	42·9	26·8
23	29·628	29·774	29·920	30·096	45·2	34·0	23	29·960	30·044	30·070	30·127	44·8	32·7
24	30·192	30·266	30·234	30·241	47·2	30·9	24	30·150	30·195	30·144	30·134	49·1	32·2
25	30·226	30·188	30·058	29·966	48·4	33·6	25	30·006	29·873	29·729	29·688	48·6	39·9
26	29·842	29·694	29·427	29·323	42·3	39·5	26	29·747	29·733	29·608	29·570	41·6	33·6
27	29·316	29·369	29·228	29·042	57·0	42·3	27	29·522	29·528	29·420	29·282	40·2	34·0
28	28·976	28·728	28·962	28·974	53·8	40·0	28	29·120	29·203	29·297	29·420	39·5	34·7
29	29·212	29·540	29·761	29·949	44·8	33·2	29	29·547	29·679	29·831	29·937	43·9	31·0
30	30·055	30·133	30·126	30·148	46·2	30·8	30	29·925	29·890	29·837	29·847	47·3	30·7
31	30·112	30·105	30·047	30·041	49·5	33·1	31	29·795	29·771	29·757	29·947	50·6	36·5

BAROMETER READINGS, &c.

NOVEMBER, 1880.

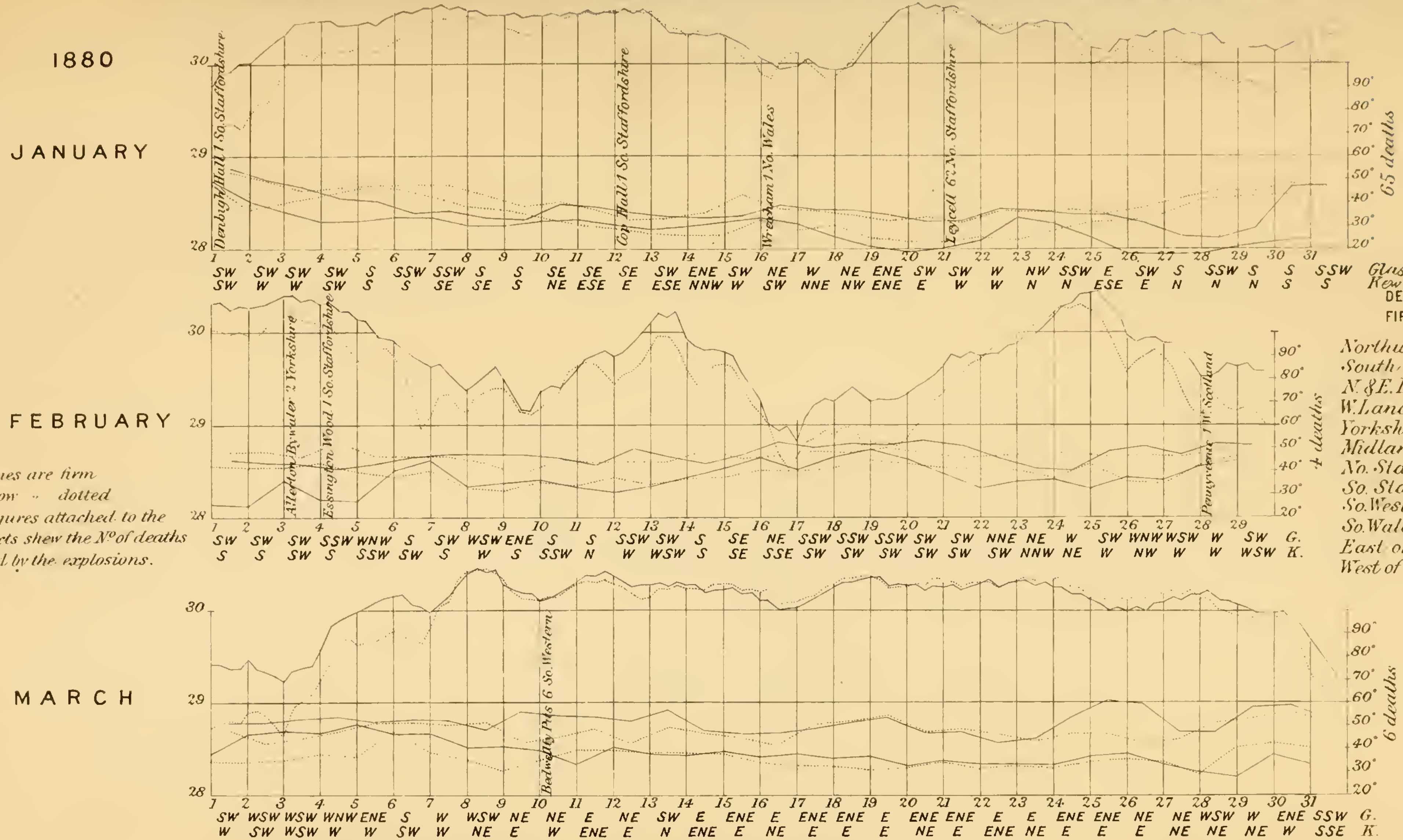
KEW.							GLASGOW.						
	Barometer.				Temperature.			Barometer.				Temperature.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Maximum.	Minimum.
1	30·071	30·197	30·247	30·270	45·0	28·9	1	30·056	30·178	30·197	30·232	39·8	27·2
2	30·222	30·158	30·046	30·041	44·1	26·4	2	30·204	30·150	30·070	30·103	38·9	21·2
3	30·057	30·169	30·234	30·341	45·9	34·1	3	30·169	30·205	30·241	30·372	38·5	28·5
4	30·359	30·419	30·351	30·337	45·2	32·0	4	30·311	30·273	30·258	30·257	48·7	31·9
5	30·321	30·355	30·328	30·343	45·0	30·6	5	30·257	30·220	30·190	30·211	49·6	43·8
6	30·334	30·371	30·311	30·315	50·7	38·3	6	30·154	30·110	29·995	29·951	52·6	46·9
7	30·255	30·231	30·157	30·113	51·2	42·5	7	29·853	29·891	29·929	29·990	50·5	39·8
8	30·081	30·215	30·313	30·420	50·0	33·0	8	30·113	30·221	30·348	30·306	40·1	34·4
9	30·388	30·323	30·145	29·967	44·9	28·3	9	30·097	29·768	29·615	29·715	50·0	39·5
10	29·932	30·059	30·104	30·138	50·2	36·1	10	29·854	29·958	29·918	29·829	47·8	37·9
11	30·086	30·062	30·019	30·030	51·9	40·0	11	29·746	29·763	29·747	29·700	51·9	45·7
12	29·984	29·950	29·967	29·961	55·2	47·4	12	29·676	29·638	29·638	29·564	52·3	46·4
13	29·833	29·761	29·713	29·660	57·5	51·9	13	29·178	29·192	29·220	29·149	54·3	44·7
14	29·518	29·394	29·245	29·131	56·9	53·2	14	29·041	29·054	29·132	29·356	45·1	31·0
15	29·457	29·725	29·497	29·470	53·8	40·0	15	29·519	29·578	29·461	29·300	33·1	25·8
16	29·059	29·801	29·741	28·945	53·1	39·7	16	28·980	28·695	28·708	28·876	40·5	27·8
17	29·037	29·115	29·166	29·254	44·1	31·8	17	28·940	29·040	29·122	29·221	35·4	26·5
18	29·269	29·184	28·948	28·722	38·3	27·0	18	29·248	29·283	29·247	29·286	31·9	18·4
19	28·954	29·332	29·583	29·795	42·3	33·0	19	29·348	29·554	29·767	29·982	35·8	21·2
20	29·957	30·138	30·285	30·415	40·8	30·4	20	30·120	30·265	30·312	30·376	25·1	15·2
21	30·452	30·413	30·269	30·133	37·0	27·0	21	30·376	30·362	30·264	30·288	33·0	20·0
22	29·993	29·942	29·920	29·921	33·9	25·2	22	30·932	29·900	29·751	29·704	31·5	18·3
23	29·889	29·872	29·867	29·907	45·2	30·0	23	29·588	29·492	29·463	29·368	46·1	26·6
24	29·890	29·883	29·836	29·838	52·3	44·0	24	29·434	29·436	29·417	29·248	48·7	42·8
25	29·580	29·626	29·776	29·958	55·7	41·5	25	28·981	29·131	29·265	29·458	51·1	42·1
26	29·750	29·588	29·602	29·730	55·9	42·0	26	29·165	28·760	29·003	29·193	52·0	43·7
27	29·830	30·026	30·125	30·298	52·2	39·5	27	29·333	29·510	29·741	29·837	48·0	41·6
28	30·349	30·401	30·371	30·379	52·1	39·2	28	29·772	29·772	29·717	29·804	52·3	45·2
29	30·382	30·415	30·397	30·417	50·5	41·5	29	29·952	30·074	30·098	30·150	46·9	43·4
30	30·425	30·429	30·353	30·294	47·2	33·4	30	30·168	30·122	29·911	29·872	49·1	41·9

DECEMBER, 1880.

1	30·214	30·142	30·052	30·066	49·6	44·2	1	29·779	29·746	29·780	29·932	48·3	39·2
2	30·146	30·243	30·250	30·300	46·1	30·0	2	30·000	30·072	30·117	30·157	44·5	37·4
3	30·300	30·315	30·287	30·335	49·1	29·0	3	30·097	29·987	29·995	30·127	48·1	37·2
4	30·359	30·439	30·453	30·497	50·8	41·0	4	30·209	30·275	30·272	30·258	48·6	41·6
5	30·502	30·491	30·454	30·470	51·8	41·6	5	30·213	30·190	30·134	30·180	52·4	46·0
6	30·446	30·456	30·454	30·522	52·2	47·0	6	30·169	30·167	30·268	30·391	52·5	40·9
7	30·572	30·620	30·608	30·633	51·0	45·1	7	30·415	30·393	30·362	30·367	51·2	39·8
8	30·595	30·598	30·503	30·475	50·3	46·9	8	30·336	30·268	30·142	30·142	50·9	45·7
9	30·418	30·421	30·369	30·337	51·9	43·1	9	30·117	30·194	30·155	30·130	50·1	46·2
10	30·316	30·274	30·252	30·332	55·5	40·9	10	29·965	30·049	30·057	30·148	51·5	44·9
11	30·322	30·298	30·142	30·080	47·0	36·1	11	30·098	29·870	29·768	29·704	50·6	41·8
12	30·038	30·118	30·124	30·103	49·0	43·4	12	29·743	29·824	29·842	29·706	43·8	39·6
13	29·984	29·975	29·956	29·929	52·3	46·5	13	29·696	29·748	29·758	29·689	45·8	35·1
14	29·865	29·922	29·954	30·007	51·3	36·8	14	29·782	29·834	29·878	29·858	37·9	30·9
15	29·884	29·634	29·475	29·530	51·9	34·9	15	29·648	29·414	29·279	29·325	36·0	29·6
16	29·504	29·530	29·627	29·710	47·6	37·6	16	29·477	29·668	29·766	29·836	36·9	22·9
17	29·711	29·725	29·673	29·643	39·9	36·3	17	29·818	29·812	29·731	29·629	31·0	15·5
18	29·583	29·595	29·467	29·472	46·4	35·8	18	29·416	29·160	28·966	28·837	36·8	26·9
19	29·466	29·520	29·559	29·532	44·2	37·9	19	28·762	28·960	29·119	29·132	39·8	32·9
20	29·417	29·459	29·439	29·600	40·5	33·4	20	29·233	29·317	29·348	29·450	38·8	31·8
21	29·579	29·875	30·056	30·127	39·8	26·8	21	29·670	29·871	29·905	29·901	36·0	30·3
22	30·021	29·772	29·689	29·632	52·5	26·0	22	29·820	29·696	29·521	29·265	33·8	30·2
23	29·501	29·576	29·474	29·226	54·2	48·9	23	29·190	29·170	29·085	28·970	44·3	33·2
24	29·135	29·155	29·268	29·442	50·2	36·8	24	28·923	28·921	29·213	29·276	39·8	30·0
25	29·478	29·517	29·590	29·712	39·0	32·2	25	29·229	29·352	29·422	29·513	37·2	30·9
26	29·714	29·698	29·637	29·545	36·5	30·0	26	29·510	29·527	29·439	29·407	35·0	27·8
27	29·349	29·318	29·463	29·510	50·3	33·1	27	29·363	29·422	29·469	29·523	33·2	29·6
28	29·523	29·567	29·555	29·576	53·1	49·8	28	29·475	29·507	29·490	29·472	36·9	30·0
29	29·554	29·445	29·126	29·151	51·2	42·0	29	29·443	29·404	29·211	29·097	36·9	34·1
30	29·396	29·350	29·448	29·645	43·2	32·3	30	29·120	29·290	29·452	29·694	38·0	32·5
31	29·817	30·073	30·213	30·289	36·3	32·3	31	29·880	29·994	30·061	30·006	39·0	26·9

DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES of KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND.

1880



Kew lines are firm
Glasgow " dotted
The figures attached to the districts shew the No. of deaths caused by the explosions.

DEATHS FROM EXPLOSIONS OF FIREDAMP DURING THE YEAR 1800

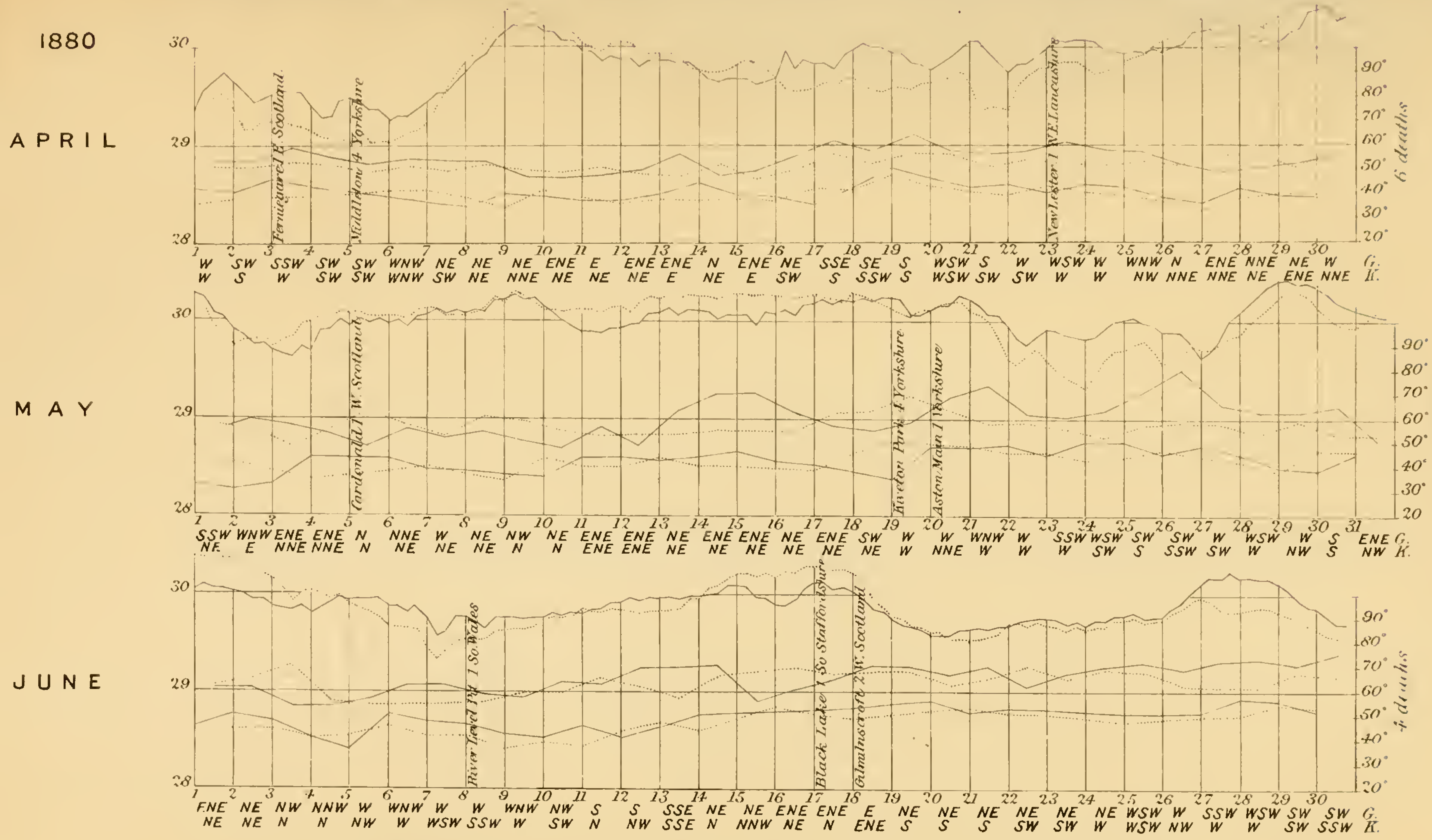
Northumberland &c	1	deaths
South Durham	164	"
N. & E. Lancashire	2	"
W. Lancashire & N. Wales	10	"
Yorkshire	11	"
Midland	0	"
No. Staffordshire &c	65	"
So. Staffordshire &c	5	"
So. Western, Monmouth &c	126	"
So. Wales	108	"
East of Scotland	1	"
West of Scotland	6	"
	499	"

The firm top line is the Barometer reading at Kew taken 4 a.m. 10 a.m. 4 p.m. & 10 p.m.
The dotted top line is the Barometer reading at Glasgow taken do. do. do. do.
The lower lines are the Maxima and Minima temperatures at Kew & Glasgow observed respectively at 10 p.m. & 10 a.m.

Proceedings No. F. I of M&M.F. 1880-81.

A. Reid Newcastle

DIAGRAM SHEWING THE HEIGHT OF THE BAROMETER, THE MAXIMA & MINIMA TEMPERATURES & THE DIRECTION OF THE WIND AT THE OBSERVATORIES of KEW & GLASGOW TOGETHER WITH THE EXPLOSIONS OF FIREDAMP IN ENGLAND & SCOTLAND



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Proceedings N.º E.I of M.&M.E. 1880 81.

Andʷ Reid Newcastle

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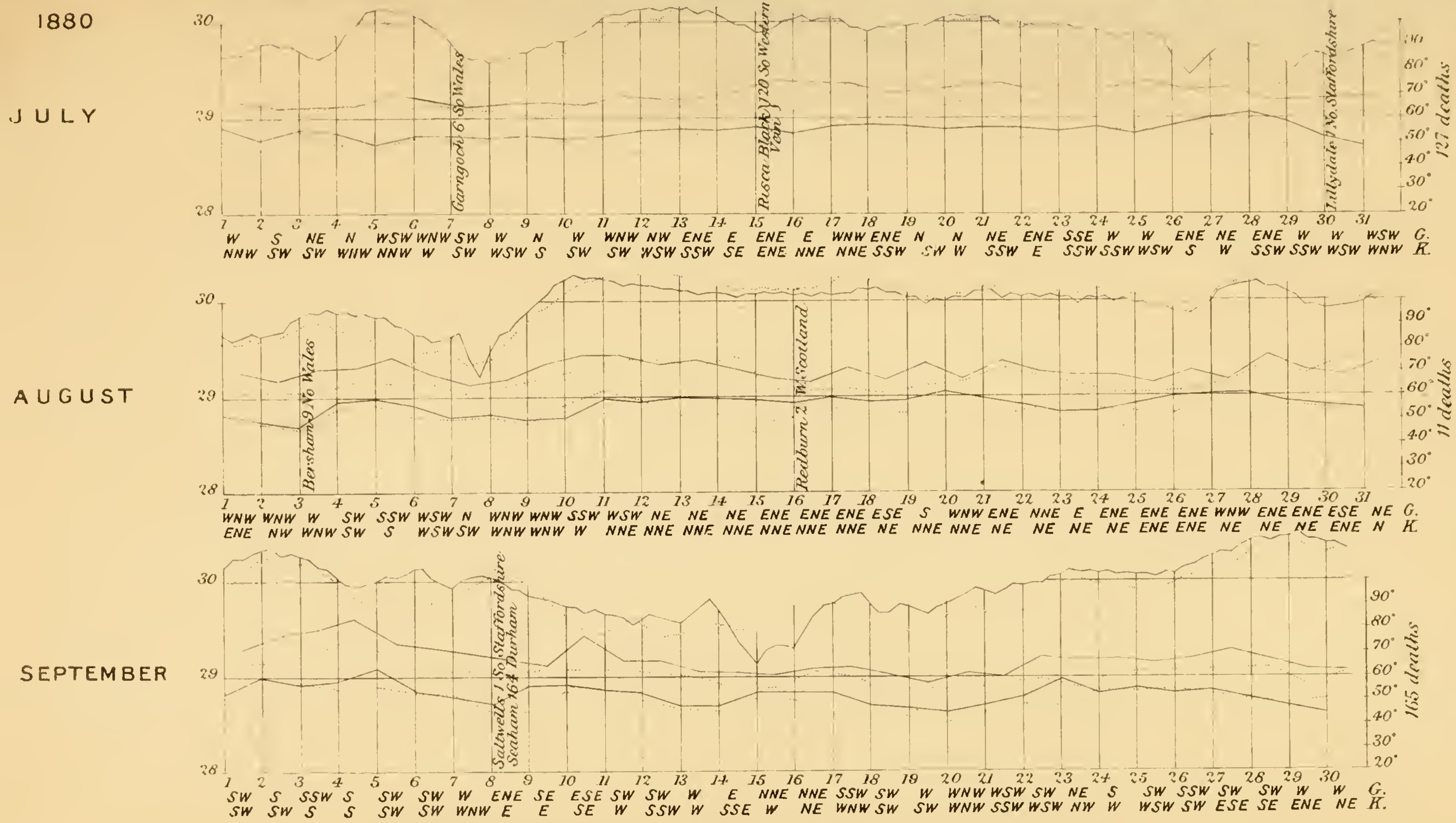

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Andw Reid Newcastle

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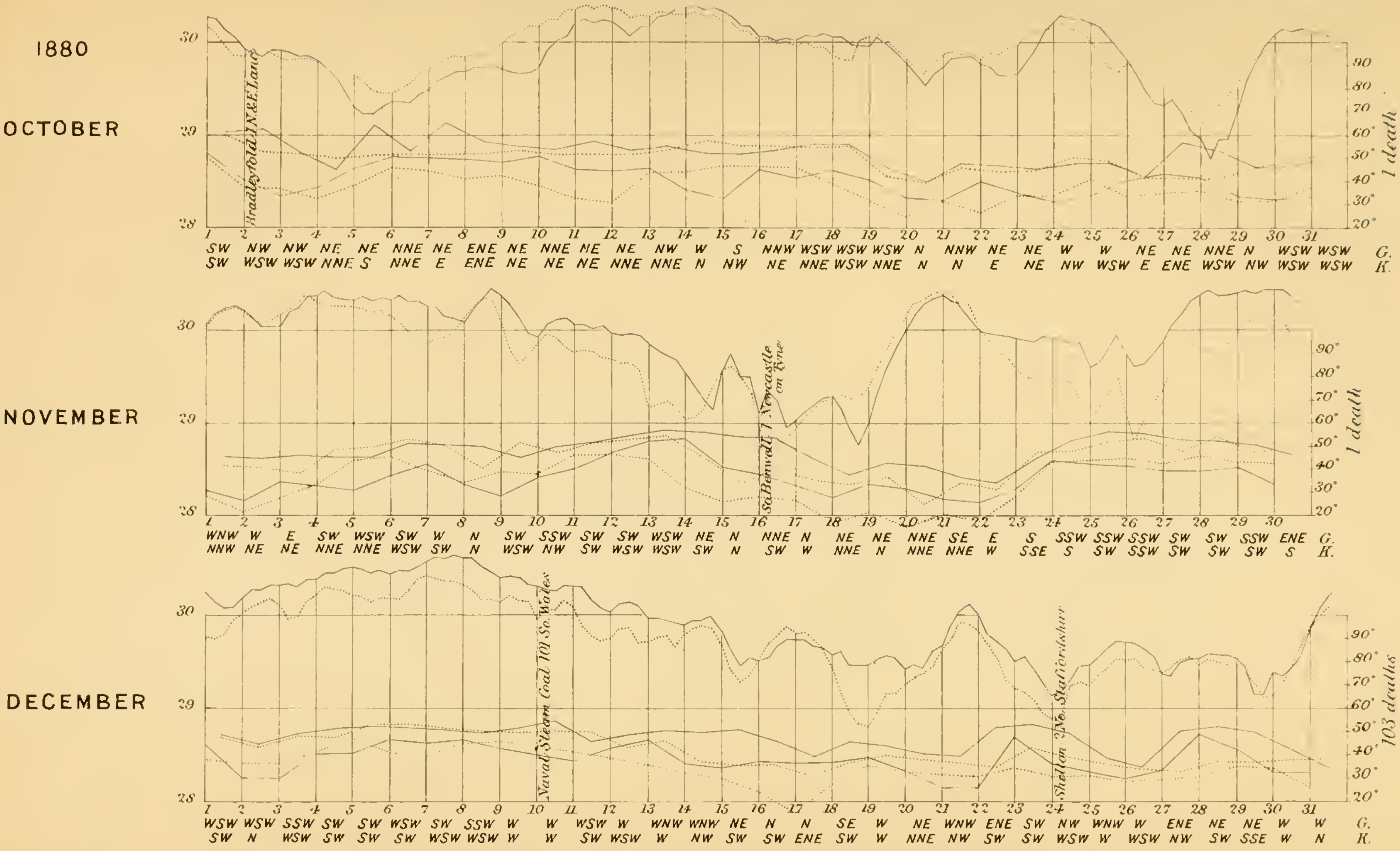

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Andw. Reid Newcastle

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