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NORTH OF ENGLAND INSTITUTE OF MINING ENGINEERS.

TRANSACTIONS.

VOL. 5.

1856-7.

Newcastle-on-Tyne: Andrew Reid, 40 & 65, Pilgrim Street.

1857.

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ADVERTIZEMENT.

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

Report

The Anniversary of Thursday, the 6th August, 1857, completes the fifth year of the existence of this Society, and the Council have much pleasure in recording that the year just closed has exhibited signs of a prosperous and satisfactory progress, equally marked with those occurring during any former year. As far as increase of numbers may be taken as a symptom of beneficial progress, the year just passed is signally fortunate. During the period of the last twelve months, thirty-eight new members have been added to the list of ordinary members. This, however, is the gross addition. From this must be deducted four members, who are, unfortunately, withdrawn from the society by death and other causes. By the operation of the first of these causes, the Institute has lost the services and society of the late Mr. John Robson, of Durham; of Mr. Todd, late of Mickley; of Mr. Hynde, late of Ruabon Iron-works, Denbighshire; and Mr. Murray, of this town, has also withdrawn, which renders the net increase upon the list of ordinary members thirty-four. The total ordinary members are now two hundred and twenty-two—a list which has grown to its present extent within the brief period of five years, and which certainly augurs well for the existing prosperity as well as the future success of an Institution so supported.

On the subject of the papers contributed, the Council may be permitted to remark that they are equally valuable with those of any former year. Certain it is that the papers read and discussed by this Society during the twelve months now at an end, are eminently calculated to furnish those engaged in mining pursuits with a species of information which must be considered as especially desirable.

The following are the subjects which form the bulk of the Transactions for the year 1856-7.

A paper "On the Coal and Iron-works of Besseges, in the Province of Gard, and the Arrondissement of Alais, in the south of France" by Mr. Matthias Dunn.

A highly interesting account of the "Winning of Murton Pit" through the limestone and under-lying sand, by Mr. Edward Potter, one of the Vice-Presidents of this Society.

A paper of minute detail "On the Conveyance of Coals Underground,'' by the President.

A paper, also, by the President, "On the Sinking through the Magnesian Limestone" at Seaham and Seaton.

"Suggestions towards a more general System of Draining Coal Mines," by Mr. Thomas John Taylor; an essay of highly important bearings, both as regards the present and future mining operations of this district.

A paper of minute detail "On the Cleveland Ironstone, its discovery, application, and results," by Mr. John Marley.

And lastly, "An account of the late Accident at Lundhill Colliery, in Yorkshire," by the President.

Such has been the progress and such the transactions of this Institute for the year just now concluding. There remain, however, several minor topics, upon which the Council must venture to trouble the members with a few necessary remarks.

It was recommended on the occasion of the last anniversary meeting that the Council should compile a list of books, proper to be placed, as occasion may offer, in the library of this Institution. It was also recommended that a rule should be to-day enacted, in accordance with a resolution then passed, forbidding contributors of papers to the volumes of Transactions, sending their essays (the copyright of which is vested in this Society) to other publications, or publishing them separately, a practice which, if it became general, would necessarily and seriously detract from the value of the published Transactions of this Institution.

The latter of these recommendations the Council anticipate you will yourselves carry into effect, as a rule, before the meeting shall separate.

The former has been already complied with. A general list of publications deemed to be suitable for the Library and congenial to the pursuits of the members of this Society, has been compiled from various

lists, kindly given in by several members of the Council, which will be found at length in the pages of the recommendation book. Some of these have now been acquired, and the rest will be obtained as opportunities for doing so with advantage shall occur.

The subject of the fossil specimens of the Newcastle Coal Field, which were made use of by Messrs. Lindley and Hutton, in the "Fossil Flora," was referred to Mr. Thomas John Taylor, on a resolution of a General Meeting, on the 2nd April last, by which Mr. Taylor was requested to make enquiry into the completeness, or otherwise, of that standard collection. This duty has been discharged by procuring from Mr. Hutton a certificate, which will be read to the meeting, purporting that, on examination, Mr. Hutton finds the collection essentially perfect. It will be for the meeting finally to dispose of the question by a resolution for that purpose; the Council venturing at the same time to remind them that it is agreed, to be a matter not merely of utility but also of feeling, to retain these fossils in that part of the country to which they most properly belong.

The price asked by the present owner, Mr. Laws, (which is understood to be the lowest) is £150, adding to that sum a copy of the "Transactions" up to this time, including the cabinets containing the fossils and such documents as accompany them.

The Institute is now in possession of the requisite instruments for performing experiments on air-currents and on ventilation generally. These instruments, which are of the best make by Newman, will be employed by the Committee, already appointed, to investigate the subject, and it is expected that great light will be thrown, by their labours, on many important points which are now obscure, and may, indeed, be regarded as belonging to an entirely new field of enquiry.

Adverting to a subject in which the Institute have always taken so deep an interest, the establishment of a projected Mining College, the Council have to state that a meeting of the College Committee has been held at Manchester, which was attended by Dr. Playfair. And as the subject is now under consideration by the Committee, it would at present be premature to enter upon the question, beyond stating the expectation of the Council that there is a prospect of (his important undertaking being carried out, in connection with the District Schools, which are meant to act as feeders to the proposed College.

In conclusion, the Council need only refer to the Report of the Finance

Committee, as exhibiting the general prosperity of the financial matters of the Society. In such recommendations as may be there embodied they agree. To the unwearied attention of the Treasurer, and of the Committee assisting him, much of the pleasing position described is to be mainly attributed; and any suggestions for still further improving that position, the Council join in earnestly recommending to the adoption of the members of the Society at large.

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The Finance Committee have the satisfaction to lay before the Society the Fifth Annual Statement of Income and Expenditure. From this it results that the Balance in the hands of the

Treasurer is................................. £725 1 0

There are also assets, consisting of volumes in hand and subscriptions not yet received, in all.446 4 0

Making the entire funds of the Society £1171 5 0

One of the more pleasing features of this account is the increase of Sales of the Society's Transactions, which, during the year just passed, have reached the sum of £114 7s., compared with £65 16s. 6d., the amount of the preceding year.

During the year just ended £84 6s. 6s. has been expended on Books for the Library of the Institute and Instruments for Experiments, and the Committee strongly recommend further additions to be made to the Library, in accordance with the resolutions on this subject already passed.

There is also room for a still further increased Sale of the Society's Publications.

Whilst they congratulate the members of the Institute on the promising position of these Funds your Committee must regret that the subscriptions from Collieries are not so numerous as might have been expected, and must express a hope that further efforts will be made to increase these subscriptions.

P. S. REID, WM. BARKUS, CHARLES CARR, EDWD. F. BOYD.

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[see in original text The treasurer in account with north of England Institute of Mining Engineers - 1856-7.]

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Patrons

His Grace the Duke of Northumberland.

The Right Honourable the Earl of Lonsdale

The Right Honourable the Earl Grey

The Right Honourable the Earl of Durham.

The Right Honourable Lord Wharncliffe.

The Right Honourable Lord Ravensworth.

The Right Reverend the Lord Bishop of Durham.

The Very Reverend the Dean and Chapter of Durham.

The Venerable Archdeacon Thorpe, the Warden of Durham University.

Wentworth B. Beaumont. Esq., M.P.

OFFICERS, 1857-8.

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NICHOLAS WOOD, Hetton Hall, Fence Houses.

Vice-Presidents

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THOMAS JOHN TAYLOR, Earsdon, Newcastle, Northumberland.

ROBT. STEPHENSON, M.P., 24, Great George Street, Westminster, London, S.W.

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C. BERKLEY, Marley Hill Colliery, Gateshead.

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List of Members

1 Adams, W., Ebw Vale Works, Newport, Monmouthshire.

2 Anderson, W., Dene House, South Shields, County of Durham.

3 Anderson, C. W., St. Hilda's Colliery, South Shields, County of Durham.

4 Arkless, B., Tantoby, Gateshead, County of Durham.

5 Arkley, G. W., Harton Colliery, South Shields, County of Durham.

6 Armstrong, Jun., W., Wingate Grange, Ferry Hill, County of Durham.

7 Ashworth, —, Poynton, Cheshire.

8 Atkinson, J., Coleford, Gloucestershire.

9 Attwood, Charles, Towlaw, Darlington, County of Durham.

10 Baker, J. P., Chillingworth Colliery, Wolverhampton, Staffordshire.

11 Barkley, J. T., Constantinople.

12 Barkus, W., Low Fell, Gateshead, County of Durham.

13 Barkus, Jun., W., Eighton Lodge, Gateshead, County of Durham.

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16 Bassett, A., Tredegar Mineral Estate Office, Cardiff, Glamorganshire.

17 Beacher, E., Thorncliffe and Chapeltown Collieries, Sheffield, Yorkshire.

18 Bell, C. W., 1, Gresham Place, Newcastle-on-Tyne, Northumberland.

19 Bell, I. L., Washington, Gateshead, County of Durham.

20 Bell, J. T. W., Higham Place, Newcastle-on-Tyne, Northumberland.

21 Bell, T., Cassop Colliery, Ferry Hill, County of Durham.

22 Bell, W. H., Sacriston Colliery, Chester-le-Street, Fence Houses, County of Durham.

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23 Berkley, C., Marley Hill Colliery, Gateshead, County of Durham.

24 Bewick, J., Grosmont, Whitby, Yorkshire.

25 Bigland, J., Bowden Close Colliery, Bishop Auckland, County of Durham.

26 Binns, C., Claycross, Derbyshire.

27 Bolckow, H. W. F., Middlesbro'-on-Tees, Yorkshire.

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29 Bourne, S., Shelton Colliery and Iron-works, Stoke-on-Trent, Staffordshire.

30 Boyd, E. F., Urpeth, Chester-le-Street, Fence Houses, County of Durham.

31 Brown, J., Bank-top, Darlington, County of Durham.

32 Brown, J., Barnsley, Yorkshire.

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35 Byram, B., Wentworth, Rotherham, Yorkshire.

36 Cadwallader, R., Ruabon Colliery, Wrexham, Denbighshire.

37 Carnes, J., West Hetton, Ferry Hill, County of Durham.

38 Carr, Charles, Seghill, Newcastle-on-Tyne, Northumberland.

39 Carr, J., Wallsend, Newcastle-on-Tyne, Northumberland.

40 Chapman, G., West Auckland Colliery, Bishop Auckland, County of Durham.

41 Charlton, G., Little Town Colliery, County of Durham.

42 Clark, W. S., Aberdare, Glamorganshire.

43 Cochrane, A. B., The Heath, Stourbridge.

44 Cochrane, C., Ormesby Iron Works, Middlesbro'-on-Tees.

45 Cope, J., King Swinford, Dudley,, Worcestershire.

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47 Cossham, R., Shortwood Lodge, Bristol, Somersetshire.

48 Coulson, W., Crossgate Foundry, Durham.

49 Cowen, J., Blaydon Burn, Newcastle.

50 Coxon, F., Trimdon Colliery, Ferry Hill.

51 Coxon, S. B., Usworth Colliery, Gateshead.

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53 Crawford, Jun., T., Little Town Colliery, County of Durham.

54 Crawhall, E. G., Weldon Bridge, Morpeth.

55 Creswick, Theophilus, Merthyr Tydvil, South Wales.

56 Crone, S. C., Pontop Colliery, Gateshead.

57 Croudace, C., Washington, Gateshead.

58 Croudace, J., Washington Colliery, Gateshead.

59 Daglish, J., Seaton Colliery, Fence Houses.

60 Day, J. W., Pelaw House, Chester-le-Street, Fence Houses.

61 Dees, J., Whitehaven, Cumberland.

62 Dixon, G., Cockfield, Staindrop, County of Durham.

63 Dixon, R., Claypath, Durham.

64 Dobson, S., Treforest, Pontypool, Glamorganshire.

65 Douglas, T., Pease's West Collieries, Darlington.

66 Dumolo, J., Danton House, Coleshill, Warwickshire.

67 Dunlop, C., St. Petersburg, Virginia, U.S. America.

68 Dunn, T., Richmond Hill, Sheffield, Yorkshire.

69 Easton, J., Hebburn Colliery, Gateshead.

70 Elliot, G., Houghton Hall, Fence Houses.

71 Elliott, W., Etherley Colliery, Darlington.

72 Embleton, T. W., Middleton Hall, Leeds, Yorkshire.

73 Errington, — C. E., Westminster, London.

74 Evans, J., Dowlais Iron Works, Merthyr Tydvil, South Wales.

75 Fletcher, C.E., Jos., Dawson Place, Whitehaven, Cumberland.

76 Foord, J. B., General Mining Association Secretary, 52, Broad Street, London.

77 Forster, J. H., Old Elvet, Durham.

78 Forster, G. B., Cramlington Hall, Newcastle.

79 Gilroy, G., Orrell Colliery, Wigan, Lancashire.

80 Gooch, G., Lintz Colliery, Gateshead.

81 Gray, J., Garesfield Colliery, Gateshead.

82 Green, G., Rainton Colliery, Fence Houses.

83 Greene, Jun., Wm., Framwellgate Colliery, Durham.

84 Greener, W., Pendleton, Wigan, Lancashire.

85 Greenwell, G. C, Radstock Colliery, Bath, Somersetshire.

86 Haggie, P., West Street, Gateshead.

87 Hall, T. Y., Eldon Square, Newcastle.

88 Hann, W., Hetton, Fence Houses.

89 Hardy, Benjamin, Woodhouse Close Colliery, Durham.

90 Harris, C.E., John, Woodside, Darlington.

91 Harrison, C.E., T. E., Central Station, Newcastle.

92 Hawthorn, R., Engineer, Newcastle.

93 Hawthorn, W., Engineer, Newcastle.

94 Heckels, G., Shincliffe Colliery, Durham.

95 Heckels, R., Bunker's Hill, Fence Houses.

96 Hodgson, R., Engineer, Whitburn, Monkwearmouth, Sunderland.

97 Holdsworth, Joseph, Edinburgh.

98 Holt, J., Stanton Iron Works, Derby, Derbyshire.

99 Hopper, A. F., West Auckland Colliery.

100 Horsley, Jun., W., Seaton Cottage, Hartley, Newcastle.

101 Hunter, S., Tredegar Iron Works, Newport, Wales.

102 Hunter, Wm., Spital Tongues, Newcastle.

103 Hurst, T. G., Backworth Colliery, Newcastle.

104 Jeffcock, P., 3, Stuart Terrace, Green Hill, Derby, Derbyshire.

105 Jobling, T. W., Point Pleasant, Wallsend, Newcastle.

106 Johnson, G., Laffack Colliery, St. Helen's, Lancashire.

107 Johnson, J., Willington, Newcastle.

108 Johnson, R. S., West Hetton, Ferry Hill.

109 Joicey, Jas., Quay, Newcastle.

110 Joicey, John, Tanfield Lea, Gateshead.

111 Jones, E., Lilleshall Iron Works, Sheffnall, Salop.

112 Kimpster, W., Quay, Newcastle.

113 Knowles, A., Crescent, Salford, Manchester, Lancashire.

114 Knowles, J., Pendleton, Manchester, Lancashire.

115 Laws, J., Blyth, Northumberland.

116 Levick, Jun., F., Cwm Celyn, Blaina and Colebrook Dale Iron

Works, Newport, Monmouthshire.

117 Liddell, J., Killingworth, Newcastle-on-Tyne.

118 Liddell, M., Benton Grange, Newcastle-on-Tyne.

119 Llewellin, Wm., Glanwern, Pontypool, Glamorganshire.

120 Locke, C, Rothwell Haigh, Wakefield, Yorkshire.

121 Locke, M.P., Jos., Westminster, London.

122 Longridge, H. G., Barrington Colliery, Morpeth, Northumberland.

123 Longridge, J., Fludyer Street, Westminster, London.

124 Love, Jos., Brancepeth Colliery, Durham.

125 Low, Wm., Vron Colliery, Wrexham, Denbighshire.

126 Marley, J., Mining Offices, Darlington.

127 Marshall, Robt., Wylam Colliery, Newcastle-on-Tyne.

128 Matthews, Richard, South Hetton Colliery, Fence Houses.

129 Maynard, T. C., North Bailey, Durham.

130 McLean, J. C.

131 Mercer, J., St. Helen's Lancashire.

132 Middleton, J., Davison's Hartley Office, Quay, Newcastle-on-Tyne.

133 Morton, H., Lambton, Fence Houses.

134 Morton, H. J., 2, Basinghall, Leeds, Yorkshire.

135 Morton, H. T., Lambton, Fence Houses.

136 Mulcaster, H., Blackley Hurst Colliery, St. Helen's, Lancashire.

137 Mundle, W., Ryton, Gateshead.

138 Murray, T., Chester-le-street, Fence Houses.

139 Ogden, J. M., 49, West Sunnyside, Bishopwearmouth, Sunderland.

140 Palmer, A. S., Seaton Burn Colliery, Newcastle-on-Tyne.

141 Palmer, C., M., Quay, Newcastle-on-Tyne.

142 Palmer, J. B., Jarrow, South Shields.

143 Paton, Wm., Alloa Colliery, Alloa, North Britain.

144 Peace, Wm., Hague Cottage, Wigan, Lancashire.

145 Pease, J. Wm. Woodlands, Darlington.

146 Philipson, R. H., Cassop Colliery, Ferry Hill.

147 Pickup, Peter, Burnley, Lancashire.

148 Pilkington, Wm., St. Helen's, Lancashire.

149 Plews, H. T., Newcastle, New South Wales, Australia.

150 Plummer, B., Ryhope, Sunderland.

151 Plummer, Jun., R., Flax Mills, Ouseburn, Newcastle-on-Tyne.

152 Potter, E., Cramlington, Newcastle-on-Tyne.

153 Potter, W. A., Mount Osborne Collieries, Barnsley, Yorkshire.

154 Powell, T., Newport, Monmouthshire.

155 Ramsay, J., Walbottle Colliery, Newcastle-on-Tyne.

156 Ravenshaw, J. H., Sunderland.

157 Reed, R. G., Cowpen Colliery, Blyth, Northumberland.

158 Reed, Wm., Cowpen, Bedlington, Morpeth.

159 Reid, P. S., Pelton Colliery, Chester-le-Street, Fence Houses.

160 Richardson, Dr., Portland Place, Newcastle-on-Tyne.

161 Robinson, R., Evenwood Colliery, Bishop Auckland.

162 Robson, J. G., Old Park Hall, Ferry Hill.

163 Robson, G., Tondu Iron Works, Bridge End, Glamorganshire.

164 Robson, M. B., Field House, Borough Road, Sunderland.

165 Rogers, E., Abercarne Colliery, Newport, Monmouthshire.

166 Rosser, William, Mineral Surveyor, Llannelly, Carmarthenshire, Wales.

167 Routledge, Jun., Wm., Shincliffe Colliery, Durham.

168 Rutherford, J., South Tyne Colliery, Haltwhistle, Northumberland.

169 Sanderson, Jun., R. B., West Jesmond, Newcastle-on-Tyne.

170 Sawyers, W. G., Whitehaven, Cumberland.

171 Seymour, A., Farnacres Colliery, Gateshead.

172 Seymour, M., South Wingate, Ferry Hill.

173 Sewell, W., Wellington Street, Gateshead.

174 Shortreed, T., Newbottle Colliery, Fence Houses.

175 Simpson, L., Medomsley Colliery, Durham.

176 Simpson, R., Ryton, Gateshead.

177 Sinclair, E., Morpeth, Northumberland.

178 Smith, C. F. S., Derby, Derbyshire.

179 Smith, F., Bridge water Canal Office, Manchester, Lancashire.

180 Smith, Jun., J., Monkwearmouth Colliery, Sunderland.

181 Sopwith, T., Allenheads, Haydon Bridge, Northumberland.

182 Southern, E., Kibblesworth Colliery, Gateshead.

183 Southern, G. W., Springwell Colliery, Gateshead.

184 Southern, J. M., Whickham Grange, Gateshead.

185 Spark, H. K., Darlington, County of Durham.

186 Spencer, Jun., W., Corporation Road, Middlesbro'-on-Tees.

187 Steavenson, A. L., Woodifield Colliery, Crook, Darlington.

188 Stenson, W., Whitwick Colliery, Ashby-de-la-Zouch, Leicestershire.

189 Stenson, Jun., W., Whitwick Colliery, Ashby-de-la-Zouch, Leicestershire.

190 Stephenson, M.P., Robt., 24, Great George Street, Westminster, London.

191 Stobart, H. S., Etherley, Darlington.

192 Stobart, W., Roker, Monkwearmouth, Sunderland.

193 Storey, T., St. Helen's Auckland, Bishop Auckland.

194 Stott, R., Ferry Hill, County of Durham,

195 Straker, J., North Shields, Northumberland.

196 Taylor, H., Earsdon, Newcastle-on-Tyne.

197 Taylor, H., Backworth Hall, Newcastle-on-Tyne.

198 Taylor, J., Haswell Lodge, County of Durham.

199 Taylor, T. J., Earsdon, Newcastle-on-Tyne.

200 Telford, W., Cramlington, Newcastle-on-Tyne.

201 Thomas, J. T., Coleford, Gloucestershire.

202 Thomas, W., Bogilt, Holywell, Flintshire.

203 Thompson, T. C, Kirkhouse, Brampton, Cumberland.

204 Thorpe, R. C., Bebside Colliery, Morpeth.

205 Tone, C.E., John F., Market Street, Newcastle-on-Tyne.

206 Trotter, J., Newnham, Gloucestershire.

207 Vaughan, J., Middlesbro'-on-Tees.

208 Wales, J., Hetton Colliery, Fence Houses.

209 Wales, T. E., Abersychan Iron Works, Pontypool, Monmouthshire.

210 Walker, J., Lakelock, Wakefield, Yorkshire.

211 Walker, Jun., T., High Street, Maryport, Cumberland.

212 Ware, W. H., The Ashes, Stanhope, Weardale.

213 Watson, H., High Bridge, Newcastle-on-Tyne.

214 Webster, R. C., Hoyland Hall, Barnsley, Yorkshire.

215 Willis, James, Whitelee Colliery, Crook, Darlington.

216 Wilmer, F., Pensher Colliery, Fence Houses.

217 Wilson, J. B., Haydock Rope Works, Warrington, Lancashire.

218 Wilson, R., Flimby Colliery, Maryport, Cumberland.

219 Wood, C. L., Black Boy Colliery, Bishop Auckland.

220 Wood, N., Hetton Hall, Fence Houses, County of Durham.

221 Wood, W. H., 4, Victoria Terrace, Jesmond Road, Newcastle-on-Tyne.

222 Woodhouse, J. T., Midland Road, Derby, Derbyshire.

Rules

1. —That the Members of this Society shall consist of Ordinary Members, Life Members, and Honorary Members.

2. —That the Annual Subscription of each Ordinary Member shall be £2 2s. 0d., payable in advance, and that the same shall be considered as due and payable on the first Saturday of August in each year.

3. —That all persons who shall at one time make a Donation of £20 or upwards, shall be Life Members.

4. —Honorary Members shall be persons who shall have distinguished themselves by their Literary or Scientific attainments, or made important communications to the Society.

5. —That a General Meeting of the Society shall be held on the first Thursday of every Month, at one o'clock p.m., and the 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 Meeting of the Society may be called whenever the Council shall think fit, and also on a requisition to the Council signed by ten or more Members.

6. —No alteration shall be made in any of the Laws, Rules, or Regulations of the Society, except at the Annual General Meeting, or at a Special Meeting and the particulars of every alteration to be then proposed shall be announced at a previous General Meeting, and inserted in its minutes, and shall be exhibited in the Society's meeting-room fourteen days previously to such General Annual or Special Meeting.

7. —Every question which shall come before any Meeting of the Society shall be decided by the votes of the majority of the Ordinary and Life Members then present and voting.

Person desirous of being admitted into the Society as Ordinary or Life Members, shall be proposed by three Ordinary or Life Members, or both, at a General Meeting. The proposition shall be in writing,

and signed by the proposers, and shall state the name and residence of the individual proposed, whose election shall be ballotted for at the next following General Meeting, and during the interval notice of the proposition shall be exhibited in the Society's room. Every person proposed as an Honorary Member must be recommended by at least five Members of the Society, and elected by ballot at the General Meeting next succeeding. A majority of votes shall determine every election.

9. —The Officers of the Society shall consist of a President, four Vice-Presidents, and twelve Members who shall constitute a Council for the direction and management of the affairs of the Society; and of a Treasurer, and a Secretary; all of whom shall be elected at the Annual Meeting, and shall be re-eligible, with the exception of Four Councillors whose attendances have been fewest. Lists containing the names of all the persons eligible having been sent by the Secretary to the respective Members, at least a month previously to the Annual Meeting;—the election shall take place by written lists, to be delivered by each voter in person to the Chairman, who shall appoint

scrutineers of the lists; and the scrutiny shall commence on the conclusion of the other business of the meeting. At meetings of the Council, five shall be a quorum, and the record of the Council's proceedings shall be at all times open to the inspection of the members of the Society.

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

11. -The Council shall have power to decide on the propriety of communicating to the Society any papers which may be received, and they shall be at liberty, when they think it desirable to do so, to direct that any paper read before the Society shall be printed. Intimation shall be given at the close of each General Meeting of the subject of the paper or papers to be read, and of the questions for discussion at the next meeting, and notice thereof shall be affixed in the Society's room ten days previously. The reading of papers shall not be delayed beyond 3 o'clock, and if the election of members or other business should not be sooner dispatched, the President may adjourn such business until after the discussion of the subject for the day.

12. —That the Copyright of all papers communicated to and accepted by the Institute, becomes vested in the Institute; and that such communications shall not be published for sale, or otherwise, without the permission of the Council.

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It was resolved at the Annual Meeting, 6th August 1857 that an alteration of Rule 5 should be tried for the twelve months next ensuing; during which there shall be General Meetings only on the first Thursday, respectively, of the months of October, December, February, April, June, and August.

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NORTH OF ENGLAND INSTITUTE of MINING ENGINEERS.

MONTHLY MEETING, FRIDAY, SEPTEMBER 5, 1856, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

Nicholas Wood, Esq., President of the Institute, in the Chair.

The minutes of the Council having been read,

The President called attention to an invention of Mr. Ramsay for the purpose of keeping the tokens safe in the tub. The peculiarity of the invention is that it is fixed at the top of the tub and remains until the tub was emptied. Mr. Ramsay had introduced it into Walbottle Colliery, and had presented one to the Institute, for which they were much obliged to him.

Mr. Ramsay, who was present, explained the nature of the invention.

The President referred to the resolutions read in the minutes and agreed to be submitted to the consideration of the meeting by the Council. Before making any observations he would read the first resolution, which was as follows:—

"That the copyright of all papers communicated and accepted by the Institute becomes vested in the Institute, and such communications may not be published without permission of the Council; and that this resolution be proposed to be incorporated as a rule at the next anniversary meeting."

The President then observed that it had been represented to the Council that papers had been sent to other publications without the consent of the Council, and as that was so, he need scarcely tell the meeting that

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such a course was wrong, as all papers were the copyright of the Institute and could not legally be published by any other party without obtaining permission to do so from those to whom the papers belonged. It having come to the knowledge of the Council, as before stated, that some papers had been published elsewhere, the Council deemed it proper to submit the resolution just read in order to put a stop to such proceedings in future. It was, nevertheless, for that meeting to say how far it agreed with the wishes of the Council, by either rejecting or adopting the resolution. If passed, it would, at the next anniversary meeting, be incorporated with the rules.

Mr. Hall, without wishing to oppose the resolution, thought they could not prevent parties from publishing as the papers were for sale.

Mr. J. Longridge—Yes, the papers published by the Institute? Now what the resolution sought to attain was to prevent any person publishing, as the copyright of every paper belonging the Institute was its property: and of course legal proceedings could be instituted against any party so offending.

Mr. T. J. Taylor agreed with Mr Longridge as to the copyright of papers belonging to the Institute. That was a matter of fact, and of course the Institute could legally stop any party publishing.

Mr. Hall, had there been any document published without the consent of the Council?

The President—Yes, there had.

Mr. Berkley was of opinion that if a gentleman sent in a paper which the Council did not print, such party ought to be allowed to publish it if he chooses.

Mr. Longridge—If the paper was refused by the Council, then it could not be considered the property of the Institute; but when a paper was accepted, then it became the property of the Institute.

Mr. Dunn—How could it be the property of the Institute if the paper was only received and not published?

Mr. Longridge replied that such a rule existed in the London Institute.

Mr. Berkley—Then, when a paper was read it became the property of the Institute.

Mr. Longridge—Certainly.

Mr. T. J. Taylor—With regard to the printing of separate papers he thought that ought to be left to the discretion of the Council.

The President thought it well that a discussion had taken place on

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the subject, as it would appear obvious that the practice of publishing papers independently of the Council could not be allowed to go on for the future. The Council, however, would be glad to do everything in their power to encourage the production of papers, as it was not their wish to prevent the publication or circulation of any paper useful to the Institute or creditable to the author. Besides, it was their wish to do every thing to promote their sale; but as yet it was not the rule of the Institute to circulate separate papers for sale. What had hitherto been done was to print the proceedings in a yearly volume; but if any member considered they ought to print separate papers a resolution to that effect could be proposed at any meeting. If the effect of selling separate papers was such as what had been described by Mr. Hall, then such a system would interfere with the sale of the yearly proceedings. At present it was clear that it was quite irregular and illegal for any member to publish and sell separate papers belonging the Institute, and any party acting in such a manner could be prosecuted by law, as the copyright of every paper belonged the Institute. It was therefore desirable that members of the Institute should know that it was neither legal nor equitable, according to the rules of the Institute, to print and dispose of, separately, any paper after it was published by the Institute, without their consent. As to the question raised by Mr. Dunn relative to a paper having been read and not published, it was always understood that if a paper was read it had to be published. He, however, thought that when a paper was not read it ought to be returned to the author.

Mr. Dunn—That was exactly what he thought. If a paper was rejected by the Council it ought to be returned to the author.

The President—They had always acted upon the principle, that when a paper was read, it was printed. There had been no exception to that rule.

Mr. Hall thought the President said that papers were never sold separately, but he (Mr. H.) recollected that the monthly papers read at the first year's proceedings of the Institute were sold separately. For himself, he thought that any paper printed in that Institute the public ought to have the benefit of, whether in a separate or joint form with other papers, the profits derived from the sale of them to go into the funds of the Institute.

The President said, that he had already stated that any member publishing a separate paper was guilty of a breach of the rules affecting the

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copyright which the Institute possessed. If, however, Mr. Hall, or any other member, were of opinion that separate papers, generally, or any particular paper, ought to be published, then it would be better for them to bring forward a motion to that effect.

Mr. T. J. Taylor said the whole question resolved itself into whether or not discretionary power should be invested in the Council as to the propriety of publishing separate papers when they deemed it necessary. At present they had no such power.

The President then put the resolution to the meeting, when it was carried unanimously.

The President next called attention to the second resolution suggested in the minutes of the Council, relative to the Library Committee being instructed to present a list of books which they deemed should be ordered for the use of the Institute. It was also suggested that every member should be at liberty to do the same, as it was obvious, looking at the bare state of their shelves, that their library was not in a very efficient condition. With the view of replenishing it the following resolution had been drawn up by the Council:—

"That the Library Committee be requested to prepare a list of works which they may consider proper for the Library of the Institute, and to submit the same to the next meeting of the Council; and that each member be also invited to recommend to the Council at the same meeting such works as he may deem advisable to be purchased."

The resolution on being put was carried unanimously.

The President then remarked that with respect to the subject of separate papers being published, the question was still an open one, and any member was at liberty to make a proposition, but of course due notice ought to be given in order to prepare the members to discuss it.

Mr. Hall gave notice of a motion to the effect, that at the next monthly meeting he should propose that separate papers be published.

The meeting then proceeded with the election of gentlemen nominated at the previous meeting, when the following were duly elected members of the Institute:—Mr. Hugh Taylor, Backworth; Mr. Geo. Dixon, Cockfield; Mr. Joseph Love, Brancepeth Colliery; Mr. Robert Plummer, Jun., Flax Mill, Newcastle.

The President next called attention to the discussion of papers in

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arrear. Notice (he said) had been given, that the papers of Messrs. Elliot, Greenwell, and Dunn, should be discussed. They could not, however, well proceed with the discussion of Mr. Dunn's paper, as it had only been recently printed, and he, therefore, doubted it had reached the hands of all the members to read and consider. For himself, he only got his copy of the paper that morning. Probably Mr. Dunn's paper might be discussed at the same time as the papers read by Mr. Armstrong and Mr. Daglish, which would be at the next meeting. The paper first on the notice list was that of Mr. George Elliot, but he was sorry that he was not present, more especially as it was stated in the paper, that he (Mr. Elliot) would be prepared to give his reasons for certain phenomena in reference to the subject. He (the President) scarcely knew how to deal with the matter, as it was not desirable to discuss a paper during the absence of the author of it. There also was another paper to be discussed, viz., that of Mr. Greenwell, who also was not present, but that circumstance could hardly be supposed to militate against their proceeding with it, as Mr. Greenwell resided at such a great distance from the neighbourhood; and any explanation respecting the paper might be given hereafter by Mr. Greenwell, when he could attend the meeting. It would appear obvious that, if they did not get on with the discussion of papers, they would get into arrears and into confusion. Again, the paper read some time ago by Mr. Longridge, was in arrear, and ought to have been discussed some time ago, but as notice had not been given respecting it, they could not proceed with it, and a question arose respecting it whether the discussion ought not to be postponed until the experiments which the committee were making were laid before the Institute. He knew that Mr. Longridge thought his paper would not interfere with these experiments, but whether or not, it was necessary that notice of its discussion should be made in the usual way. Having made these remarks, he would be glad to hear any observations on Mr. Greenwell's paper.

Mr. Hall considered the paper a very useful one, although Mr. Greenwell had not clearly shown what was the charge for putting coals into the wagons at the top of the pit. Mr. Greenwell appeared to confine himself to the underground charges, which was only a portion of the expenses. He was of opinion that the cost of working coals in Mr. Greenwell's district was expensive, as they were not able to send their coals at any great distance from the pit; and, at present, the trade was confined to the locality.

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The President—They would observe that Mr. Greenwell's paper was a comparison between thick and thin seams. He appears to have confined himself entirely to that point, so that he had not included the expenses above-ground, as they varied so much at several places. It was, nevertheless, an important thing to show the comparative cost between thick and thin seams, and Mr. Greenwell makes out that they worked the thin, at little more expense than the thick veins, by which they brought into operation a large extent of coal hitherto only occasionally worked. The discussion, therefore, would apply only to Mr. Greenwell's elements of cost for working thin seams.

Mr. Hall—If Mr. Greenwell brought thin seams to bank cheaper than thick, that certainly was a great object.

Mr. Berkley would observe that the workmen in this district were not accustomed to work thin seams; and before they could be worked men would have to be trained for the purpose.

Mr. Hall—It was clear that if all the seams were thin they might all stand still, as workmen could not be found for that kind of work. Parties would have to be trained from childhood, and of course there would have to be a new generation of workmen.

The President thought Mr. Berkley's objection was not a fatal one, because if there was nothing but thin seams the workmen would soon get accustomed to them. He remembered a thin seam worked of only eleven inches thick, when one of the workmen remarked that if it was another inch in thickness it would be magnificent. That seam was worked extensively, and he should have liked to have had at hand the cost incurred in working it.

Mr. T. J. Taylor observed, that we had thick seams here, and also thin ones, which last were more a consideration for the future; and when the time arrived he thought they would be able to work the thin seams with profit. Some thin seams already had been worked. For instance, there was one at Pasture Hill, about 14 inches high, which had been worked for some years. There also was another at

Shilbottle. Mr. Greenwell stated that 3s. 0¼ d. per ton was the cost of working a 20-inch seam in his district, while at Shilbottle, with a 29-inch seam, the cost, on equal terms of comparison, was 2s. 9d. per ton. The seam at Shilbottle was remarkably hard; Mr. Greenwell put down his produce at 73 per cent., while at Shilbottle, it was 80.55 per cent. He mentioned these cases to show that when the proper time arrived for working thin seams they would be able to work them well. He recollected having some

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discussion on this subject with the late Professor Johnson, when that gentleman expressed it as his opinion that the coal-fields would never be exhausted, but that as the exhaustion progressed the expense of working the coal would be increased. He confessed that he did not concur in all the views of the learned Professor. With regard to the long way of working, it was obvious that a very admirable principle was in that system brought into operation, a principle which consisted in availing ourselves of the superincumbent pressure to assist in extracting the coal.

The President was of opinion that the long-wall system was being very much extended in this district.

Mr T. J. Taylor concurred that things were progressing in that direction.

Mr. Dunn thought one essential for a thick seam was its having a soft bottom. Now, it was well known that the seams of that district had no soft bottoms.

Mr. Hall said, they had a thin instead of a thick seam, and could work it. But it was his opinion that instead of depending upon workmen, they might have a cutting machine to work out the long-wall system. He knew of several ingenious inventions, but in regard to one especially, he had recently suggested some alteration in the shape of the cutters, which when finished would be able to do the work effectually.

The President hoped that Mr. Hall would bring the matter before the Institute after the machine succeeded.

Mr. Dunn said that Osbald Hedley had a working model of a cutting machine.

Mr. Longridge thought there was one point in Mr. Greenwell's paper omitted, and that was the comparative price of wages paid in the two districts, for without that they could not tell the expenses attending the working of thin and thick seams. It appeared that the hewers in the thick seam received 1s. 1d. per ton; while in the long-wall it was 1s. 10d. per ton. Then again, he found the quantity of coal which each man worked in Mr. Greenwell's district was equal to 150 tons, while in the north it was upwards of 490 tons, which was more than three times the quantity. How then was it possible for the men in Wales to make the wages of those in the north.

Mr. T. J. Taylor agreed with Mr. Longridge that they could not get at the cost otherwise than by comparing the wages paid in each district. While on the subject of thin seams, he might suggest that as these seams were left in our district for future working, it seemed hardly

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right to excavate in to the thicker seams above and below them, but rather to leave, in some properly selected situation of a royalty, one or more small solid plots to facilitate future winning operations.

The President thought that an important consideration. With respect to the long-wall system, he had seen at one place the coal for upwards of 100 yards of wall face fall at once. The fact was, the wall-face was curved during the night, and the superincumbent strata, pressing upon the undermined coal, the solid block of coal was thus brought down. Such a system required little amount of labour to separate a large quantity of coal. Mr. Greenwell, in his paper, said it was a long sort of coal and came down in large lumps. He had, however, no doubt but that they would renew the discussion of the subject when Mr. Greenwell was present.

The subject here dropped.

The President again called attention to Mr. Elliot's paper, when

Mr. Longridge wished to draw the consideration of the meeting to the propriety of having papers discussed more regularly. He thought, as a general principle, that when a discussion was fixed for a paper, it ought, except under very peculiar circumstances, to be proceeded with whether the author was present or not.

Some conversation ensued respecting the irregularity into which the Institute had fallen in allowing papers appointed for discussion to be postponed from time to time; ultimately it dropped, by the following resolution being proposed and agreed to:—

"It being indispensable for the writers of papers to attend the discussions thereon, that such discussions be fixed to take place at the second meeting after the reading of the same, the attendance of the authors, it is hoped, will thus be secured, by his punctuality in observing this resolution."

Mr. Berkley then presented to the Institute Turnbull's Danger Indicator for steam engine boilers, after which the meeting broke up.

NORTH OF ENGLAND INSTITUTE of MINING ENGINEERS.

Monthly meeting, Friday, October 3, 1856, in the rooms of the Institute, Westgate Street, Newcastle-upon-Tyne.

Nicholas Wood, Esq., President of the Institute, in the Chair.

The Secretary having read the minutes of the Council Meeting, the two following gentlemen were then elected as members of the Institute, Mr. Benjamin Hardy, Woodhouse Close Colliery; Mr. George Gooch, Lintz Colliery.

The President called attention to a portion of the minutes of the Council, having reference to a letter received from Thos. Sopwith, Esq., relative to a paper by Mr. Dobson, a native of this district, on the coincidence of explosions in coal mines with the sudden barometrical changes which are generally known to precede great storms. The Council, in considering the matter, thought it was inconsistent with the rules of the Institute to read a paper which had been previously read at another society: and they doubted whether it accorded with the rules of the British Society to permit a paper belonging to them to be read at another institution. Under these circumstances he would make some enquiries, but, he thought a copy of Mr. Dobson's paper would be very desirable. Explosions often occurred in the mines when the glass suddenly fell, and any statistics relative thereto could not but be useful to the Institute. The resolution of the Council, they would perceive, was to the effect, to thank Mr. Sopwith for his communication, and to state that the rules of the Institute did not permit a paper to be read which had been previously read before another society; but adding, at the same time,

that the Council would be glad to receive a copy of the paper in question. The President then put the question to confirm the resolution of the Council, which was carried unanimously.

The President then read a letter from Mr. Edward Sinclair, Morpeth, to the Secretary, accompanied with a large specimen of hematite as a gift to the Institute, and also containing the analysis of a similar specimen, of which the following is a copy:—

Morpeth, October 1, 1856.

My dear Sir,—I expected to have been at your meeting on the 3rd, but I am obliged to go to London to-morrow, and cannot, therefore, attend the meeting of the Members of the Institute. I left a large specimen of Hematite, which I wish to present to the Institute, as it is one of the finest specimens of Hematite I have ever seen. I got it at the Garpel and Whitehaugh Hematite Quarries, near Muirkirk, in Ayrshire, where there is a very large deposit of this ore. It is apparently very rich. The following was given to me as the analysis:—

Peroxide of Iron 96.65

Columbic Acid (?)............................1.45

Alumina..0.79

Water... 1.00

99.89

I am, my dear Sir, yours faithfully, EDWARD SINCLAIR.

The President then referred to papers which stood over for discussion, viz., those of Messrs. Elliot, Armstrong, Daglish, and Dunn. As neither Mr. Elliot nor Mr. Armstrong were present, it was not desirable to discuss their papers in their absence, but as Mr. Daglish and Mr. Dunn were present, they could proceed with theirs; and as Mr. Daglish's paper stood first, he would be glad to hear any observations upon it. As the paper was on the comparative results of round and small coals in evaporating water, perhaps Mr. Daglish would explain how he obtained such results. He should also wish to know the description of boiler used, whether any means were used to consume the smoke, and whether any difference was observed in the smoke during the trials on the different description of coal.

Mr. Daglish stated that the boilers were tubular and cylindrical, with return flues, that an apparatus for consuming smoke was used, and seemed very effectual, and no difference in the smoke was at any time observed between the use of round or small coals, the steam was kept continually at the same pressure, as indicated on a mercurial gauge in the boiler house.

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The President asked Mr. Daglish to what he ascribed the very great difference in the heating powers of round and small?—the general impression certainly was in favour of round coal, but not to the extent here shewn.

Mr. Longridge concurred in this, and instanced the case that in certain parts of the manufacture of iron, and where considerable heat was required, round coals only were used.

Mr. Daglish ascribed the difference in part, to the greater loss of gaseous matter in the smaller coals, and from their greater admixture with stones and other foreign matter.

Mr. Barkus thought a portion of the smaller coals might pass through the bars unconsumed.

Mr. Daglish stated that this was specially noticed in these experiments and did not occur; although there was no apparent difference in the smoke from the different descriptions of coal, still, a portion might pass off not thoroughly consumed, as carbonic oxide, and not be apparent.

The President said, that gas makers were certainly aware of the superiority of round to small coals for manufacturing gas, and refused to receive the dust. It was, however, an important consideration to ascertain if round and small coals would do the same work without waste. The experiments show that small coals were 25 per cent. less effective than round coals; and if so, there must be some cause for it. He thought some attention ought to be paid to the subject, as there must be some reason for the difference, independently of the waste; if it is the fact that there is a saving of 25 per cent. on small coals, this is no unimportant consideration. Further experiments, therefore, on the subject might prove highly beneficial.

Mr. Dunn enquired if they could not keep up the steam equally well with small as with round coal?

Mr. Daglish understood Mr. Dunn having reference to each quality of coal being of equal weight, and that, in such a case, the same results would be arrived at.

Mr. Reid said, a great deal depended upon the shape of the furnace, as the same weight of small coal would be found to answer the same purpose as that of round, if the same quantity of air was kept up. For himself, he did not consider round coals of any advantage to the ventilating of the furnace.

Mr. Barkus-—But in making gas they preferred the best coal.

The subject, after a few more observations of the same import as the

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foregoing, was dropped; after which the meeting proceeded with the discussion of Mr. Dunn's paper relative to the production of coal in Belgium and France, as compared with England and Scotland.

Mr. Dunn called attention to the comparative results of 100 workmen in Belgium with that of England and Scotland. He found by reference to Mr. Hunt's Annual Geological Survey of Great Britain, that he quoted from Mr. Hall's paper on the subject. What was there stated he took to be correct: and comparing the statistics of Belgium with the counties of Durham and Northumberland, he ascertained that there was an immense disparity. It appeared that while 100 workmen of Belgium above and below ground raised 12,151 tons of coal, the same number in England and Scotland produced 15,915 tons. Then, while the same number of workmen underground in Belgium only raised 39,744 tons, those in this country raised 54,870 tons, which was a great preponderance of one over the other. But again, he found by reference to Mr. Greenwell's paper, that in the collieries belonging to his district, as compared with Northumberland and Durham, there also was a great disparity. In Mr. Greenwell's paper it was stated that the quantity of large and small coals worked was upwards of 400,000 tons, which was equal to 115½ tons per man; but comparing this result with the statistics given by Mr. Hall, relative to Northumberland and Durham, he found that in 1844 the quantity of coal produced in these counties was equal to 382 tons per head, and that in 1854 it was equal to 494 tons per head. All these facts went to show the superior system of working mines in Northumberland and Durham, over any other district or country.

Mr. Liddell said there could be no doubt but that this superiority was attained through the aid of machinery, and the improved mode of working coals, and to the workmen generally being a hardier and better class of men.

The President thought the results shown in regard to Belgium were similar to the Somersetshire district, where the coals were about the same thickness: although he doubted whether the Belgium colliers did the same amount of work as the men in Somersetshire. In Belgium it was well known that the wages were very low; besides he knew the men did not work so hard as those in this country. He certainly would like to see the statistics of Scotland, for he thought that even there the men did not do the amount of work as the men of the northern district. He was of opinion that no class of men worked harder than those of the north of England.

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Mr. Reid thought if they ascertained the difference of the thickness of the beds of coal they would find there was little in favour of the English workman. In fact the result would be very nearly the same.

Mr. Dunn was of opinion that the difference would be found in the economic manner they worked the coal in England compared with that of Belgium.

The subject here dropped, after which the meeting broke up.

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NORTH OF ENGLAND INSTITUTE of MINING ENGINEERS.

MONTHLY MEETING, FRIDAY, NOVEMBER 7, 1856, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

Nicholas Wood, Esq., President of the Institute, in the Chair.

The minutes of the Council having been read,

The President then said, the first business of the meeting would be to discuss the paper by Mr. George Elliot, on the "Effect of Working-Seams of Coal overlying one another in different Collieries and under different circumstances.''

Mr. Elliot said, before offering any observations on the phenomena described in his paper, which was read on the 1st May, 1856, he begged to apologise for his non-attendance lately, which had, he understood, caused some delay in the discussion of this interesting subject. He trusted that this subject, when fully understood, would prove of importance to persons connected with coal mining. It was stated in the paper that in making a goaf, or, in other words, working out a large portion of coal in an upper seam, the coal in the seam immediately below became much harder, and in the case of Monkwearmouth much improved the merchantable value of the coal, while at Usworth it rendered the coal so extremely hard that it was found impossible to work it without gunpowder, and blasting not being permitted there it had to be abandoned. He had also stated that in pits of little depth, viz., under eighty fathoms from the surface, the same effect was not perceived as in mines of greater depth, and imagined that one way of accounting for this phenomenon was as follows. Suppose we have two seams of coal, one at the depth of say 200 fathoms and the other 220 fathoms, and

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we work out a considerable portion of the upper seam, leaving a pretty large extent of goaf, this, in a measure, relieves the lower seam of the enormous pressure of 200 fathoms of strata, so that the gas, which is therein fixed and confined by the pressure or thick covering of the superincumbent strata, having no longer such a pressure or covering upon it, ascends into the higher seam through the intervening strata of twenty fathoms (especially if it be of a loose or porous nature). Thus, when our works or explorings are carried forward in the lower seam, we have no longer the internal pent up pressure of gas to help to throw down and burst off the coal which is being worked, in fact, as the hewer terms it, it has become "winded". In proof of this view of the case, he mentioned, that on working the top seam they generally found the gas making its way through the thill or floor of the upper bed, while on working the bottom seam, although there were indications and proofs of the presence of gas, yet there was none of the hissing noise generally heard when working the whole mine in ordinary cases, nor did the coal crack or burst out as usual. And, again, looking upon it in another point of view, taking for illustration the same seams as before, viz., the one at 200 fathoms and the other 220 fathoms, and a considerable portion of the upper seam being worked out, this, as it were, formed a sort of dome or arch in the higher plane of coal, which, in a manner, transferred the weight of the superincumbent strata of 200 fathoms off the coal seam immediately beneath, upon, or to the outer edges or circumference of such dome, and thereby reduced the effect of the superincumbent pressure to, in fact, a seam with only twenty fathoms of cover, with this difference, indeed, that it had been pressed into a more compact mass by the infinitely greater original pressure, and that pressure being removed the gas, which was incorporated with the coal and imprisoned by the great pressure, escaped immediately it became reduced, leaving a hard coal, with, comparatively, little weight of strata to break it down. In concluding, he pointed out to the notice of the meeting the observation at the end of the paper, viz.:—"It will then become a question for practice and further experience to determine if it will not be the better way of working collieries, especially of great depth, by excavating the upper seams first, although, as a rule, the coal is not so strong, and yields more small coal than the same seam of coal would do at a less depth, and, although, it might not in itself be so remunerative to the owner to work, still, I conceive, that the advantage gained by the improved value of the lower seams would fully compensate for the diminished profit on the upper

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seam. The peculiar result and disadvantage from working the upper seam at Usworth Colliery first will prove to be exceptional, and applicable only to similar situations where the coal is not required to be worked large, and where the use of gunpowder cannot be adopted."

The President referred to a working in the Maudlin, over the Low Main, which (he said) presented the same phenomenon as at Monkwearmouth Colliery. He had also observed the same effects produced at different collieries under his management, both in seams at great depths from the surface, and in seams at more moderate depths. It was well known that in seams of coal at great depths, gas or gaseous products existed in a state of great tension. A paper had been read on the subject by Mr. Thomas John Taylor, showing that in some cases the tension was equal to that of several atmospheres. The gas thus pent up in all the interstices of the coal throws off the layers or superficies of the coal as the workmen successively lays bare fresh portions of the mass, and materially assists him in his operation of separating portions of coal from the bulk or mass of the seam. It, thus, in mining language, and in fact, becomes easy to work, or the coal worked becomes more easily separated from the mass. Many cases have occurred where the effect of the tension of the gas in deep mines has been so great as to detach and throw off from the mass or bulk of the mine portions of coal more than three feet in thickness. When, therefore, as Mr. Elliot states, that in working an upper seam this gas escapes either by forcing its way through the porosity of the intermediate strata into the part excavated, or that the strata forming the base of the space excavated becomes relieved from the superincumbent strata, and thus becomes unable to resist the extreme tension of the gas through which it escapes to the goaf or part excavated, the coal bed immediately underneath being relieved from the tensile force of the gas, becomes, as the miners term it "winded," or becomes hard or difficult to work. And, in the same manner the stone or roof of the mine, which, when liable to be split or shivered into pieces by the tensile force of the gas, becomes hard and firm when relieved from its effects.

Mr. Potter said, it seemed there was no difference in the effect between the different depths of the beds from the surface, as the same results were observed in both cases, though the paper showed that they had a lesser depth between the seams in the one case than in the other.

Mr. Barkus—But they had not precisely the same effect at eighty

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fathoms as at the greater depth. With regard to the stone breaking down, that was caused by the elasticity of the strata itself. He, therefore, was of opinion that the gas did not produce it altogether, because, after the pressure was taken off by the ordinary working, the top would swell out or break down by the elasticity of the stone itself.

The President—In the case of working the upper seam the effect was to harden the stone, or to make it more firm. In visiting Monkwearmouth Colliery he found the coal in the Hutton seam, when the men struck a pick into it, to fly off in splinters, so much so, as to cover the arms of the men with thin particles of coal. He was anxious to ascertain if this was caused by inflammable gas, but he found when the candle was held to it, that it did not present the least alteration. It was certainly not inflammable gas which escaped in the operation of working, but it escaped with great force, in smart cracks or explosions. Mr. Elliot, he thought, seemed to attribute the flying off of the particles of coal to the escape of inflammable gas, in the cases he named, but this case shewed that other gases existed which produced the same effect as inflammable gas.

Mr. Elliot—No; he did not in all cases attribute it to inflammable gas, because it did not appear to relieve the district entirely from the appearance observable of gas. There might, however, be some inflammable gas, though not observable. The indication of its existence by a hissing noise was entirely relieved.

The President had given the subject a good deal of consideration, and at one time thought the effect might be produced by the natural elasticity of the strata at great depths, or as Mr. Barkus said, the effect of great pressure, as the effect was not observed except when there was considerable pressure. He was, however, quite convinced that the effect was to be attributed to the fact, at great depths, of gas in a state of great tension, which, escaping with great force in the act of the excavation of the coal forced off the superficies, and so rendered it easy to work, or in the case of the roof, split it, or broke it down, until relieved from the tensile force.

Mr. Dunn—With regard to the hissing noise, that he thought, depended upon the depth of the seam, and of course on the force with which the gas escaped. There was one thing certain, and that was, the working of the upper seam let off the gas from the lower, and so rendered it hard to work.

The President—From Mr. Elliot's explanation, a certain area of

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the upper seam was relieved from the weight of the superincumbent pressure, which enabled the gas to penetrate from the lower to the upper bed, and so to produce the effects described.

Mr. Dunn—Suppose the intermediate strata was very strong, and the elasticity of the gas not sufficient to break it, there would then be no escape of gas.

Mr. W. Anderson said, when the upper bed was goafed, the stone would fall and form a cone or arch, and so take the pressure of that area.

Mr. Dunn could not imagine the pressure to be taken off in that manner, as the stone would fall in the excavated part and there would still be considerable pressure on the part excavated.

Mr. Anderson—But the pressure would be greater around the part excavated than on the area worked, and, as is well known, in removing pillars the part excavated heaved up in the bottom.

Mr. Dunn—No doubt, if the strata heaved it shewed that the pressure was relieved, and that the gas or elasticity of the strata underneath was being raised up.

The President—There could be no doubt that by taking off the pressure it did cause the bottom to heave, and it was well known that in such cases the gas was known to escape.

Mr. Greenwell confirmed this view of the case, by stating that he found it so in working out the long-wall system.

The President stated, that in the Eppleton Pit, at Hetton Colliery, in working to the dip, they found it necessary to drive three drifts for the main or waggon ways. Two of the drifts were driven in advance, and they found the stone was bad, and broke very much down, but after the gas had escaped from the roof of the mine into those two drifts, the middle drift was then driven, and they found the roof very strong. In driving the bords for minor roadways, they found the stone in such bords fall very much, they then came back and took away a strip of coal alongside of such bord, when they found that the original driving had relieved the stone of the gas contained in it, and it has become quite firm and hard, and made an excellent roof for the roads. Mr. Barkus said such an effect was not produced in beds of coal at small depths from the surface, but at the Black Boy Colliery, where the depth was not great, they found, when the gas had escaped, that the coal was much harder to work, produced larger blocks, and on being exposed to the weather did not fall to pieces.

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Mr. Barkus had his doubts as to whether it was gas or not, and was inclined to think that it was owing to the springing of the coal. When four bords were driven, it relieved the resistance, and it was natural that springing would take place. He could not altogether fall in with the views of Mr. Elliot, as he had known upper seams to work as hard as the coals below. They found it so in working the Hutton seam under the Low main, but not so throughout. Where the pillars were taken away in the Low main they found no difference. They had, however, difficulty in supporting the upper seam, as it had crept when the pillars were reduced.

The President—But it was observable that immediately under the excavation the coal hardened, and where it was not excavated it was soft. The elasticity of the strata could not account for the facts stated by Mr. Elliot and observed in other cases.

Mr. Elliot—After four yards of bords were worked out, it left eight yards of wall, and that wall would have to carry all the pressure of twelve yards. If it was pressure, and not gas, there would not be heard the crackling noise attributed to the presence of gas.

The President—In working out the lower seam there was much less gaseous noise where the pillars were removed.

Mr. Armstrong thought the case adduced by Mr. Elliot was an exceptional one, and certainly contrary to his (Mr. A.'s) experience. In the case cited, where the seams were separated 20 fathoms, it was more than probable that little injury was caused to the intermediate strata from the coal having been removed from the upper seam and the fact was that the gas from the lower seam had permeated 20 fathoms of undisturbed strata. He was aware of the case mentioned by Mr. Barkus, as being described by Mr. Buddle, of the effect of the creep in the main coal seam, but there were many other similar instances in the main coal seam at West Auckland. At the latter place the thill of the seam was so hard that a creep was impossible, and a thrust was the only effect where the pillars were removed. Assuming that the 20 fathoms between the seams, such as was described by Mr. Elliot, had not been interfered with, and that the hardening of the lower seam arose from the escape of gas into the goaf of the upper seam, he could not see, in so short a time, from the natural porosity of the strata, how the gas had been discharged from the lower seam, or that from the many years since its deposition it had not all escaped long ago at the surface. With regard to the tension of the gas in situ, to which the President had referred

there were curious instances of gas at South Wingate Colliery, where a valve loaded to 120lbs. per square inch, discharged the gas from behind the sand tub in certain states of the atmosphere, and this was much within the ultimate tension of the gas. Unless there was a fractured state of the strata from the creep in the upper seam and that this extended, as in Wallsend, downwards to the low seam, he did not think that the mere removal of the coal in the upper seam, was a sufficient relief of the overlying pressure upon the lower seam to give such immediate egress to the gas. He had worked the Bensham seam on the Tyne, which extended under the high main coal wastes for a great extent, and judging from the quantity of gas in the former seam he could not suppose that any had escaped upwards to the high main coal wastes or goaf. It was, after all, a question of time; for if the gas could penetrate the strata for twenty fathoms, he saw no bar to its escape with any amount of overlying cover. He, therefore, thought Mr. Elliot's example as exceptional, and except under the same conditions not again likely to be observed.

Mr. Elliot begged to make one remark, and that was the fact of the effect extending only for a short distance laterally in the seam below from where the pillars had been worked above. Thus, in working the lower seam, they knew where the seam had been worked above. In one district the roof was as hard as a metal sheet below where the pillars had been removed, whereas within a short distance therefrom it was much broken.

The President thought that a very important fact, and proved that the working of the seam above had an undoubted effect upon a lower seam within a distance of about 20 fathoms, in beds at a great depth from the surface.

The discussion on the Paper then terminated.

The President then called attention to Mr. Armstrong's paper "On the Constitution and Action of the Chalybeate Mine Waters in Northumberland and Durham," and said he would be glad to hear any observations upon it. With regard to his own experience, he would mention one case, which had recently occurred, where a considerable quantity of free acid existed in the water pumped out of the Killingworth Colliery, and where lime had been used with a good effect. An analysis of the water before its use and afterwards showing a considerable diminution of the free acid. In looking round for instances, he had heard with pleasure the measures adopted by his friend Mr. Anderson, at Heworth,

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and which to a certain extent had been successful. The mode adopted was to pass the water through a trough containing lime, so that instead of having free sulphuric acid they would have sulphate of lime. If, therefore, the quantity of lime was sufficient the condition of the water would be entirely altered and the injurious effects would cease.

Mr. Anderson said, the President was perfectly correct in his remarks respecting the mode they adopted at Heworth to counteract the effects of sulphuric acid in the water. They first got the water analysed by the foreman of Mr. Hugh Lee Pattinson; after which the foreman told him that if he mixed the water with a certain quantity of lime it might have the tendency to check the corrosive nature of the water. He (Mr. A.) then got a large trough made, into which lime was thrown among the water, and he must say that it had worked remarkably well for several years. The quantity of water might be about seventy gallons per minute, and they used a ton of lime a week. Previous to this application the water destroyed the iron in a short space of time.

Mr. Armstrong thought that if they looked at his paper they would see the quantities of lime to be applied.

The President had applied the same relative quantity of lime at Killingworth, where the quantity of water was more considerable, but though it did not reduce all the free acid it destroyed the effect of the water considerably; he would not, therefore, have any one to despair in attaining a good result, although they could not reduce the whole of the acid. He was of opinion, that it was not necessary to have such a quantity of lime as to take up the whole of the acid, and that it was only necessary to do so to a certain extent, in order to counteract the effect of the free sulphuric acid upon the iron with which it came in contact in pumping, to ameliorate its effect to a very great extent.

Mr. Longridge said, that when lime took up a certain quantity of sulphuric acid the other part would not act so injuriously.

The President said, that undoubtedly in some cases they could not get a sufficient quantity of lime to reduce the whole of the acid, but his impression was that lime might be used beneficially to dilute the water to a certain extent, and although it would not take up the whole yet it was quite practicable to counteract the effects of the acid even in large quantities of water to a very great extent.

Mr. Anderson begged to say that they felt it no inconvenience at present; but previous to the water being mixed with lime it destroyed the metals in a very short time.

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Mr. Elliot said they never applied lime to the water at Monkwearmouth Colliery, although it was very bad. The buckets used to work only every six months. They, however, had the bolts covered with lead, which protected them.

The discussion here dropped; after which, Mr. Longridge drew attention to the fact of a committee having been appointed to make experiments on ventilation, but as nothing had been brought forward on the matter he begged to move that the report of the committee be forthwith presented.

The President was happy to inform Mr. Longridge that the committee had prepared a report, which had been printed, and had that day been presented to the Institute, and he hoped that the members would comply with the wishes of the committee and make the requisite experiments.

The meeting then broke up.

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NORTH OF ENGLAND INSTITUTE of MINING ENGINEERS.

Monthly Meeting, Friday, December 5, 1856, in the rooms of the Institute, Westgate Street, Newcastle-upon-Tyne.

Nicholas Wood Esq., President of the Institute, in the Chair.

The minutes of the Council having been read,

The President said, that the first business to be transacted, was the election of gentlemen proposed at the last monthly meeting.

The following gentlemen were then elected members of the Institute:- Mr. Henry Joseph Murton; Mr. Richard Thorpe, Barnsley; Mr. Theophilus Creswick, Merthyr Tydvil; Mr. W. Greener, Penderton, near Wigan; Mr. Andw. Knowles, Jun., Clifton; and Mr. John Knowles, Pendleton.

The President begged to inform the meeting that he had that morning been before Her Majesty's Inspector of Charities, sitting in the Guildhall, with reference to endeavouring to obtain a grant of money towards the establishing of the Mining College. It would be recollected that the Institute had some time ago presented a memorial to the Town Council, as they were considered persons to submit their claims in reference to the distribution of the surplus funds of the Virgin Mary Hospital, and as the Inspector was then entering into enquiries respecting the Magdalene Hospital, he had thought it proper to lay the claims of the Mining College before him, as it formed a most important institution for a branch of education. The Inspector received him in a friendly spirit, and in reply, expressed himself favourable to the objects of the College, but at the same time he could not see his way to recommend any portion of the funds of the Hospital for such a purpose. He, however, added,

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that he would lay the subject before the Commissioners. Under these circumstances, he (the President) suggested that another memorial be sent from the Institute to the Commissioners, setting forth in detail the objects and importance of the College, and respectfully requesting a portion of the surplus funds of the Hospital for educational purposes; and that such memorial be drawn up by the Committee appointed to carry out the College.

Mr. T. J. Taylor thought the Corporation was strongly in their favour on the subject of the College.

The President—Yes, in regard to assisting them. It, however, had been communicated to him that it was probable that part of the surplus fund would be devoted to the establishment of a sort of Trade Schools, for the education of boys intended for certain trades. If that were so, he thought they might have boys educated at these schools who afterwards might be drafted into the Mining College, and probably under some system of tuition which might be of great advantage to them. A gentleman some time ago, asked him if the children of those who contributed to the Mining College could be educated on more favourable terms than those belonging other parties. This he replied was practicable, as it was one of the things proposed by the Committee to have just such schools to prepare pupils for the Mining College. They might, he thought, in some way arrange with such schools established by such funds as he had alluded to, in order to make use of the boys with them.

A brief conversation ensued, when it was agreed that a memorial be presented to the Commissioners of Charities on the subject.

The President next read a letter from Mr. Randal Cossam, of Shortwood Lodge, Bristol, who, after stating that a Mining School had been established in connection with the seminary at Bristol, concluded by respectfully requesting copies of the proceedings of the Institute since its establishment for the use of the students.—Agreed to.

The next business which occupied the meeting was the reading of two papers—one by Mr. Dunn, "On the Coal Mines and Iron Works of Besseges, in the province of Gard, South of France"—the other by Mr. G. Potter, "On Murton Winning in the County of Durham."

After which, the Council adjourned.

[Geological Map of the Arondissement of Alais, Department of Gard, by Monsr. Emilien Dumas]

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ON THE COAL MINES AND IRON WORKS OF BESSEGES,

IN THE PROVINCE OF GARD, AND ARRONDISSEMENT OF ALAIS, SOUTH OF FRANCE.

BY MATTHIAS DUNN.

The parties who held these important works and concessions suffered during the Revolution of 1848, and also had differed amongst themselves, so that part of the works were standing. In this emergency it occurred to them to endeavour to interest English capitalists, to whom they could he sold. One of the partners came to England, and I was recommended by the Earl of Lonsdale as a proper person to examine and report upon the capabilities of the concern. In compliance with which I went through the following investigation, and wound up an elaborate report containing progressive quantities and profits, but which statements are foreign to the present object, which is to describe the nature of the coal and ironstone beds, with cost of working, &c.

These coal mines were possessed under two concessions, The first may be defined by a line commencing at St. Ambroix, upon the river Ceze, and drawn through Mayranne to Pierremale, thence to St. Florent and Fronlancier, and back to St. Ambroix, which district is for the most part on the north side of the river Ceze.

The second concession is at Cote de Long, upon the opposite side of the river, adjoining to Lalle, and contains an area of about 16 hectares.

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The concession of iron mines are three in number:—1st, that of Bordisac; 2nd, that of Travers,—both chiefly on the north side of the Ceze, including the concession of Lalle, although the coal mines belong to other parties; the 3rd consists of that of Robiac and Besseges, chiefly on the south-west side of the river, and containing about 25 hectares.

The other mines of Pierremort belong to a company of manufacturers of iron. The proprietary of the coal and iron furnaces and that of the forges being distinct parties, although it is now matter of consideration to unite all the interests into one general company.

The colliery company built two blast furnaces, with an 100 horse-power engine then in work, also a cupola for casting, let to the iron company at an annual rent of 40,000f. The price of mixed coal was fixed at 6f. per ton of 1,000 kilos., for all coal supplied by the colliery.

The coking ovens were built and maintained at the cost of the furnace company.

The forges consisted of seven steam engines for working rolling mills, one of Naysmith's steam hammers, &c. There were seven puddling furnaces, also several other furnaces, together with workshops, warehouses, agents, houses, &c, suitable for carrying on every branch of the iron trade.

The principal coal field is situate at Besseges, adjacent to a mountain side 264 metres in height, and consists of twelve well ascertained seams of coal, lying at an angle with the horizon of one to four main rise, nearly west. The thickness of these seams varies from one to two and a half metres, lying very regular, and the aggregate thickness of which may be stated at thirteen feet, all the seams being workable, and under very favourable circumstances as to roof and thill. The coal itself is of a rich caking quality, and not only produces excellent coke, but will hold out for general trade two of large for one of small coal.

The coal field is peculiar (see section), as resting upon micaceous schist, and that upon granite, and as towards the south point it

The concession to this Company was in 1827, then Mons. Robiac. The Furnace and Foundry Company became interested in 1834.

Mons. Gruner, on the coal beds of Besseges, states that the number of beds may be taken as at least thirteen, of which seven or eight are one to two metres in thickness. Three or four others are from .80 to 1 metre, but could be easily worked. Three or four others united thicknesses may be called fourteen metres. Iron-stone lies below the coal.

WEIGHTS, MEASURES, &c.

A Franc ....10d. Centime one-tenth part.

„ Kilometre ....39,371 inches.

"Hectare ....11,960 square yards = 2.47 acres.

„Kilogramme....................2.21bs. avoirdupois. 1000 such per ton.

" Metre.........................39.371 inches.

[Profile of the Mountain of Besseges with Inclination of Coal Beds]

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approaches a formation of trias (new red sandstone and blue limestone), the levels suddenly turn, and the upper seams, as at present explored, seem terminated by zig zag, or being, as it were, doubled up, and make their exit in a nearly perpendicular position.

Hitherto the working has been confined to surface levels, the lowest being upon a level with the works in No. 9 seam, 2 to 2.20 m. thick; the second and third above being also entered from the mountain side, and the coals brought down by means of railways and inclined planes. By this means Nos. 4, 5, 6, 7, 8, and 9, have been partially worked. The other seams have not been touched, neither has anything been done to work the coal below the surface level before spoken of, although, from the experience of the past, and the closeness of the schist and sandstones, there is no reason to expect much water. No. 9 levels are extended 650 metres, and to the rise 120 to 130 metres.

From No. 9 a stone mine is executed towards the rise till it cuts No. 8, which may be called 1.12m. in thickness, and the explorations are extended from north to south 400 metres, and similar distances from east to west as No. 9. The stone mine is further extended till it cuts No. 7, 90 to 100 cen. thick, with a thin schistose band towards the top. The level is further extended to No. 6, 1.50 to 2 in thickness, and sometimes 2.50. A further extension produces No. 5 section:—

Coal.......................... 0.20

Band............................15

Good coal................. 1.

1.35

The upper part of this schist sometimes disappears, and the seam thickens to two metres.

A further extension of the level to No. 4 section:—

Top coal..........................0.40

Band .... .15

Good coal...................... 1.10

1.65

All these seams are stopped towards the dip by zig zag.

Contents of the present coal field above the level of the works:—	Tons.
south side of the mountain, twenty-five hectares, and thickness of coal fourteen feet, after deducting one-tenth	3,500,000
In the western field, sixteen hectares, thickness of mines eight metres	1,280,000
	4,780,000

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COAL AT MOLIERE.

At the distance of 7,000 yards down the river Ceze, and towards St. Ambroix, in the same concession, another set of seams, four in number, are seen, dipping in the same direction, which have been very little explored, but there is reason to believe that this field is very extensive.

During my investigation I was furnished with a copy of a report made in 1846, by Mons. Gruner, a mining engineer of eminence. He states that the number of beds at Besseges may be stated at 13, and their aggregate thickness 14 metres = 46 feet. He calculated there was coal enough to maintain the works for forty years, whilst he excluded all coal below the level of the valley, all suitable for coke making.

The coal at Moliere he described as follows. The upper beds are four in number, amounting to fifteen metres in thickness. Towards the north, near to Pigere, a great dyke occurs, which throws down the system upwards of 200 metres, the whole thickness of the known beds in that quarter is four to five metres. The beds of the other district are supposed to lie underneath.

The levels in the present coal field extend from 600 to 650 metres in length before reaching the zig zag.

[see in original text Table of Analyses of coal from Mons. Gruner].

MODE OF WORKING.

The mode of working is alike in all the seams, all being excavated four yards wide, leaving the pillar from ten to fifteen yards square, and in order to facilitate the working, the places are driven echelon, viz: at an angle of 12½ degrees. The coals are brought down to the levels in wicker baskets, with sledge feet, and thence transferred into waggons containing 850 kilos. The basket contains 300 kilos. of large, or 250 kilos. of small coals. As soon as the basket is emptied the traineur (putter) turns it upside down and carries it upon his head up into the workings, the weight being about thirty kilos. The baskets can be carried by boys of twelve years of age. The piquer is paid 2fr. 30c. per ton for large, and 1fr. 50c. per ton for small coal, out of which he pays the traineur 40c. per ton. An ordinary piquer can earn 2½ fr. per day, out of which

[Section from Besseges to Robiac and Molieres - 7,000 yards]

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he pays the traineur. The rouleurs (waggon boys) are paid 43c. per ton, including the wagoning and inclined planes upon the surface. Every one finds his own light.

It must be observed, that previous to the Revolution in 1848, these prices were nearly double, they are now much depressed by the prostration of trade, but may be expected again to revive.

The pillars are all expected to be got, owing to the goodness of the roof and the hardness of the coal. They anticipate that, notwithstanding the consumption of timber, the pillars will be worked cheaper than the whole coal, say 30c. per ton.

2nd Level.—Upper series of work. This level is 35 metres perpendicular from the former level, entered at No. 8, and returned eastward towards No. 9. The same level also leads to Nos. 7, 6, 5, and 4. Nos. 3, 2, and 1 are unexplored, but their thickness is well known.

3rd Level.—This is 38 metres above the 2nd level, and embraces Nos. 8, 6, and 5. Nos. 7 and 9 are untouched. Nos. 10, 11, and 12 are entirely untouched, but are all perfect. The deep valley causes some of these beds to disappear, but they exist again on the north side of the river towards Lalle, from 600 to 650 metres in length.

The workmen are provided dwelling-houses, which are charged 60frs. per chamber per annum.

According to their practice of mining, it is found impracticable to extend the workings to the rise of each level more than from 120 or 130 yards, on account of the deficient ventilation, and then a new set of levels are provided; several seams being brought into one horse-road by means of horizontal stone drifts from seam to seam.

The payment to the Government is 5 per cent. upon the net profits, allowing certain expenses as a deduction. A Mining Council sits at Nismes once a year, composed of the Prefect; the Commissioners of Taxes; two Members of the General Council of the Department, chosen by the Prefect; two Concessionaires, also chosen by the Prefect on the nomination of the Engineer in Chief; also the Mining Engineer of the Government. Mode generally satisfactory.

The following is an authentic statement of the expense of raising a ton of coals, of 1000 kilos.

[see in original text Table]

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The workmen work their own fire coals and are allowed 100 kilos. per week.

The principal markets to which these coals are carted, and the cost of carting, may be stated as follows:—

	Per Ton.	
St. Ambroix	4.50f.	5.0f.
Alais		9
Nismes...		16
Pont St. Esprit on the Rhone		15
Montpelier		19
Cette, on the Mediterranean.......................		23
Aigue Mortez...		20
Aubenas		20
Marseilles		23

Also, the silk mills at Ardeche.

The present selling price at the colliery is 11 fr. for large and 5 fr. 6c. for small coals per ton.

[see in original text Table]

Contents of the known coal-field, as commanded by the surface-level at No. 9, viz:—

South side of mountain, taking an average of the seams, the area may be assumed at 25 hectares, and the thickness of coal 14 metres, deducting $\frac{1}{10}$ may be stated at 3,500,000 tons.

Western field, area 16 hectares, thickness of seam 8 metres, with similar deduction......... 1,280,000

Total.................................... 4,830,000

Independently of which there are great quantities of coal to be gained by sinking at No. 9, to command the lower mines, as also a supposed new field at Moliere, near the River Ceze, distant 6 or 7 kilometres from Besseges, together with a quantity of about 1,280,000 tons, south of the level at the works.

This coal-field is about 175 metres above the level of the Mediterranean.

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In 1846, there were raised and disposed of as follows:—

[see in original text table]

COKE MAKING.

The chingle small coal produces 60 per cent. for the furnaces, without accounting loss by washing, the expense of which, by hand, they say costs 8s. per ton, but is well repaid in the production of iron.

ALLEGED COST OF COKE.

[see in original text table]

No raw coal is used in the furnaces. The iron is of first-rate quality, and worth on the spot £11 to £12 per ton.

$$\left.\begin{array}{l}\text{Rough small......317}\\ \text{Ordinary small ...531}\\ \text{Waste ....132}\end{array}\right\}\ 1000$$

LIMESTONE.

Limestone is an inexhaustable quantity from a mountain contiguous to the works, conveyed to the top of the furnaces by inclined planes 100 metres in length. The expenses amount to from 1f. 70c. to 1fr. 80c. per ton of 1000 kilos.

IRON STONE MINES.

The supply of iron stone is also very abundant, although very little iron stone is found in connection with the coal strata.

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No. 1—From Pierremorte, in the Oxford clay formation, consists of two beds, one 1.50, and the other .50 in thickness. The latter stone-yields 60 per cent., the former 40, and both beds can be commanded by the same gallery.

No. 2—Is found at "The Travers" in the new red sandstone, the roof being marl and sandstone, and the floor yellow limestone. This bed averages in thickness 1.50 to 3.6, and lies at an angle of 41; yields 40 per cent., and contains a good deal of manganese.

No. 3—From Bordezac, Cote de long and Castelas, the base also of the new red sandstone, consists of three beds, the lower of which is 70 to 80 per cent. The middle bed 1.20 to 2.0, and the upper one 30. Average yield 25 to 28 per cent.

These ores are mixed for manufacture, and cost upon the average, for working and conveying to the works in carts, from eight to nine francs per ton, but preparations are making to reduce the carriage by means of a new road from Bordesac.

Judging from the report of Mons. Gruner, and from my own survey of the district, I have no hesitation in assuming that there is in the concession a great abundance of mineral for very many years to come, which, I doubt not, also exists throughout districts out of the concession, and, in case of extensive working, and a railway, would be supplied to the works at a very moderate cost, considering the excellence of the qualities.

COST OF MANUFACTURING PIG IRON.

[see in original text Table]

[Section showing the Ironstone mines belonging the Concession]

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Another statement tendered [see in original text table]

I think this too limited as to expense. According to Mr. J. Bell, 100 tons of coke will smelt above 150 tons of calcined mineral.

At present the establishment is much too large for one furnace, therefore the cost is enhanced. By another statement they shew that if there were one or more additional furnaces the cost would be reduced to 55s. or 60s. per ton.

These furnaces, and everything belonging to them excepting the coke ovens and hot-air apparatus, belong to the Coal Company, and are rented by the Pig Iron Company at the rate of 40,000f. per annum, whether they work one or two. The Lessees are also bound to pay 6f. per ton for the small coal, but they are entitled to not exceeding 20 tons per day of large coal at the same price when the forge is working.

The produce of the furnace is black iron, for the purpose of the foundry, and white iron for the forge. The value of the foundry quality is 12 to 13f. per 100 kilos., = £11 per ton; forge quality 8 to 9f. per 100 kilos = £7 10s.

It is remarked that the present establishment is greater than necessary, and if the works were in full operation many of these charges would be modified. But it must also be remembered that in proportion as exhaustion progresses, the cost of materials will be enhanced, as well as the wages of the workmen, therefore, it may not be safe to reduce materially from the above, although sixty francs per ton may be taken as a fair calculation.

THE RESULT OF MANUFACTURING FROM THE PIG.

The difficulty will be easily appreciated of arriving at any very definite result with respect to the profits arising from this branch, viz., bar, bolt, and flat iron (such as boiler plates). I, therefore, advised with persons well acquainted with the subject in England, and also

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received from the agents at the works copious statements of the respective charges which accrue, which I have reason to believe were faithfully reported, and will now communicate my ideas as to the result of manufacturing at Besseges, being first charged with pig iron at cost price.

[see in original text Diagram of Elevation of blast furnaces]

This furnace will yield 120 tons of pig iron per week. One of the furnaces has a width at top of 8ft. 8in. Top to belly twenty-five feet, and diameter of belly 15ft. 9in. This furnace will produce twenty-four tons per day.

PUDDLED IRON.

[see in original text table]

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The boiler plates will cost, in addition to the ordinary bar iron from the state corryer, 60 + 166 = 226 francs. Selling price varying from 450 to 480 francs.

These were the prices before the revolution of 1848, but which have decreased since, and as the works are not in operation details cannot be arrived at here.

If these forges and rolling mills were supported by a suitable number of puddling furnaces they might manufacture 10,000 to 12,000 tons per annum.

Mr. Bell, of Newcastle, states that with 37 puddling furnaces and five engines, whose aggregate power is 308 horses, they could produce 450 tons of bar iron per week.

THE NEIGHBOURING CONCESSION OF LALLE.

My opinion respecting the annexation of this property having been demanded, I examined the nature of the coal field, which is under partial working. Owing to the important fault before spoken of, the coal beds in this concession dip the contrary way from those of Besseges. The working is carried on by means of a surface entry on the north side of the river Ceze, the produce of the mine being brought up in wicker baskets on the backs of men.

Mons. Gruner, the French engineer before noticed, calculates that this concession contains, in 4 or 5 beds of coal from .60 to .80c. each in thickness, five million tons, which can be produced at from 5 to 5½ francs per ton; but the mines dip most rapidly, and to work which heavy machinery would be required, and I am not aware that Mons. Gruner, in his view of the case, duly appreciated the results of an extensive working under such an extraordinary dip, and with such thin seams.

Undoubtedly, the property lying contiguous to Besseges, to a certain extent would be an acquisition in case of an extensive working, especially as the iron mines are in the hands of the company; at the same time I am quite unprepared to assign the value which ought to attach to its annexation.

CAPABILITY OF EXTENDING THE WORKS BY MEANS OF RAILWAYS.

It is quite clear that to enable the property to extend itself materially, possessing both coal and iron stone of the very best quality, railways are absolutely necessary. The first of these railways prominently presents

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itself for execution along the margin of the river Ceze, to the county town of St. Ambroix, distant about seven miles, and to which the present cartage may be calculated at 5f. per ton. By establishing depots here whence many important public roads radiate, and by a diminution, say of 3f. per ton, would at once advance the quantity and profit of both coal and iron.

The second of these railways is of much greater importance, and would go to connect the town of St. Ambroix with that of Alais, which the public railway connects with the great towns upon the coast, as well as with the banks of the Rhone, and the canal of Beaucaire; the advantage of which markets is sufficiently exhibited by the following vend of coals down this railway from the collieries of Grand Combe, in the neighbourhood of Alais, with coal vastly inferior to that of Besseges:—

Year.	Tons.
1842	177,185
1843..............................	205,195
1844...............................	257,128
1845	288,703
1846	298,875
1847	337,325
1848*...............................	227,352

The following are the sources of trade laid open by that railway, where they have depots, with the respective quantities sent in the year 1848:— [see in original text table]

* Year of the Revolution.

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The magnitude of the above trade, therefore, shows the incalculable advantage which would be derived from a junction of these collieries with the railway at Alais, which would be distant by the railway from thence to St. Ambroix 13 miles.

A railway from St. Ambroix to Pont St. Esprit, upon the Rhone, would be about twenty miles, and would have the effect of bringing the coal of Besseges into competition with those of St. Etienne and Rive de Gier, and also lignite, which is obtained at several places in that district, as well as enable a shipment to be made upon the Rhone. But I am of opinion, in the present state of matters, this consideration must stand over, because the route to Alais is of much more extensive import, and would lead to an important ready-made market. I, therefore, did not devote time to the consideration of this portion of the subject.

The railway to St. Ambroix, single rails, 60 lbs. per metre, with one-tenth for passing places, I calculated to cost, together with depots and 100 waggons, £35,000. Total length seven miles.

The railway to St. Ambroix would save:—

	Francs per Ton.
Present cartage..........................	5
Per rail	1.72
Say 3 francs saving...................	3.28

This alone would increase the coal traffic 20,000 tons per annum, with a slight reduction of price.

That from St. Ambroix to Alais 13 miles, adding 1-5th for sidings and passing places, and with 400 waggons for distant traffic, is calculated to cost £80,000.

No account is taken of locomotive engines, because it is expected an amicable arrangement will take place with the established railway of the Grand Combe Company, for the profitable occupation of their spare power.

It is a material point in the consideration to weigh well the advantage which is derived from the duties upon coal and iron imported into France, together with the heavy freight from Great Britain, in consequence of which, the coal of Grand Combe, notwithstanding a railway of nearly 100 miles in length, can supply the quantities of coal exhibited in page 38 to the seaports of Marseilles, Cette, &c.

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DUTIES UPON COAL AND IRON IMPORTED INTO FRANCE.

[see in original text table]

At this moment the coal owners of England are petitioning the minister to urge upon the French Government a reduction of the duties to the same charges as the coals imported from Belgium, but it is scarcely expected to succeed.

COST OF CONVEYANCE PER RAILWAY.

By the published accounts of the Grand Combe in the year 1848, the cost of coal traction was .032f. per ton per kilometre, including maintenance of waggons, greasing, &c,

[see in original text table]

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The Grand Combe large coal is sold at the Port Abouc for 32 f. per ton, and as the whole cost to Marseilles is

	Francs per ton
11.34f., say 12f., add cost at the colliery 5f. =	17
Selling price	32
Would leave	15

It is also material to observe that the coal of Besseges is vastly superior to that of Grand Combe.

PROBABLE RESULTS OF THE DEVELOPMENT OF THESE WORKS SIMULTANEOUSLY WITH THOSE OF GRAND COMBE.

From the published accounts of the Grand Combe colliery and railway, notwithstanding their enormous capital and extensive working, it would appear that the former have not been at all successful, which is attributed, partly to the expense of raising the coal from a widely extended area, but chiefly from the soft and inferior quality of the coal, which incurs a destructive breakage at the depots and during their conveyance from place to place; but the railway is represented as being profitable, and would become more so in proportion to the greater quantities of tonnage and passenger traffic.

I am, therefore, of opinion that in the event of these mines and railways being developed, it would materially tend to the interests of both concerns to form an amicable arrangement whereby the selling prices would be steadily maintained, and in case the coal of Besseges had the effect of lessening the sales of Grand Combe, yet the profits of the railway would be increased, also, that the excellence of the coal and coke of Besseges would be the means of opening out new sources of commerce by shipments at the ports of the Mediterranean, as well as increased demand for iron.

Other collateral advantages may also be looked for should the affairs of France settle to a spirited extension of railways, and to a general expansion of commerce, in which case the data of the present report may be considerably altered for the better, viz.:—

1. —The advantage in extensively coking the small coal.

2. —Improved prices and extended consumption of iron and cast iron.

3. ---Revenue to be derived from passengers and merchandise.

4. —From the superior quality of this coal an almost unlimited demand might be calculated upon, when improved modes of working and railway

facilities are accomplished, so as to reach Marseilles at a price considerably less than the produce of England can be supplied at.

The colliery was already producing nearly 60,000 tons per annum, viz., 34,000 to the general trade, and 25,000 to the two furnaces, &c., and realizing a profit of £7000 to £8000 per annum, whilst other two furnaces were in course of building. Working cost of coals 4.25f. per ton.

[Section of the pits and machinery at Murton Winning, 1841]

ON MURTON WINNING in THE COUNTY OF DURHAM.

BY MR. EDWARD POTTER.

Thinking that a Paper on this subject would be interesting and acceptable to the Institute, I have drawn together the most prominent features of this extensive undertaking and tabulated some of the more detailed particulars in such a way as may be easy of reference. The details, although not presenting any novelty to the senior members of the Institute, may, I trust, be found serviceable to the student in the art of Coal Mining.

The preliminary process of sinking, or in its more enlarged signification—winning a colliery, is one which is of the most vital importance to future well-being of the undertaking either as an investment or speculation, whether we consider the amount of capital to be expended before the coal is reached, or again, the position or site of the plant for the future effective and economical working of the mine when completed.

In new or unexplored districts the risk of error in position, or powers of machinery required to overcome the ordinary difficulties met with in sinking is necessarily greater; but even where the district is better known, improper or unfortunate positions have frequently been selected, and the future well-being of the colliery seriously affected.

The general rise and dip of the seams of coal in the county of Durham and Northumberland are now well known, as well as the principal dislocations of the stratification by Dykes, &c; but a prudent miner will

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think it advisable before commencing operations for a new colliery to prove the ground, by boring or otherwise, before he embarks the capital of his employer.

The magnesian limestone, overlying the eastern part of the county of Durham, and increasing in thickness in its eastward course by the natural dip of the coal measures in that direction, has attained its greatest known thickness at Castle Eden, the bottom of the bed there found being 105 fathoms from the surface.

Depths from the surface to bottom of limestone proved at the following places:—

At Murton Winnings........76 fathoms. At Wingate Grange......................58 fathoms.

Seaton Park...................67 " " Seaham Harbour (not through)..56 „

South Hetton..................64 " " Monkwearmouth ....52 „

Shotton Colliery.............63 " " Haswell......................................50 „

The upper portion of the limestone is soft and often overlaid by a marl of a light cream colour, generally free from moisture and easily worked. As you proceed downwards the limestone becomes more compact and hard, the lower portion being difficult to work on account of the gunpowder finding vent in the cavities with which this rock abounds.

Underneath this limestone generally lies a bed of sand, varying in thickness and hardness, accompanied by feeders of water also varying very materially in quantity.

Several shafts have been put through this treacherous stratum, in various parts of the county, and its structure, in some places, found very soft and dry, in others interspersed with hard chert riders, having a honeycombed appearance, the cells being divided by cherts, in some cases these flinty parts are almost stratified. Near to the Ferryhill Station, on the North Eastern Railway, a good section of it may be seen capped with the magnesian limestone, also under the Castle and Lighthouse at Tynemouth.

After these preliminary observations, I shall proceed with the more immediate subject of this paper.

Murton Winning is situated to the north-east, or nearly full dip of South Hetton Colliery, and was projected to win the extensive range of dip coal intervening between that colliery and the German Ocean. It is within two miles of Seaham Harbour, and a short distance from the village of Dalton-le-Dale, which circumstance for some time gave it the name of the "Dalton Winning."

After several borings had been put down in various directions, through

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the limestone rock, to prove the thickness of the sand, the site was selected and the ground broken for the first shaft on the 19th February, and for the second shaft on the 10th April, 1838.

The winning was first arranged to consist of two shafts, of fourteen feet clear diameter each, and to be divided so as to form ultimately three drawing pits, and one engine or water drawing pit.

The engine power consisted of three 120-horse power winding machines, and one pumping engine of 250-horse power, together with other small engines in lieu of jacks and gins.

It being the intention of the parties to use some, if not all, the machines as auxiliary pumping engines during the progress of sinking, these machines were so placed that in the event of an accident occurring to any of them, the ropes or other appliances could be made available for a time to the others until any necessary repairs were effected.

To the main engine were attached six sets of 19-inch pumps, in three lifts of twin sets, viz.: the two top sets in a staple worked by the back bram, the two middle sets worked by the V bob in the pit, and the two bottom sets hung on sevenfold blocks in the bottom of the sinking shaft.

To each of the machines were attached three sets of 16-inch pumps, viz.: the top set in the counterbalance staple under the end of the crank shaft, the middle and bottom sets being worked by a horizontal spear and quadrants placed over the shaft.

The sinking of the two shafts proceeded, without obstruction, to the depth of thirty-five fathoms each, where the feeders of water, gradually met with, accumulated to fifty gallons per minute in one pit, and seventy gallons per minute in the other, the water being, hitherto, drawn out by iron water tubs, containing 60 and 140 gallons each. The sinking was then suspended, and the first metal wedging crib (14 inches by 6 inches) laid, and two fathoms of light metal tubbing put on to outset the main body of the feeder, and the shaft walled up and secured to bank, and further sinking suspended until the machinery was ready. The counterbalance staples for the machines were then sunk, and galleries driven between them and the two pits for conveying the water between the middle and top sets of pumps.

The machinery and pumps being in readiness, the sinking was resumed on the 19th of November and continued down to the depth of 70 fathoms, when a double metal wedging crib was laid to rest the two standing sets upon, and the shafts tubbed off and closed under the first wedging crib. The sinking was then resumed and continued six fathoms further, where

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another wedging crib was laid and the shafts rendered dry to this point, being the last tubbing got in before arriving at the sand. After leaving a sufficient strength of limestone as a support to this last named crib, the shafts were enlarged or belled out before arriving at the sand to enable us the better to contend with the anticipated difficulties, and also to maintain in the end the full diameter of the shafts.

This latter resumption of sinking had not been proceeded with far before the bottom of the pit blew up like a blast, and a deluge of water, sand, &c, was thrown up which speedily drove all hands out of the bottom. The lower sets of pumps being then short and hung upon strong 7-inch ground ropes attached to 7-fold blocks and crabs, were hove up out of the bottom, and the water allowed to settle. Upon plumbing the pit it was found that 9 feet in depth of sand over the whole bottom of the shaft had been sent up through the fissure. The two machines went 18 strokes per minute with a 4 feet stroke = 684 gallons per minute.

The east pit was sunk upon one of the boreholes which followed the course of that shaft pretty regularly. The borehole was kept secured in advance by a long plug, when, however, the sinking was within twelve fathoms above the bed of sand, the plug burst out and a considerable quantity of sand was thrown up. This was the first intimation we had of the loose nature of this formidable opponent. The feeder through this borehole kept the 16-inch set going 12 strokes per minute with a 4½ feet stroke. The pressure of water in the other pit being 18 fathoms. Both pits being now opened to the sand, the gross amount of the feeders of water proceeding from it was found to be more than a match for the pumping power applied, which, at this time, was confined to the 16-inch sets attached to the machines, the East Main Engine being yet in the hands of the manufacturer.

During the progress of sinking thus far, the system of intercepting each considerable feeder of water as it was met with was steadily practised and every good foundation for a wedging crib promptly, and with great success, turned to account. By this means the shafts were kept remarkably dry until the period when the sand feeder forcibly broke away through the bottom.* The metal tubbing being carefully backed up with marl, which, on being saturated with water, became like cement and formed an impervious backing.

* I understand that a different plan is now being tried at the Ryhope Winning, viz: pumping all the feeders as they are encountered in the shafts—this will probably increase the difficulties where they approach the sand.

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It may probably be interesting here to note the successive feeders dammed back by the different batches of metal tubbing.

[see in original text Tables – in the Middle Pit and the East Pit]

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The metal tubbing used in these shafts was in segments of 2 feet and 18 inches in height, having ten segments to the course or ring. The thickness of metal varied as the pressure increased, being ¾ inch at the top, 1-inch in the middle, and 1¼ inch at the lower part of the limestone and sand. In front of the sand tubbing, where the pressure was greatest, metal rings 9 inches in depth were placed for additional security in front of the joints and set firmly against them with iron keys.

The sheathing used was made out of clean memel deals, planed to a uniform thickness of ½ an inch, and wedged until no moisture was visible at the joints, which were then adzed off. Previously to being put in the tubbing was all carefully examined, the front surface scraped and painted with a strong bodied anti-corrosive paint which remained afterwards like an enamel upon its surface.

A few extracts from my diary at this period will probably give a better and more faithful view of the operations than any abridged information drawn from them.

1839. 9th August.-—The sinkers got into the middle pit for sixteen hours. Lowered the set 10 inches and took off limestone sides for scale. The two machines (middle and west) kept the feeder at 11 strokes per minute. The west machine (commenced pumping 2nd August, 1839) having a 5½-feet stroke for all the three sets of 16-inch pumps attached to it. The middle machine had also a 5-feet 8-inch stroke in the pit, and these machines were going sixteen strokes each whilst the men were in the bottom.

3rd September.—The east machine was going twelve strokes per minute (4½-feet strokes equal to 456 gallons per minute) exclusively, with water passing through the 1½-inch borehole, whilst the pressure of water in the other pit showed a column of eighteen fathoms.

9th September.—The low set of the middle machine having got choked with sand, it was hove up to the level of the standing set and hung upon the ground spears, but the water was never again drawn down to the bucket-door until the 5th May, 1840, when the east main engine started work.

26th November.—Got the water down in the east pit and put a plug in the borehole which enabled us to get the two 19-inch twin standing sets for the main engine in dry.

1840. 4th March.—Started the new twenty-horse machine (Hawthorne's) in the East Pit for drawing stones, &c.

29th April.—Started the east main engine.

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4th May.-—Resumed sinking in the East Pit, and drilled two additional holes down to the sand (7-feet) to draw off more water for the main engine.—Sunk 4½-feet the first week.

5th May.—Got the water in the Middle Pit down to the bucket-door of the choked set; this set having been hung for eight months on the ground ropes and spears.

22nd May.—The sand broke away from the bottom of the East Pit through a thin stratum of soft blue metal, the sinkers having great difficulty to save themselves. The rapidity with which the water came off, accompanied by a mass of loose sand, was so great that the two V bobs, or standing sets of the main engine, were instantly choked, and held the engine fast, whilst the column of water rose twenty fathoms up the shaft in a very short time. An auxiliary 19-inch set of pumps was hung in the fore pit and attached to the main engine after having loosed off both the two V bobs and low sets.

1st June.—Got new set started, and on 4th inst. lowered the water down to the bucket-door of the standing sets, when we found the working barrels and all below one solid mass of sand, as were also the delivery drifts leading to the high set.

The feeders were found at this time to amount to 3285 gallons per minute, as will be shewn by the subjoined table of the powers and rates of going of the respective engines.

[see in original text Table]

16th June-—The sinkers got again into the bottom of the Middle Pit, and commenced filling away the cast-up sand which was 4 fathoms above the bottom when they last left off.

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It was now clearly ascertained that the present engine and pumping power, although unprecedently extensive, was insufficient to combat with the difficulties with any apparent chance of success.

Under this state of things the advice of other mining engineers of eminence was sought, and Messrs. Wood and Johnson were appointed to confer with me on the most advisable course to pursue.

26th June.—All the engines were stopped. On referring to the plan of the works at this period it will be observed that the area of both pits was sufficiently occupied with pumps, ground spears, &c, to render it unadvisable, if not impossible, to place any additional sets in them. Hence, if more pumps and machinery were required, more pit room would also be required to accommodate them.

A proposition was then made and submitted to Messrs. Wood and Johnson to sink another shaft of larger diameter, and place upon it two pumping engines, capable of delivering at bank two sets of pumps, each from a depth of 90 or 100 fathoms. This was approved of, and no time lost in putting it into execution. This shaft became afterwards invaluable as a general upcast shaft to the colliery.

As this additional engine power would only be required for a time, they were erected on substantial rough ashlar work, so constructed that the weight of the beam pillar was made to add solidity to the cylinder pillar, and thus both simplify and economise the building. These stone pillars were completed in three weeks, and whilst the sinkers were at work in the bottom.

These twin engines, manufactured by Messrs. Hawks & Co., were of 450-horse power each, high pressure, and supplied with steam from eighteen cylindrical boilers, placed in a most formidable line, and flanked by two chimneys of eighty feet in height each. I would here remark that an unnecessary waste of material often takes place in the erection of chimneys. These, although eighty feet in height, were built with only 15-inch work at the bottom, and 10-inch at the top, and never showed any symptoms of insufficiency.

A horizontal machine of 60-horse power was erected, to draw the sinking stones; and another of 14-horse power to do the jack work, &c.

The ground was broken for this pit on the 7th July, 1840, the diameter set off being 18½ feet, to allow for walling inside; this, with nine sinkers in the bottom, in a shift, was a formidable looking shaft. Probably no pit in the whole annals of sinking ever went more rapidly down until stopped by the feeder of water. I give, as a sample, the weekly rate:—

[Plan of the ground works at Murton Wining, 1841]

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[see in original text Table]

By the end of January, 1841, this shaft was sunk, walled, tubbed, and bratticed to the depth of seventy-three fathoms; being divided into three parts, two for the pumps and one for the sinkers.

The two new pumping engines were set to work in February and March, 1841. Every appliance being completed, and the water standing in the pit was drawn down and the sinking resumed.

On the 16th April a borehole was put down from the bottom of the new pit into the sand, then within four feet, to lay the water on to the new engines. Immediately afterwards the bottom of the shaft blew up from the pressure, and the water rose to the same level as it was in the other pits, and thenceforward continued to rise and fall regularly with them, showing a free communication between them all.

9th May, 1841.—The whole of the limestone being taken off in the east pit, and that shaft belled out from fourteen feet, the finished size to 21½ feet in diameter, the first course of oak cribbing (consisting of three cribs backed with 1½ inch deals, and five feet in height), was placed, and hung from the limestone by eleven iron rods, twelve feet in length, fastened into the solid stone above.

This shaft was now fairly launched into the sand. The difficulties and delays to the advanced progress may be judged of by the following extract.

From the 16th April to the 10th May, inclusive, the sinkers have been 176 hours 20 minutes in the bottom,

176 / 24 = 7⅓ hours per day.

The number of buckets changed during the same time has been 378, and 38 clacks.

416 /24= 17⅓ average per day.

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July, 1841.—Cost of grathing the buckets at Murton Winning.

[see in original text Tables for 19-inch and 16-inch buckets]

The consumption of coals for the engines, &c, amounted to 1,000 chaldrons per fortnight whilst all the engines were employed.

Various kinds of leather were tried, including hippopotamus and buffalo hides, even caoutchouc, made to the full size of the side leathers, and also for bucket and clack falls, without entire success.

Metallic packing was also used, with partial success, the scouring of the sand through every material was a serious object. Even the bucket shells as well as bucket doors were wormed through in a most curious manner, similar to the action of the marine (teredo navalis) worm on ships' bottoms.

Having secured a similar timber ring in the other pits at the top of the sand, concentric oak cribs were then laid, backed by sheet piling 10½ feet in length, made of Norway battens, Memel deals, and rock elm 4½ inches thick, shod and hooped with iron. These were driven by a number of hand pile drivers, and the cribs drifted down with them to guide their course. The irregular structure of the sand caused a great deal of trouble; some parts being very soft and loose, whilst others were as hard as adamant, so that great difficulty was experienced in keeping the piles in line. We also found it necessary to keep a quantity of whins (gorse) and straw ready to stem the loose sand and gullets.

It was now deemed expedient to suspend the sinking at the west or new pit, and by heaving the sets up clear of the sand in the bottom, and keeping them pumping pure water, enable us to push forward the other two shafts with all the available strength. Success crowned this more, and on the 12th August the east pit, and on the 14th the middle pit,

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were safely got through the sand, with ample space to maintain their respective diameters intact.

Considerable difficulty was, however, yet experienced in getting a satisfactory foundation for the wedging cribs in both these pits, from the soft and spongy nature of the red and blue metal underlying the sand. At a distance of nine feet in the one pit we encountered a bed of hard black metal, and in this laid the crib, and the tubbing set on and closed to the last batch, put in above the sand, leaving a part of the plug holes running, to relieve the pressure in the other pit. In the east pit, after several courses of tubbing had been set on, the tubbing was found to have flattened on two sides, forming an elipse instead of a circle. These two sides not admitting the tubbing so as to maintain the full size of the shaft, we had to remove it, and were thus again exposed to the action of our old enemy. To add to our misfortune, the V bob, or middle set, burst near to the bottom, and had to be replaced before we could proceed.

After these two pits were tubbed through the sand, the sinking of the west or new pit was resumed, and continued through the sand, which was more rapidly accomplished, and on the 25th January, 1842, a double metal wedging crib was laid at seventeen feet below the sand, and on the 29th the tubbing was closed.

On the 5th February, the wedging of this tubbing being completed, the water was plugged off, and all the troubles and difficulties of this business seemed to be at an end. Next day, however, an explosion took place from the air pressure behind, which ruptured the tubbing at the top of the sand to such an extent that fourteen courses had to be reset. To prevent a recurrence of this casualty we put in several two-inch brass taps, and took pipes up into the standing set cistern. A borehole was also put down from the north engine staple into the sand, which gave a vent to any air or gas that might accumulate.

The whole of the three shafts were now completed to a depth of eighty-three fathoms from the surface, and rendered perfectly dry. The ordinary sinking being resumed, no further or unusual difficulty was met with, and they were all carried down in safety to the Hutton seam in April 1843, at the depth of 248 fathoms from the surface. The engine pit being continued down to the depth of 252½ fathoms for sump and standage. This pit contains:—

	106 fathoms of walling.	
	62 "	metal tubbing.
	80 "	naked rock.
Total ...	248	

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After the middle pit reached the Hutton seam, and before any brattice or slides had been put in, an acoustic phenomenon was observed. The distinctness with which you could hear the voices of the men, even in a whisper, between top and bottom (nearly 1,500 feet) was remarkable. This was, however, destroyed as soon as the first fittings were put in, after which, became quite inaudible ordinary sounds.

It struck me that a tube of either lead or gutta percha might be advantageously employed for communication between top and bottom, instead of the ordinary signal ropes, which, in addition to being very expensive, were often getting out of order, and I felt desirous to investigate this phenomenon. I entered into an agreement with a party to try the experiment, with the arrangement that if he failed he was to bear one-half of the expense. This was acted upon, and the experiment tested at various distances. The sound became less distinct as we proceeded, and at the depth of little more than thirty fathoms it was too indistinct to be of service, and the experiment abandoned.

The thickness of the sand was, in the east pit 34 feet 6 inches.

"	"	middle pit	27	"	8	"
„	„	west pit	26	„	0	„
	Total		88 feet 2 inches.			

In order to prove whether the feeders of water, met with in the course of sinking through the sand, had any connection with those passed through in the limestone, the several batches of tubbing were occasionally tapped, and invariably found full, and under, apparently, the original pressure.

[see in original text Summary of the rate of sinking Murton pits from the surface to the Hutton Seam.]

[No. 3 Plan showing the position of the pumps and machinery in the several shafts at Murton Winning 1841]

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I think I cannot do better than put on record a statement of the engine power, and schedule of the various appliances collected upon this plant, every one of which was most fully employed.

[see in original text Statement of the engine power, pumps, quantity of water raised per minute, and crabs]

The array of powers and materials here collected and appointed, is, I believe, without parallel in the annals of mining.

The slow process of crab work, occasioned in a great measure by the flitting of the rope on the main capstan, suggested, subsequently, to my mind, the idea of dispensing with this old fashioned mode for something more in keeping with the present day, by which greater speed could be obtained, coupled with the lessened employment of manual as well as horse labour. I sketched out a piece of mechanism for multiplying the power on a large metal drum, and attached the whole to a small steam engine. The success of this has been beyond my expectation, and the ease, certainty, and expedition, with which it does its work is highly satisfactory. This engine is erected on the Dudley sinking pit, Cramlington Colliery, and may be seen at work daily. By referring to the accompanying drawing, the application will be more clearly seen.

In this instance I have also attached, to the same engine, another pair of drums, for drawing the sinking stones, &c, so that its time is kept fully employed. It is easily thrown out of gear and applied to either work.

I would recommend this steam crab to any person having a winning of any magnitude in hand. Its services would have been invaluable at Murton, where there would have been full employment for several of them.

In taking a retrospective glance at the various localities where pits have been sunk through the limestone sand, in the County of Durham, the first upon record, I believe, is the attempt to win Hetton Colliery, by Mr. Mowbray, near to Cruddass House, considerably to the west of Hetton-le-Hole, in the year 1818. After perforating the limestone and expending a considerable sum of money in attempting to pass through the quicksand, this site was abandoned and the colliery subsequently won by the present Blossom and Minor pits in 1821. The depth to the bottom of the limestone here was 30½ fathoms, and the bed of sand four feet four inches in thickness. The feeders of water amounted to about 2,000 gallons per minute.

At the Eppleton Winning, begun in 1831, also belonging to Hetton colliery, the limestone was found only 9½ fathoms in thickness, which may, in part, be accounted for by the pit being placed in the valley at the side of the hill. The sand was here found 18½ fathoms in thickness, very free from water, and easily sunk through. In sinking the second shaft, however, too great eagerness, I fear, had been shown to get rapidly

[Illustration of Potter's Steam Crab]

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through, and sufficient timbering had not been put in, for within a short distance of the bottom the whole shaft fell in, burying the workmen while in the act of putting in some walling. This shaft was, I believe, never again opened.

South Hetton Colliery was begun in 1831, and after passing through the limestone, at a depth of fifty-seven fathoms from the surface, encountered five fathoms of sand, with a considerable feeder of water, which was drawn out by two 15-inch sets attached to the machine, there being no main engine at that time erected.

Haswell Winning commenced at the same time, and after passing through the limestone encountered much difficulty and delay in combating with the sand, which was proved to be about nineteen fathoms in thickness, and heavily burdened with water. After struggling for some time, and spending a large sum of money, the first site was abandoned, and another place opened to the west, with no better success; and finally, a third spot, about three-fourths of a mile southward, was begun and sunk to the Hutton seam without encountering any sand at all. Mr. T. J. Taylor could furnish some valuable details connected with the difficulties attendant upon this winning, which would be both interesting and instructive to the profession.*

Shotton Winning, begun in 1840, passed through the limestone at a depth of sixty-three fathoms from the surface, and had nearly three fathoms of sand in a soft state, underlaid by another fathom of hard sand or sandstone. The feeders of water being inconsiderable were easily overcome.

The Seaton Winning, begun in 1844, passed through 68½ fathoms of limestone, &c., and got to the sand in 1846. Fortunately for the company it was found only three feet in thickness, accompanied by a very small feeder of water, although a good deal of water had been successfully tubbed back whilst passing through the limestone. Mr. Wood will probably furnish the Institute with the details of this successful enterprise.

There are several others in this part of the county, such as Wingate, Castle Eden, Kelloe, Thornley, &c., &c., which have severally been put through the same strata, but not possessing any peculiarity to merit notice. Monkwearmouth Winning is the deepest in the coal trade, and occupied an unusually long time in its sinking although freed from any interruption by sand or heavy feeders of water.

*At the time this winning at Haswell was in progress there were employed three machines of 56-horse power each, and one pumping engine of 90-horse power, having three 15-inch sets worked by the machines, and one 17-inch set and one 12-inch set worked by the main engine, pumping about 2,100 gallons per minute.

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Pits in various parts of the coal-field have been put through beds of sand, of various thickness, near to the surface, and the earliest record we have of metal tubbing being used for the purpose of lining and securing shafts was at the King pit, Walker colliery, in 1796, under the superintendence of the late Mr. Barnes. It was in whole cylinders, six feet in diameter, and was cast at the Soho Works.

The greatest objection to using cylinder tubbing for passing through sand beds consists in the difficulty of keeping it in a vertical position, owing in a great measure to the irregular structure of the sand, and the immense weight or pressure required to propel it forward.

In conclusion I would add, that notwithstanding the immense quantity, as well as variety, of stock collected together for the accomplishment of this great work, and which would not afterwards be required for the current working of the colliery, very little of it now remains upon the premises. So great was the demand for pumps, spears, crabs, engines, and boilers, that a ready sale was effected, and a considerable amount of the capital thus returned.

It has often struck my mind that there is a good opening in the coal trade for a man of energy and capital, to undertake, as a contractor, the entire sinking of any new colliery, by a well assorted stock of the various implements required for such a business, and which could be removed away to another locality when no longer wanted, together with a well trained staff of superintendents and skilled workmen. These operations could be effected both more economically and readily than the present mode of each colliery proprietor, or his viewer, collecting together upon an emergency, a heterogeneous multitude of undisciplined men, together with an entire new stock of sinking requirements, which are generally either destroyed or sold below their value as soon as the particular work is completed.

[No. 4 Plan & Section showing the mode of passing through the quicksand at Murton Winning. 1841]

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[see in original text Account of the strata sunk through in the middle pit, Murton Winning, 1842]

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[see in original text Account of the strata sunk through in the middle pit, Murton Winning, 1842-continued]

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[see in original text Account of the strata sunk through in the middle pit, Murton Winning, 1842-continued [table]

No. 1—General Profile of the Winning.

" 2—Ground Plan of the Works.

" 3—Plan of the different Shafts with Pumps.

" 4—Plan and Section of the mode of passing the Quick-sand.

" 5—Drawing of Steam Crab.

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NORTH OF ENGLAND INSTITUTE of MINING ENGINEERS.

MONTHLY MEETING, THURSDAY, FEBRUARY 5, 1857, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

Nicholas Wood, Esq., President of the Institute, in the Chair.

The election and proposals of members were first proceeded with, when the following gentlemen were elected ordinary members:—Mr. Chas. Fred. Stuart Smith, of Derby; Mr. Geo. Baker Forster, of Cramlington; and Mr. William Reed, of Cowpen.

The following gentlemen are proposed for election at the General Meeting in March:—Mr. Hurst, of Backworth; Mr. Joseph Holdsworth, of Edinburgh; Mr. Richard Matthews, of South Hetton; Mr. Rosser, Mineral Surveyor, of Llanelly, South Wales; Mr. John Harris, of Woodside, Darlington; Mr. Joseph W. Pease, of Woodlands, Darlington; Mr. Wm. Horsley, jun., Seaton Cottage, Hartley, Newcastle; Mr. William S. Clark, Aberdare, Glamorganshire; Mr. James Willis, of Whitelee, near Crook, Darlington; Mr. John Trotter Thomas, Coleford, Gloucestershire.

A letter was read by the President, being the reply of the Charity Commissioners to the memorial sent them, under direction of the Society, praying for the appropriation of some portion of the revenue of the Virgin Mary Hospital, Newcastle, to the endowment of a College of Practical Mining and Manufacturing Science.

The Secretary also read a letter addressed to him by John Ramsay, Esq., of Walbottle, stating that an error in the description of his "token" appeared in the Transactions of the Meeting of December. The President

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is represented as saying that the "token" is affixed at "the top of the tub," whereas it is fixed near the bottom. It was agreed that the error should be noticed in the Transactions of the day, and the drawing accompanying the letter laid upon the table.

The Secretary also laid upon the table the votes as to Thursday or Friday being preferable for monthly meetings, which showed a majority of nine for Thursday out of fifty-five votes in all.

The President then proceeded to read his Paper "On the Conveyance of Coals Underground" which, after a few remarks by Mr. Matthias Dunn and others, was ordered to be printed.

After which, the President proceeded to read his account of "The Winning of Seaton Pit through the Magnesian Limestone and the Underlying Sand."

This was done in order that it might be discussed with Mr. Edward Potter's account of the Murton Winning in the same locality.

The consideration of a letter from Messrs. Laws and Glynn, Solicitors, addressed to Thomas John Taylor, Esq., relative to the Lindley and Hutton Fossil Flora, was postponed in consequence of Mr. Taylor's absence.

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On THE CONVEYANCE of COALS UNDERGROUND IN PITS.

Appendix to paper read at the meeting of the Institute, April, 1855.

By NICHOLAS WOOD, Esq.,

President of the Institute

In the paper which I had the honour of reading to the members of the Institute at the Meeting of April, 1855, I stated that I would lay before the Institute, at a future time, some further observations and experiments to elucidate the application of steam engines to the conveyance of coals underground, with a view of ascertaining to what distances steam engines can be placed from the shafts, or in extension of engine planes, where the engines are employed in conveying coals direct to the shafts, and thus to determine how far the system of engine power can, in deep pits and expensive winnings, be economically extended in substitution of the sinking of such pits or winnings. I now proceed to fulfil that promise and to present to the consideration of the members of the Institute such observations and experiments as I have at leisure times been enabled to make thereon; at the same time I must beg to state, that I regret my various avocations in business has prevented me from devoting that amount of time and attention to the subject which its importance demands.

In the paper to which I have already alluded, I laid down a diagram of a supposed coal-field, with a supposed inclination of 4° 50', or 1 in 12, and endeavoured to show:—

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1st.—That by a system of inclined planes, self-acting or by gravitation, all the coals on the rise of the water levels from the shaft could be brought down to those levels, or direct to the shaft.

2nd.—That along the water levels horses might be employed, and that if those levels were driven at an angle of 1 in 130 a maximum effect would be produced, by that description of power.

3rd.—That at an inclination of 1 in 28, the empty tubs or carriages would drag out from an engine a rope (without the aid of a tail-rope), by which all the coals to the dip of the line of that angle might be brought to the shaft by steam engines.

And 4th.—That between a line, proceeding at an angle of 1 in 130 from the bottom of the shaft to the rise, and a line of 1 in 28 from the shaft to the dip, all the coals could be brought out by a system of engines with double or tail ropes.

In the elucidation of those different modes of conveyance, which comprise all that is necessary to convey the coals from any portion of the coal-field to the shaft, I gave experiments on the practical performances and application of these different modes in actual operation at different collieries.

As regards the 1st, or self-acting planes, I gave, in pages 270 to 274, Vol. III., the theoretical and practical operation of this mode of conveyance sufficiently in detail, I trust, to elucidate and show to what extent this description of power can be applied, it is not, therefore, my intention nor is it, indeed, necessary for me to make any further observations in this paper on that head.

On the use of horses a similar conclusion is, perhaps, advisable; sufficient experiments and practical results are shown in pages 262 to 270, to point out the great disadvantages and cost of the employment of this description of motive power, and the necessity of resorting to mechanical means, whenever its application is practicable, and when circumstances justify its adoption.

It is, therefore, to the 3rd and 4th heads of conveyance that the observations and investigations, which I now lay before the Institute, are intended to apply. And as the 4th is, no doubt, the cheapest and most advisable mode of application of the fixed steam engine, for the conveyance of coals underground, I shall, therefore, first of all proceed to investigate to what extent this can be carried.

In page 286, Vol. III., I arrived at the conclusion, that a length of descending plane of 2,000 yards in length, of an inclination of 1 in 28,

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could, by using thirty-five tubs, be worked by a single rope; the tubs being of the ordinary description, with wheels of about twelve to fifteen inches diameter. With tubs of a superior construction, and with larger wheels, the resistances of the carriages may be diminished, as the friction of those carriages is nearly three times greater than the well finished and larger wheels of the carriages used on the railways above ground. It is probable, also, that the sheaves used underground will be improved; but every one practically acquainted with underground operations knows the great obstacles which exist in forming roads, except at a great expense, in working a bed of coal, probably not more than three or four feet in height, and the great cost attendant on improvements of this nature. I have thought it advisable, therefore, to confine my investigations more particularly to the present state of things, and to the data obtained by the experiments detailed in my previous paper; more especially as the result of any such improvements can readily be made to apply to the cases which I purpose to point out.

It will likewise occur that a greater number of tubs can be used, or larger tubs containing a greater weight of coals, and by thus adding to the gravitating force, to overcome the resistance of the rope, and so augment the length of the plane; but it may be doubted if, practically, a larger number than fifty to sixty tubs can, in many cases, be beneficially employed, and likewise, whether, generally, a tub larger than will contain a greater weight than eight or nine cwts. of coals can be used in moderately thin seams.

Taking, therefore, the examples derived from the experiments, detailed my former paper, it appears that engines have been used to an extent of about 2,000 yards in the directions Po and Pp, in the diagram plate V: between those points and more directly in the dip of the beds, the inclination being greater, the gravitation of the empty tubs will drag out a greater length of rope, say, to the extremity of the supposed coal-field, in the direction Po; when, as it may be presumed the power of the engine will be sufficient to drag up the loaded tubs, the extent of the boundary of the royalty will then become the limit of the engine plane. We may suppose, therefore, that there are few royalties with an inclination of the beds of 1 in 12 where an engine will not reach the furthest extent.

Previously, however, to entering into an investigation of the extent to which engine planes can be worked underground, I shall give experiments

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made upon two planes, of greater length than any of those given in the former paper, and where, likewise, a larger number of tubs of coals are conveyed at a time.

HASWELL COLLIERY

Experiments made at the Haswell colliery, January 14th, 1857, with an underground engine, having two cylinders, one horizontal, diameter 29½ inches, with a 3 feet 6 inches stroke, and the other vertical, 25½ inches diameter, with a 5 feet stroke; with three boilers, one 28 feet long and 6 feet diameter, the other two each 30 feet long and 6 feet diameter; the boilers being placed about eight yards from the engine. On second motion, reducing the velocity as 3 to 2, rope rolls 6 feet diameter, length of plane 2,519 yards, total descent 191 feet, 51 tubs of coals drawn at a time, each tub containing 8 cwts. 2 qrs. 8 lbs. of coals, = 21 tons 16 cwts. 3 qrs. 16 lbs. of coals, each empty tub weighing 482 lbs., making a gross load of 73,542 lbs.

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[see in original Table of Experiment I]

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During this experiment No. 1 boiler evaporated 2½ inches of water, No. 2, 3¼ inches, and No. 3, 3¼ inches. No. 1 boiler, therefore, evaporates 30.05 cubic feet of water, or 187.61 gallons in 50 minutes = 3.75 gallons per minute, and Nos. 2 and 3 boilers evaporated 93.31 cubic feet = 583,187 gallons, or 11.66 gallons per minute; therefore, total water evaporated = 15.41 gallons per minute for 50 minutes.

[see in original text Table of EXPERIMENT II]

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[see in original text Table of EXPERIMENT II - continued]

No. 1 boiler evaporated in 60 minutes 3⅜ inches of water, No. 2, 2¾, and No. 3, 2¼. Therefore, No. 1 evaporated 45.01 cubic feet of water = 281.31 gallons, or 4.69 gallons per minute, and Nos. 2 and 3 evaporated 71.77 cubic feet = 448.56 gallons, or 7.47 gallons per minute; therefore, total quantity of water evaporated = 12.16 gallons per minute for 60 minutes.

SEATON DELAVAL COLLIERY

Experiments made at Seaton Delaval Colliery, January 20, 1857, on an Underground engine, with one cylinder, 27 inches diameter and 5 feet stroke, the engine being placed about eight yards from the boilers. Four boilers altogether, viz., No. 1, 24 feet long and 6 feet diameter, No. 2, 24 feet long and

6 feet diameter, No. 3, not at work, and No. 4, 28 feet long and 5 feet diameter; rope roll 6 feet diameter on the first motion. Total length of plane 2,046 yards; the first 1,540 yards from the bottom, with a rise of 4.83 feet, and the remaining 506 yards, a rise of 18.25 feet making a total length of 2,046 yards, and a total rise of 23.08 feet. 106 tubs are taken at a time, the weight of the coals in each tub 878lbs., and of each tub 483lbs., making the gross load of the loaded set 144,266lbs., or upwards of 64.4 tons, and of the empty set 51,198lbs., or nearly 23 tons.

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[see in original text Table of EXPERIMENT I]

During this experiment, No. 1 boiler evaporated, in fifty-two minutes,

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three inches of water; No. 2, 4¼; and No. 4, 2½ inches. Nos. 1 and 2 therefore, evaporated 85.17 cubic feet, and No. 4 evaporated 28.05 cubic feet; altogether 113.22 cubic feet, or 707.62 gallons, equal to 13.40 gallons per minute for fifty-two minutes.

[see in original text Table of EXPERIMENT II]

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[see in original text Table of EXPERIMENT I - continued]

At 2h. 54m. the steam jets were put on, and shut off again at 3h. 1m.

During this experiment Nos. 1 and 2 boilers evaporated in 60 minutes 8.75 inches of water, and No. 4, 3½ inches. Nos. 1 and 2 therefore evaporated 93.57 cubic feet, and No. 4 evaporated 39.29 cubic feet; altogether, 132.84 cubic feet, or 830.25 gallons in 60 minutes, or 13.837 gallons per minute.

I have not all the details of the dimensions of the tubs, ropes, sheaves, &c, to enable me to make the requisite calculations to show the precise performances of the engines in those experiments; but, supposing the friction of the tubs, sheaves, ropes, &c, to be about the same as those of similar tubs given in the former paper, the results will be found to be much the same as those shown in that communication.

These experiments are valuable as showing the practical result of long engine planes, on which are conveyed in the one instance 51 tubs, and in the other 106 tubs at a time; thus proving the practicability of conveying from great distances, from the bottom of the pit, large quantities of coals, up to nearly a gross load of 64.4 tons, or upwards of 41 tons of coals at a time, conveyed at an average rate of 9 miles an hour.

We may now, with the assistance of the results given in these two sets of experiments, enter into the investigation of the extent to which engine power can be employed underground in the conveyance of coals. I beg, however, before doing so, to correct an error which has been made in giving the particulars and result of the Experiment No. 2, page 291, Vol. III.

In transcribing the notes of that experiment, the number of loaded tubs brought up that plane was stated at 30, whereas the correct number was 15. The mistake, it appears, arose from 30 tubs being the number taken along the level plane, page 305; between the bottom of the pit

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and the plane, page 291; while only half the number was taken up the latter plane generally. The following is, therefore, the correct details of this Experiment:—

[see in original text Tables No. 2 EXPERIMENT, made on the Performance of a Fixed Engine at Killingworth.—April, 1855.]

Since these experiments were made, a more powerful engine has been erected for the purpose of extending that plane, and for dragging up a larger number of tubs. This engine is placed on the surface, with a single rope leading down the pit, as detailed in No. 4 Experiment, page 285, having two cylinders, each thirty inches diameter, with a five-feet stroke, and it is capable of dragging with ease thirty loaded tubs up the

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plane No. 2, page 291. The performance, therefore, though erroneously given as regarded the engine then at work, may be taken as the practical work of the new engine.

We have, therefore, as resulting from those experiments, these facts:— That engine planes have been worked of a length of 2,519 yards, or nearly 1½ mile.

That a number of tubs, equal to 106 at a time, has been conveyed at a rate of speed equal to nine miles an hour.

And, that these engines are employed where the inclination of the beds of coal is equal to 1 in 5.485.

We do not think, therefore, that it is an extravagant notion, as regards the first of these points, or as regards the length of planes, that two miles may be reached; and that, taking the supposed coal-field shown in plate V, Vol. III., the engine plane Pv may be 1½ mile, when the diagonals PA and PD would be two miles from the bottom of the pit, and that the extremities of such a royalty would be reached by an engine plane of two miles in length. If the plane Pv is two miles in length, then the diagonals would be about 2.75 miles. The former would give an extent of coal-field equal to nine square miles, or 5.760 acres; and the latter to sixteen square miles, or 10.240 acres.

Then, as regards the quantity of coals which can be brought out in a day's work, which is an important consideration, we have the fact that 106 tubs can, in favourable cases, be used at a time, containing upwards of forty tons of coals, and that these can be conveyed at the rate of say eight miles an hour. If the engine is sufficiently powerful, and the plane made with a double line of rails, and suppose the length is two miles, then say that two trips may be realised in an hour, which will give eighty tons per hour, or in twelve hours upwards of 800 tons, which is much more coals than in almost any instance is requisite should be brought up one plane in any pit.

These facts will enable us to determine to what extent coals can be conveyed underground by the two first of the modes previously stated in this paper, viz., by self-acting planes, and by engines with a single rope, for we have seen, where it is necessary to apply a large number of tubs to obtain gravitating force, that up to or beyond the number of 100 can practicably be used. With an inclination of 1 in 12, as proposed in the sketch, Plate V, Vol. III., there can be no doubt that the extreme dip can be reached by a fixed engine with a single rope, and that the diagonal lines PA and PD can also be so worked, even if extended to the extreme corners of the royalty at A and D.

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Having, therefore, now explained the extent to which the coal of an-extensive coal-field, represented by the diagram, Plate V, Vol. III., can be brought out to the pit or shaft by the cheapest of engine power, viz., by engine planes, with a single rope taken out from the engine by the gravitating force of the empty tubs, and which comprehends all that part of the coal-field which lays to the dip of the shaft below a line descending 1 in 28. We now come to consider the 4th proposition, or the conveyance of coals from that part of the coal field which cannot be beneficially or otherwise conveyed by horses,—by self acting planes—or by fixed engines with a single rope—and which is the employment of a system of fixed engines with tail ropes.

The cases No. 4, page 296, Vol. III.; No. 5, page 300; No. 6, page 305; No. 7, page 308; No. 8, page 311, of the former paper, and the two cases of Haswell and Seaton Delaval in this paper, are examples of engine planes of this description, and one or two more are given in a subsequent part of this paper. All of these are worked by engines of this kind, with separate drums or rope-rolls for the main and tail ropes, with the exception of that at Andrews House Colliery, which is worked by friction sheaves. This latter is a description of engine which may be used, with advantage in particular situations, but it is not likely to be so generally used as the other description of engine power. To pump water from the end of the plane, or, in dip workings, at a distance from the shaft, by means of the sheave, as in the case of the Black Boy engine, it is peculiarly applicable, being a continuous motion.

These examples will show that there can be no difficulty in the application of fixed engines, with tail ropes, to drag coals in all the intermediate gradations of gradients, from those down which the coals can be brought by self-acting planes; and those up which the coals can be brought out by fixed engines, with a single rope, and down which the gravitation of the empty tubs will drag out the rope; including, of course, all the roads where it is practicable to use horses, and which may be summed up in the following propositions.

1stly.—As regards distances or length of planes.—That planes are now at work every day of nearly 1½ miles in length; these it is intended to extend, and two miles may now be considered a practicable length of plane.

2ndly.— With regard to the quantity of coals which can he brought out in a day's work of twelve hours.—We have shown that even on a

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single plane, two miles in length, upwards of 800 tons may be brought out in a day. But it is seldom the case that the workings of a pit are so laid out that the entire work is to be brought out by a single plane.

3rdly.—As regards gradients.—It is not necessary that the plane should have an uniform gradient; with a tail rope the gradient may either be an ascending or descending one; may vary, sometimes ascending and sometimes descending; that is the case in some of the examples given in the former paper, and the planes of Haswell and Murton are also cases of this description. The ropes being affixed to each end of the train, or set of tubs, they cannot over-run in variations of the gradients. It is, of course, desirable that the gradients should be as uniform as possible, but every practical mining engineer knows that in the undulating nature of the coal beds, and with the frequent dislocations of the beds by dykes or faults, this cannot be always accomplished, and therefore, it is desirable to show that considerable undulations of gradients may be overcome by the application of tail ropes to underground engines.

4thly.— With respect to curves.—As in the case of gradients, it is desirable that the plane should be as straight as possible. The examples shown in the former paper, and those given in this, prove that considerable deviations from a straight line may be traversed by proper care being taken to make the curves as uniform as possible, and by a judicious application of directing sheaves. Curves, therefore, are not an obstacle in the application of fixed steam engines to drag coals underground.

And lastly.—The number of districts which can be worked at a time.— It is well known to be quite necessary, in conducting the operations on a large scale in a pit, to have several distinct districts at work at a time, and that from each of those roads are to be used to bring out the coals. In each of those districts the coals are brought out to a main road, by small ponies, or otherwise; and probably there may be three or four of these main roads along which it is advisable one engine should be employed in bringing out the coal. Some of such branch roads are shown in the sketches attached to the former paper; but there is no difficulty in working three or four, or more, branch roads, by a system of tail ropes working upon separate drums, or separate rope rolls attached to the engine, and which are severally detached when not required, or attached when the coals are required to be brought out of the particular district for which such rope is provided; each district requiring a separate tail rope. It is not, perhaps, necessary for me to

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point out the particular application in each case, as they are so well known to practical engineers, and there being a variety of detail in the several modes of application, would lengthen this paper, already perhaps, too long.

Having, I trust, sufficiently explained the different systems of conveyance of coals underground, the most important of which are that of the employment of steam engines; the only remaining part of the subject is the mode, or particular manner in which these engines can be applied, and this is by no means an unimportant part of the subject.

In the progress of these investigations, it will almost have been premised, that the engines by which the planes were to be worked were placed at the bottom of the pit, or at the end of the planes next the pit, and that the ropes proceeded from that point. There are, however, various modes of application of such engines.

1st.—The engine may be placed at the bottom of the pit, and the boilers producing the steam at the bottom of the pit likewise.

2nd.—The engine may be placed at the bottom of the pit, and the boilers producing the steam may be placed at the top of the pit, the steam being conveyed down the shaft in pipes.

Or, 3rd.—Both engine and boilers may be placed on the surface, and the ropes taken down the shaft, and so led by sheaves to the plane to be worked.

It is, of course, very desirable to know the relative advantages and disadvantages of each of these several modes of application, as there are in all collieries cases where one or other of those modes are either inapplicable, or where obstacles prevent, or render their application inadvisable.

In performing the experiments detailed in the previous paper, and in the former part of this paper, I did not lose sight of this part of the inquiry, more particularly with reference to the loss of steam in its conveyance, where the cylinders were placed at considerable distances from the boilers, and which involved the relative effect of placing the boilers on the surface, and conveying the steam down the shaft, or of placing the boilers at the bottom of the pit. Before proceeding to give the result of the experiments which were then made, I have to state that I found the subject required further investigation, and I therefore found it necessary to institute further experiments, which my friends, at some of the neighbouring collieries, kindly enabled me to perform, and which I shall now proceed to lay before the Institute.

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For the purpose of more clearly illustrating- the subject, I have-arranged the experiments in the order in which the several modes of application are proposed to be discussed, viz. —

1st.—Engines at the bottom of the pit and boilers likewise.

Elemore Colliery Engine, page 294, Vol. III.

Haswell do. previously given in this paper;

Seaton Delaval do. do.

Murton do. Experiment No. I. following.

2nd.—Engines at the bottom of the pit and boilers on the surface, the steam being conveyed down the pit in pipes.

Black Boy Colliery Engine, page 309, Vol. III.

Andrews House Colliery Engine, page 307, do.

Heworth do. Experiment No. II following

3rd.—Both engine and boilers on surface; ropes taken down the shaft.

Killingworth Colliery Engine, Experiment No. III. following.

In the course of these experiments it was found that a considerable waste of steam, or a great deficiency in the quantity of steam which passed through the cylinders existed, compared with the quantity of water evaporated; I found it, therefore, advisable to ascertain if such a deficiency was peculiar to the engines above experimented upon, or whether it existed in the ordinary engines employed in winding the coals up the pits and for that purpose the following experiments were made:—

4th.—West Minor Colliery Engine, No. IV. Experiment following.

Crook Bank do. No. V. do.

The following are the experiments which have been recently made for this purpose, with the several results:—

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No. I.

Experiments made with an underground engine at Murton Colliery, two cylinders eighteen inches diameter two feet stroke; with two boilers underground each thirty-five feet long, and four feet six inches diameter; length of steam pipe from boilers to cylinders, 300 yards, seven inches diameter, and fifty yards of exhaust pipe 6½ inches diameter; and two drums, each five feet diameter

[see Table No.I in original text]

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[see Table No.I in original text - continued]

The two boilers evaporated during the seventy minutes, each five inches of water, the boilers being thirty-five feet long, with two circular ends, will = 366 x 54 + 2290.2 area / 1728 = 12.76 cubic feet, for one inch surface x 10 inches = 127.6 x 6.25 / 70 minutes = 11.39 gallons per minute or 5.69 gallons per minute for each boiler.

[83]

[see in original text Table of Second experiment]

[84]

[see in original text Table of Second experiment - continued]

In this experiment the two boilers evaporated each 5½ inches of water, therefore 12.75 x 11 x 6.25 / 60 = 14.62 gallons per minute for both boilers, or 7.31 for each.

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No. II.

Experiments made with the underground engine at Heworth Colliery, two cylinders two feet each in diameter; length of stroke, four feet ; three drums, six feet diameter; dimensions of boilers are as follows, No. 1, 26 ft. 3 in. length; 5 ft. 6 in. diameter; No. 2, 26 ft. 1 in. length; 5 ft. 9 in. diameter; and No. 3, 25 ft. 10½ in. length; 5 ft. 9 in. diameter.

[see in original text Table of No. II experiment]

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[see in original text Table of No. II experiment - continued]

[87]

[see in original text Table of No. II experiment - continued]

[88]

[see in original text Table of No. II experiment - continued]

[89]

[see in original text Table of No. II experiment - continued]

At the end of this Experiment, from 11.30 a.m. to 1.20 p.m., found the evaporation as follows, No. 1 boiler, 4½ inches, No. 2, 3¼ inches, and No. 3, 3¼ inches.

[see table in original text]

[90]

[see in original text Table of No. II experiment - continued]

Experiments continued after an interval of one hour and thirty-five minutes for refilling the boilers.

[91]

[see in original text Table of No. II experiment - continued]

[92]

[see in original text Table of No. II experiment - continued]

At the end of this Experiment, from 2.55 p.m. to 3.59 p.m., found the evaporation as follows:—No. 1 boiler, 2¾ inches; No. 2, 2¼ inches; and No. 3, 1¾ inches.

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No. III.

Experiments at Killingworth Colliery to ascertain the Evaporation of Water in the Boilers of the Underground Engine. The boilers are placed as near to the engine as they conveniently can be.

The boilers having all been filled to the same level (viz., three inches above the centre), the experiments were commenced, and (without pumping any more water in the boilers) continued until the floats showed the water to be three inches below the centre of the boiler, at which point it was requisite to put on the feed. The experiments were then discontinued until the boilers had been filled to the original level of three inches above the centre, when the experiments were renewed and continued three hours. During Nos. 16 and 17 runs, in first experiment, a stop occurred of about eighteen minutes, during which time the water fell a quarter of an inch in each boiler; and during the second set of experiments, three stops occurred, amounting in all to forty minutes, in which time the floats had fallen 11-16ths of an inch.

[see in original text Table of No. III experiment I.]

[94]

[see in original text Table of No. III experiment I. - continued]

[95]

[see in original text Table of No. III experiment I. - continued]

Total quantity of water evaporated during this Experiment 120.186 cubic feet.

[96]

[see in original text Table of No. III experiment II.]

[97]

[see in original text Table of No. III experiment II. - continued]

[98]

No. IV

Experiments taken at Hetton Colliery West Minor Pit. Machine with three boilers attached; cylinder 24 inches diameter, 5 foot stroke; rope roll 10 feet 8 inches.—Nov. 28, 1856.

[see in original text Tables of Experiment I and II]

No. 2 boiler, during Experiment I., partially fed with water. 23.75 strokes for two tubs, therefore, number of cylinders full of steam—1st Experiment, 2137; 2nd Experiment, 2280; cubic feet of water evaporated in 1st Experiment, 110.80; 2nd Experiment, 122.83.

[99]

No. V.

Table of Experiments made at Crook Bank Colliery winding engine showing the pressure of steam and evaporation of water. Two cylindrical boilers.—January 7th, 1857. (see in original text)

Number of strokes the engine makes in drawing one tub 7¾ double strokes = 15½ cylinders full of steam for each tub of coals drawn to bank; and as there were 47 scores 6 tubs drawn, equal to 946 tubs, therefore, 946 x 15.5 = 14,663 cylinders full of steam.

No. 1 Boiler.—Cylindrical Boiler, with hemispherical ends, twenty-three feet long over all, six feet three inches diameter.

The experiments were commenced at 4 o'clock a.m., and continued for twelve hours.

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The boiler was, at four o'clock, filled with water to a depth of 4 feet 4⅝, and was allowed to boil down six inches. The feed was then put on, and the boiler filled up again to 4 feet 4⅝ inches.

The time of filling, boiling down, refilling, &c, are given in the table, with the pressure, &c., of the steam.

The average area of the boiler, or surface of the water at the depth of 4 feet 1⅝ inch, is 121.66 square feet; and as twenty-five inches of water were converted into steam in eight hours forty minutes, and supposing the same rate of evaporation was continued during the time of filling up the boiler, namely, three hours twenty minutes, it would equal eight inches of water; making a total of water evaporated equal to thirty-three inches.

But as, in the course of the experiment, the engine stood 1½ hour, during which no steam was taken from the boiler, except what was wasted, and it was found at the end of that time (1½ hour) that one inch of perpendicular water had been evaporated; making a total amount of evaporation of thirty-two inches, or which is equal to 324.42 cubic feet of water evaporated in No. 1 Boiler.

No. 2 Boiler.—Cylindrical Boiler, with hemispherical ends, twenty-three feet ten inches long over all, five feet nine inches diameter.

The experiments were commenced, as in the other boiler, at 4 o'clock, a.m.

The boiler was, at four o'clock, filled with water to a depth of 4 feet 0½ inch, and was allowed to boil down nine inches in the first time. The feed was then put on, and the boiler filled up again to 4 feet 0½ inch, and was then allowed to boil down six inches, and so on.

The time of filling, boiling down, refilling, &c., are given in the table, with the pressure of steam, &c.

The average area of the boiler, or surface of water, taken at the average depth of 3 feet 9½ inches is 120 square feet, and as 24 inches of water was converted into steam in nine hours, and supposing the same rate of evaporation was continued during the time of filling up the boiler, namely, three hours, it would equal eight inches of perpendicular water, making a total of water evaporated equal to thirty-two inches.

And in this, as in No. 1 Boiler, one inch of perpendicular water was evaporated during the time the engine was standing 1½ hour, steam blowing off at 27 lbs. per inch pressure, will make the total evaporation of No. 2 Boiler 31 inches, or 310 cubic feet of water evaporated in No. 2 Boiler, and a total evaporation of the two boilers of 624.42 cubic feet of water.

[101]

Table of Experiments of Crook Bank Colliery Winding Engine, showing the pressure of steam, evaporation of water. Two cylindrical boilers.—January 10th, 1857. (see in original text)

[102]

Number of coals drawn	46	6
Number of empty cages and men	1	15

Number of strokes made by the engine in drawing one tub = 7¾ turns of the fly-wheel; or 15½ cylinders full of steam for each tub of coals drawn to bank; and as there were 48 scores one tub drawn equal to 961 tubs, therefore 961 x 15.5 = 14,895 cylinders full of steam.

The boilers being in every respect similar to the first experiments as to dimensions and average area of surface of water. The same order being preserved in this, as in the last experiment.

No. 1 BOILER.

The average area of the surface of the water 121.66 square feet; and as 23 inches of water was converted into steam in 8 hours 50 minutes, and supposing the same rate of evaporation was continued during the time of filling up the boiler, namely, 3° 10', it would equal 8¼ inches of water, making a total of water evaporated equal to 31¼ inches in twelve hours, or 316.82 cubic feet of water evaporated.

No. 2 BOILER.

The average area of the surface of the water is 120 square feet; and as 24 inches of water was converted into steam in nine hours, and supposing the same rate of evaporation was continued during the time of filling up the boiler, namely, three hours, it would equal eight inches of perpendicular water, making a total of water evaporated equal to 32 inches in twelve hours, or 320 cubic feet of water evaporated, and making a total evaporation of 636.82 cubic feet of water.

The results of all these experiments are shown in the following tables:—(see original text)

[103]

Diameter of 2 cylinders, 12 inches each; length of stroke, 2 feet; area of 2 pistons, 226.19 inches.

Number of cylinders full of steam 9,400.

Average pressure of steam in cylinders 31lbs.

Bulk of steam compared with water 855.

Therefore, 76.95 x 855 = 65,793 cubic feet of steam produced, and 9400 x 226.19 x 24 / 1728 = 29,530 cubic feet of steam passed through cylinders, consequently 29530 / 65793 = 44.88 per cent. of useful effect.

[see in original text Table of Haswell Colliery Engine, Experiment, Page 68]

Diameter of cylinder, one, 29½ inches; 3½ feet stroke; area of piston, 683.49 inches.

Diameter of cylinder, the other, 25½ inches; 5 feet stroke; area of piston, 510.70 inches.

Number of cylinders full of steam, 1st Experiment, 2100; 2nd Experiment, 2100.

Average pressure of steam, 1st Experiment, 33lbs.; 2nd Experiment, 33.3lbs.

Bulk of steam compared with water, 1st Experiment, 808; 2nd Experiment, 815.

1st Experiment—Therefore 123.35 x 808 = 199,333 cubic feet of steam produced; and 683.49 x 42 + 510.7 x 60 x 2100 / 1728 = 72,125 cubic feet of steam passed through cylinders, consequently 72125 / 199333 = 36.18 per cent.

2nd Experiment—-Therefore 116.78 x 815 = 190,351 cubic feet of steam produced; and 683.49 x 42 + 510.7 x 60 x 2100 / 1728 = 72,125 cubic feet of steam passed through cylinders, consequently 72125 / 190351 = 37.98 per cent.

Average 37.08 per cent. of useful effect.

[104]

[see in original text Table of Seaton Delaval Colliery Engine Experiment, Page 71]

Diameter of cylinder, 27 inches; length of stroke, 5 feet; area of piston, 572.55 inches.

Number of cylinders full of steam, 1st Experiment, 2072; 2nd Experiment, 2082.

Average pressure of steam, 1st Experiment, 33.4 lbs.; 2nd Experiment, 32.6 lbs.

Bulk of steam compared with water, 1st Experiment, 816; 2nd Experiment, 838.

1st Experiment.—-Therefore 113.21 x 816 = 92379 cubic feet of steam produced; and 572.55 x 60 x 2072 / 1728 = 41,192 cubic feet of water passed through cylinders, consequently 41192 / 92379 = 45.63 per cent.

2nd Experiment.—Therefore 132.85 x 838 = 111,328 cubic feet of steam produced, and 572.55 x 60 x 2082 / 1728 = 41,391 cubic feet of steam passed through cylinders, consequently 41391 / 111328 = 37.18 per cent.

Average 41.40 per cent. of useful effect.

[see in original text Table of Murton Colliery Engine, Page 81]

Diameter of cylinders, two, each 18 inches; length of stroke, 2 feet; area of two pistons, 508.93 inches.

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Number of cylinders full of steam, 1st Experiment, 3968; 2nd Experiment, 6060.

Average pressure of steam in cylinders, 1st Experiment, 35 lbs.; 2nd Experiment, 34.8 lbs.

Bulk of steam compared with water, 1st Experiment, 765; 2nd Experiment, 771.

1st Experiment.—Therefore 127.6 x 765 = 97,614 cubic feet of steam produced; and 508.93 x 24 x 3968 / 1728 = 28,047 cubic feet of steam passed through cylinders, consequently 28047 / 97614 = 34.80 per cent.

2nd Experiment.—-Therefore 140.36 x 771 = 108,107 cubic feet of steam produced; and 508.93 x 24 x 6060 / 1728 = 42,835 cubic feet of steam passed through cylinders, consequently 42835 / 108107 = 25.24 per cent.

Average 30.02 per cent. of useful effect.

[see in original text Table of Black Boy Colliery Engine, Page 309, Vol. III]

Diameter of cylinders, two, each 12 inches; length of stroke, 2 feet; area of two pistons, 226.19 inches.

Number of cylinders full of steam, 1st Experiment, 48,790; 2nd Experiment, 81,265.

Average pressure of steam in cylinders, 1st Experiment, 37.5 lbs.; 2nd Experiment, 36 lbs.

Bulk of steam compared with water, 1st Experiment, 718; 2nd Experiment, 746.

1st Experiment—Therefore 554.44 x 718 = 389,923 cubic feet of steam produced; and 48.790 x 226.19 x 24 / 1728 = 153,276.5 cubic feet of steam passed through cylinders, consequently 153276 / 389923 = 38.54 per cent.

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2nd Experiment.—Therefore 78.23 x 746 = 58.359 cubic feet of steam produced; and 81,265 x 226.19 x 24 / 1728 = 25,530 cubic feet of steam passed through cylinders, consequently 25530 / 58359 = 43.75 per cent.

Average 41.14 per cent. of useful effect.

[see in original text Table of Andrews House Colliery Engine, Page 307, Vol. III.]

Diameter of cylinders, two, each 13 inches; length of stroke, 25¾ inches; area of two pistons, 265.46 inches.

Number of cylinders full of steam, 65.632.

Average pressure of steam in cylinder, 29.5 lbs.

Bulk of steam compared with water, 895.

Therefore 276.1 x 895 = 247,104 cubic feet of steam produced; and 65.632 x 265.46 x 25.75 / 1728 = 129,813 cubic feet of steam passed through cylinders,

consequently 129813 / 247104 = 52.53 per cent. of useful effect.

[see in original text Table of Heworth Colliery Engine.]

Diameter of cylinders, two, each 24 inches; length of stroke, 4 feet; area of two pistons, 904.78 inches.

Number of cylinders full of steam, 1st Experiment, 2592; 2nd Experiment, 1926.

Average pressure of steam in cylinders, 1st Experiment, 28 lbs.; 2nd Experiment, 26 lbs.

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Bulk of steam, compared with water, 1st Experiment, 939; 2nd Experiment, 1005.

1st Experiment. Therefore 158 x 939 = 148,362 cubic feet of steam produced; and 904.78 x 48 x 2592 / 1728 = 65,093 cubic feet of steam passed through cylinders,

consequently 65092 / 148362 = 43.88 per cent.

2nd Experiment. - Therefore 97.93 x 1005 = 98,419 cubic feet of steam produced; and 904.78 x 48 x1926 / 1728 = 48,406 cubic feet of steam passed through cylinders,

consequently 48406 / 98419 = 49.19 per cent.

Average 46.52 per cent. of useful effect.

[see in original text Table of Killingworth Colliery Engine]

Diameter of cylinders, two, 30 inches; length of stroke, 5 feet; area of piston, 706.86 inches.

Number of cylinders full of steam, 1st Experiment, 12, 095; 2nd Experiment, 10, 430.

Average pressure of steam in cylinders, 1st Experiment, 24.65 lbs.; 2nd Experiment, 25.05 lbs.

Bulk of steam, compared with water, 1st Experiment, 1056; 2nd Experiment, 1042.

1st Experiment. Therefore 240.474 x 1056 = 253,356 cubic feet of steam produced; and 12095 x 705.86 x 60 / 1728 = 148,428 cubic feet of steam passed through cylinders,

consequently 148428 / 253356 = 58.58 per cent.

2nd Experiment. Therefore 221.7 x 1042 = 253,181 cubic feet of steam produced; and 10430 x 705.86 x 60 / 1728 = 127,957 cubic feet of steam passed through cylinders,

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consequently 127957 / 253181= 50.55 per cent.

Average 54.56 per cent. of useful effect.

[see in original text Table of East Minor Winding Engine, Hetton Colliery.]

Diameter of cylinder 24 inches; length of stroke 5 feet; area of piston 452.39 inches.

Number of cylinders full of steam, 1st Experiment, 2137.5; 2nd Experiment, 2280.

Average pressure of steam in cylinders, 1st Experiment, 30 lbs.; 2nd Experiment, 30 lbs.

Bulk of steam, compared with water, 1st Experiment, 882 lbs.; 2nd Experiment, 882 lbs.

1st Experiment—-Therefore 110.8 x 882 = 97,725 cubic feet of steam produced; and 452.39 x 60 x 2137.5 / 1728 = 33,576 cubic feet of steam passed through cylinders,

consequently 33,576 / 97725 = 34.35 per cent.

2nd Experiment—Therefore 122.84 x 882 = 108,345 cubic feet of steam produced; and 452.39 x 60 x 2280 / 1728 = 35,814 cubic feet of steam passed through cylinders, consequently 35814 / 97725 = 31.71 per cent.

Average, 33.03 per cent. of useful effect.

[see in original text Table of Winding Engine, Crook Bank Colliery.]

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Diameter of cylinder, 26½ inches, length of stroke, 4 feet, area of piston, 551.54 inches.

Number of cylinders full of steam, 1st Experiment, 14,663; 2nd Experiment, 14,895.

Average pressure of steam in cylinder, 1st Experiment, 27 lbs.; 2nd Experiment, 23¾ lbs.

Bulk of steam, compared with water, 1st Experiment, 971; 2nd experiment, 1093.

1st Experiment—Therefore 654.56 x 971 = 635,477 cubic feet of steam produced; and 551.54 x 48 x 14663 / 1728 = 224,645 cubic feet of steam passed through cylinders, consequently 224645 / 635477 = 35.36 per cent.

2nd Experiment—-Therefore 636.82 x 1093 = 696,044 cubic feet of steam produced; and 551.54 x 48 x 14895 / 1728 = 228,200 cubic feet of steam passed through cylinders, consequently 228200 / 696044 = 32.78 per cent.

Average, 34.07 per cent. of useful effect.

[see in original text Table of the results of the foregoing Experiments in a tabular form, with the different classification of engines.]

In considering the result of the previous experiments, it will have no

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doubt occurred to the members of the Institute, as it has to me; the extreme difference between the amount of evaporation of water and the quantity of effective steam produced therefrom. The average result is not equal to more than 40 per cent., showing that more than 60 per cent, of the quantity of water, (heated to that temperature which should, with a little increase of temperature, have produced an equivalent quantity of steam,) has been wasted, or has not produced any useful effect. It can only be accounted for by the supposition, that the surplus quantity of water so heated is held in mechanical suspension in the steam, and has passed through the cylinders in the state of water; and that, consequently, all the fuel expended in raising more than 60 per cent. of the water to that temperature has been wasted.

It has been long known, that a considerable quantity of water was passed through the cylinders of a high-pressure steam engine with the steam in which it was in contact; but, before making these experiments, I was certainly not prepared to expect that so large a proportion was so passed through.

Mr. Pambour, in his Treatise on Locomotive Engines, gives the result of several experiments in the waste in those engines, 2nd edition, page 289, which, in seven experiments, he found to be equal to an average amount of 24 per cent.—the maximum being 36, and the minimum 10 per cent.

It is quite evident, that this effect is produced by the peculiar circumstances under which the steam produced in a boiler is conveyed to the steam chest of the cylinders. If the capacity for steam in the boiler is small compared with the constant and rapid requirements for steam, when the cylinders are drawing from the boiler rapid and large quantities, then, it appears, a considerable proportion of water passes off with the steam. When the boiler is full, and there is, consequently, small space, the rapid evolution of the production of steam increases this effect, and then there is carried off a large quantity of water, and the boiler is said to prime, and this is more particularly felt when the water is foul or when a film of scum exists on the surface of the water; this scum being carried off, conveys with it a large quantity of water, which is passed through the cylinders, not only without any practical utility, but resulting in a great waste of fuel, and likewise producing a serious obstacle and diminution to the useful effect of the steam itself.

The ordinary steam engines used at collieries are without any domes to the boilers, and the space above the water line in the boilers, as a

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reservoir for the steam, is very small compared with the quantity of steam currently required for working the engine ; hence we find a very great quantity of water carried off through the cylinders when the engines are at work.

The Experiments, No. IV., were instituted to ascertain the amount on two engines of the ordinary description, used in the North of England for drawing coals to bank, and these experiments were made with great care. From these it will be seen that the useful effect did not average 32 per cent. of the quantity of water evaporated, and that more than two-thirds of the quantity of water evaporated was wasted.

Two conclusions seem to result from these experiments:—1stly. That it is necessary, that there should be adequate space for the steam upon the surface of the water in the boiler in which it is generated, so that, in drawing off the steam into the cylinders, it should pass off with as little velocity as possible, and so prevent the water from being carried along with it; and if there is not adequate space, domes or reservoirs should be used to allow the steam to pass off from the boiler as quietly as possible. And 2ndly. That, inasmuch as all these experiments lead to the conclusion that the capacity of steam for carrying off water is, in some respects, inversely as its elasticity, low-pressure steam carrying off more than high-pressure steam, (and hence the dryness, as it is termed, of high-pressure steam) it will be an economical use of steam to raise the steam in the boiler to a much higher pressure than is required in the cylinders, and to allow it to expand to the requisite elasticity. In this case, when the steam is expanded, the sensible heat of the high-pressure steam being no longer required for the elasticity of the lower-pressure steam, is set at liberty, and evaporates a corresponding part of the water already above the temperature required for the low-pressure steam, into steam, and hence a saving of fuel will be accomplished.

It will also appear, from an examination of the results of these experiments, that there is no practical disadvantage in placing the engine at the bottom of the pit, the boilers being on the surface, or in placing the engine underground, at a considerable distance from the boilers, if, as in some of the cases given, the pipes for conveying the steam be of sufficient capacity, and that they are carefully wrapped with some non-conducting material, to prevent condensation.

The average per centage of useful effect produced by the evaporation of the water in the boilers, it will be perceived, is greater with engines where the boilers are placed on the surface, the cylinders being at the

bottom of the pit, than with engines where the boilers are placed near the cylinders; but this, it is presumed, arises from the causes which have been previously explained, and which do not result from the difference of situation of the respective engines, other than the effect which the accidental position of the boilers placed at a distance from the cylinders may have in producing such a result.

If the waste of steam, by its conveyance down the shaft, is not considerable, it will be seen, on comparing the relative pressures in the boilers and in the steam reservoir near the cylinders, that there is no material diminution of effect in that respect. The general average difference at Heworth is scarcely 1 lb. per square inch, when the pipes conveying the steam are 10 inches in diameter. The same effect was observed at Killingworth, as may be seen in the experiments on the steam jet; there was no perceptible difference of pressure in the reservoir at the bottom of the pit and in the boilers on the surface. At the Black Boy Colliery Engine, where the pipes are 8 inches in diameter, the difference is less than 2 lbs. per square inch, page 311, Vol. III.; and at Andrews House Colliery, though the pipe is only 5 inches in diameter, the difference is not more than 1½ lb., as will be seen in page 308, Vol. III.; but in this case the pit is only 87 yards in depth.

I would beg, however, to notice that, as regards the waste of steam, experiments showing the relative elasticity of the steam in the boiler, and at the reservoir at the bottom of the pit, are not conclusive as to the amount of condensation. For instance, in the case of the Killingworth engine, page 305, Vol. III., the boilers being placed on the surface, the steam was taken down the shaft 690 feet, and then 36 feet to a receiver No. 1, with 10½-inch pipes; and then 36 feet back to the shaft, down the pit 360 feet further, and 34 feet to receiver No. 2. On an examination of the experiments, it will be seen that the average pressure of steam in the boilers, during the whole of the experiment, was 33 lbs.; in the receiver No. 1, 31.21 lbs.; and in the receiver No. 2, 31.12 lbs. Now, it was ascertained that there was no condensation of steam between the boilers and No. 1 receiver, (the pipes being carefully covered between the boilers and the shaft, and the 10½-inch pipes passed down an upcast shaft, where the temperature was very high,) while between the receivers Nos. 1 and 2, there was a very great condensation; (the part of the shaft down which the pipes were taken being a downcast, and being, moreover, a shaft in which water was drawn,) yet, on examination of the pressures in the receivers, Nos. 1 and 2, page 365, Vol. III, it

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will be seen that there is no great practical difference in the pressures of the steam. The explanation being that the area of the pipes was sufficiently large for the transmission of the steam, and that the production of steam in the boilers was sufficiently rapid to keep up the pressure throughout, notwithstanding the intense condensation, a glance at the boiler power and the performance of the engine will illustrate this to a remarkable extent. I may add that an entirely different arrangement is now in operation.

Although it is shown, by the preceding experiments and investigations, that boilers might be placed at considerable distances from the cylinders or engines, and that, if the pipes are carefully protected against condensation, and the pipes are sufficiently large, there is no substantial difference in the elasticity of the steam in the boilers and in the receiver placed near the cylinders at the bottom of the pit. Yet there is a limit to the distance to which steam can be conveyed, depending principally upon the area of the pipes. I speak now of the practicability—the amount of condensation is of an economical character; but the dimensions of the pipes regulate the distance to which steam can be carried without a material or corresponding diminution of elasticity.

I have been favoured with an account of the result of the conveyance of steam down the pit, and to a distance of 1,100 yards therefrom underground. This is at St. Helen's Auckland Colliery, near Bishop Auckland. It appears that when the pressure in the boilers is 40 lbs. per square inch, the working pressure in the receiver near the cylinders is about 8 to 10 lbs. per square inch, 75 per cent. of the pressure in the boilers being lost in forcing the steam through the pipes, which are only 5 inches in diameter. This engine is placed at the extremity of a plane 1,100 yards in length, descending from the bottom of the pit at an angle of 15°, and is used for the purpose of pumping water from the extremity of the plane to the shaft. The cylinder is 32 inches in diameter, 4½ feet stroke, working a double-acting force-pump 9 inches in diameter; length of stroke of each pump, 24 inches, and working 10½ strokes per minute, and forcing 260.19 gallons of water per minute through pipes 5 inches in diameter to the shaft. The engine is worked as a condensing engine. It would appear, from the result of this experiment, that it requires a force of 40 lbs. per square inch to force steam 1,250 yards through a pipe 5 inches in diameter, at a rate of 64.5 feet per second, to keep up a regular supply of steam to the cylinders at 8 lbs. pressure per square

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inch. The engine works equal to 35 horses—the boilers being equal to 78 horses, according to the usual calculation.

I had likewise, a short time ago, an opportunity of making an experiment on the conveyance of steam in pipes of small diameter. The boilers were placed near the bottom of the pit, and the steam conveyed a distance of 1,012 yards therefrom in pipes of 4 inches diameter. The result was, that though the pressure in the boilers was kept up at 35 lbs. per square inch, the steam did reach the receiver at the end of the drift, but when the engine was put in motion, no practical result was obtained, the resistance of the steam when in motion absorbing the entire pressure of 35 lbs. per square inch. Like all elastic fluids, if we have to convey them to any considerable distance in pipes, the pipes must be of an adequate size to produce a given velocity. That steam can be conveyed a considerable distance with very little diminution of power will appear from the foregoing experiments. The amount of condensation will depend upon the care taken in covering the pipes with a non-conducting material.

It will, perhaps, be interesting, while on the subject of producing power to work cylinders at great distances from the mouth or bottom of the pit, to give an instance where this has been done, and at work for several years past, in Scotland, by the transmission of air.

This is an engine which was erected about six years ago at Govan Colliery, near Glasgow, by Messrs. Randolph, Elliott, & Co. It has been at work ever since, and, so far as the purpose for which it was erected was concerned, it has been quite successful. It appears that the Govan Pit is 176 yards deep—the first seam being 92 yards from the surface. In this seam a gallery was driven, 706 yards from the shaft, at the end of which it was found necessary to sink a shaft, 26 yards deep, to work another seam of seal. As a steam boiler was inadmissible at that distance from the shaft, it was proposed to erect a compressing engine on the surface, and to convey air thus compressed to the top of the second shaft, and to erect an engine there, to be worked by such compressed air.

A very interesting paper, giving all the details, plans, &c, of this engine, was read at the Manchester Institution of Mechanical Engineers, by Mr. Charles Randolph, of Glasgow, on the 17th September, 1856, the following being the general result:—

The steam cylinder on the surface, for compressing or forcing in the

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air, is 15 inches diameter; stroke, 3 feet; working two condensing air pumps, 21 inches diameter each ; stroke, 18 inches. The usual speed of the steam engine is about 25 revolutions per minute with a pressure of steam of 18 lbs. per square inch, giving a pressure of air averaging about 20 lbs. per square inch.

The air engine at the second shaft has a cylinder of 10 inches diameter, 18 inches stroke, and also works usually about 25 revolutions per minute. The pressure of the air at this engine being only, as stated by Mr. Randolph, 1 lb. per square inch below the pressure at the compressing engine at the top of the pit, great difficulty arose from the great heat of the compressed air at the engine at the top of the pit, and the great absorption of heat on its sudden liberation at the discharge of each stroke at the lower engine, as well as the bakage of the air in its highly compressed state. These difficulties have been very ingeniously overcome by Mr. Randolph; and the engine is said to have been at work for six years, working night and day, without requiring any repairs in the valves and pumps.

The compressed air is conveyed to the lower engine by pipes 10 inches in diameter, the same as the air cylinder. We thus see that only 1 lb. per square inch pressure is lost in the conveyance of the air; but the quantity of air is seriously diminished, and, of course, the useful effect. The two engines, it appears, make the same number of strokes per minute, viz., 25 each. The relative area of the cylinders is 176.715 to 78.54, or nearly 2 to 1, and the length of strokes is as 2 to 1; consequently their relative power is as 4 to 1, the pressures upon the pistons being the same. The engine on the surface has a pressure of steam of 18 lbs. per square inch, and the air engine 1 lb. less 20 lbs., or 19 lbs. per square inch; so that the effective pressure of air upon the piston of the air engine, is little more than one-fourth of the pressure of steam on the piston of the steam engine.

Taking, likewise, the quantity and elasticity of the compressed air at the steam engine and at the air engine, a nearly similar result is arrived at. The two air-pumps are 21 inches diameter each, with a stroke of 18 inches; the area of the two pistons is, therefore, 692.72 inches; the diameter of the air cylinder is 10 inches—78.54 inches area; but, being double (the air-pumps being only single), the relative area between the air-engine and the air-pumps is as 157.08 : 692.72; and the pressure of air at the air-pump being 20 lbs., and at the engine 19 lbs. per square

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inch, it results that not quite one-fourth of the power is effective. It would be an important experiment, to pass the steam used in the steam engine through the 10-inch pipes to the air-engine, and thus ascertain the effect. The result of the experiments on the steam engine at Killingworth and Heworth would prove that, in all probability, no diminution beyond 1 lb. per square inch would ensue, the former being conveyed 410 yards, and the latter 300 yards; then the only difference would be, the condensation of the steam in the one case, and the loss of power by the elasticity of the air in the other.

[Plate 1. Plan shewing the district of the Magnesian Limestone lying over part of the coal field in the County of Durham.]

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ON THE SINKING THROUGH THE MAGNESIAN LIMESTONE at the SEAHAM AND SEATON WINNING, NEAR SEAHAM.

By NICHOLAS WOOD, Esq.,

PRESIDENT OF THE INSTITUTE.

The sinkings which have been made through the magnesian limestone overlying the coal measures in the county of Durham have been, in some instances, of a most formidable and costly nature. There occurs a bed of sand between the newer formation of the limestone, and the coal measures, which, when of some thickness, and when it lies at a considerable depth below the sea level, has been most difficult to pass through, producing, as it does, immense quantities of water. It could not, therefore, but be extremely interesting and valuable for the Institute to possess all the information possible on such important operations of mining. In my address on the opening of the Institute, I took the opportunity of alluding to this information as most valuable to be obtained by the Society. Mr. Potter has, at the last meeting of the Institute, presented to us a full and detailed account of the sinking of the extremely difficult undertaking at the Murton Colliery, where, probably, the largest quantity of water ever met with in sinking was overcome, as well as the still more difficult task of sinking through a thick bed of sand impregnated with such an immense quantity of water.

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I have, therefore, thought it advisable, before the discussion takes place on that important paper, to lay before the Institute the result of a sinking through the same limestone in a locality about two miles distant from the Murton Winning, which may, I trust, be useful in discussing all the phenomena attendant upon sinking through such strata; and I venture to hope that, as we have in the members of the Institute other gentlemen who have also made sinkings through these measures, they will also, either previously to, or at, the discussion of those papers, favour the Institute with their experience, or with any documents which may have come into their possession on so interesting a subject.

Previously, however, to giving the particulars of the sinking at Seaton it may be advisable to take a rapid glance at the geological position, and character, and connection of this limestone and its associated sand and red sandstone with the coal measures which they overlie in this locality. For this purpose I have sketched out the district where the most important sinkings have been made, from which the details of the operations at the respective winnings will be made more intelligible to the absent or distant members of the Institute. I have likewise had a section made as nearly along the line of the coal measures as could practically be done, where the sinking at Murton and that at Seaton has taken place; such line embracing other collieries where the limestone has been difficult to pass through; and I have also made two cross sections, where it appeared to me desirable to do so, in order to more clearly show the position of the limestone, and its connection with the unconformable coal strata underneath. These, I trust, may be useful, as well at this time as on the discussion of any future operations in this locality.

With the assistance of this plan and sections, I shall now endeavour to point out generally the position of the overlying limestone, and its connection with the underlying coal measures.

Commencing at the northernmost extremity of its occurrence in this district, we find a small patch of the limestone and accompanying red sandstone, reposing upon the depressed strata of the coal measures of the great downcast dyke to the north, on the banks of the sea, and for a short distance inland to Whitley, near Cullercoats. And it is, perhaps, necessary to remark, that this dyke or fault, which is called the Ninety Fathom Dyke (though in some parts of its course it is double this throw), passes through the coal and associated beds from this point westward to the extremity of the coal measures and beds of the carboniferous series of rocks in Cumberland, to the escarpment on the edge of the plain of

[Plate II Section of the Magnesian Limestone]

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the Carlisle red sandstone beyond Tynedale Fell; and it may be added that, though the beds of the magnesian limestone are not by any means conformable with the beds of the coal measures, the former are not horizontal, but have clearly had their original position disturbed by the dyke.

Proceeding southwards, from Cullercoats, a cap of magnesian limestone exists on the promontory at Tynemouth. The debouchure of the Tyne then occurs, and we do not find the limestone until we reach a point about a mile south of that river. From thence along the sea coast to the extent of our investigation the limestone forms the cliffs of the sea, except where it has been washed away at the mouth of the river Wear. The Section No. 1., Plate II, will show that, from the cap of limestone at Tynemouth to the extremity of the range at Castle Eden Colliery, the beds of limestone and sand become more depressed, or have a regular dip from the north to the south;—that, whereas at Tynemouth the bottom of the limestone beds is fifty or sixty feet above the level of the sea; at Castle Eden Colliery, which is a considerable distance inland, and consequently more to the rise of the beds, the bottom of the limestone is 270 feet below the level of the sea; and at Seaham Harbour a boring was made close to the sea, and which was bored to the depth of 336 feet without reaching the bottom of the limestone beds.

The Cross Sections Nos. 2 and 3, Plate II, show the position of the limestone beds in lines nearly at right angles to the line of the Section No. 1. From these it will be perceived that, there is a regular rise of the beds towards the west. The water level line of the beds from the mouth of the Tyne to Ferry Hill being nearly S.S.W.; the full rise N.N.W. At this point a change takes place in the line of escarpments of the limestone: the direction, for some distance, is nearly west towards Bishop Auckland, and it is worthy of remark, as bearing upon the subject of this inquiry, that this is nearly in the direction of a slip dyke of considerable magnitude, as will be seen by an inspection of the map, Plate I. Proceeding southwards, the geological maps show the limestone reposing upon the edge of the coal strata, until the latter beds rise out of the basin to the surface; then upon the lower edge of the millstone grit formation, where those beds are not elevated much above the level of the sea, until it reaches the Yorkshire coal measures, along the eastern edge of which it then reposes for a considerable distance southwards.

In all this distance, the limestone beds are not raised much above the

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level of the sea, at least compared with the more elevated strata of the millstone grit or limestone and sandstone beds of the carboniferous series. But it is requisite to observe that, along the whole course of its route, the line of elevation of the limestone is from the sea towards the west. Thus, taking the Sections Nos. 2 and 3, Plate II, it will be seen that, from the Murton Winning to the Moorsley Pit at Rainton, the elevation is upwards of 590 feet, in a distance of 3½ miles, and from Castle Eden to Kelloe, a distance of 5 miles, 620 feet; and this, it will be observed, is, as nearly as can be, at angles to the range of the elevated hills of the carboniferous series, or to the great Pennine chain of hills, the protrusion of which has formed the physical features, character, and position of the strata, and hills of this district.

Although, therefore, there can be no doubt of the uncomformable character of the limestone beds, as regards those of the coal measures on which they are deposited (shown by the sections accompanying this paper); there is as little doubt that the elevation of the limestone beds to the west, has been produced by the same causes which elevated the underlying strata, and probably at the same period.

If we arrive at this conclusion, then an important consideration arises as regards the particular character of the junction of the lower beds of the deposit of the limestone and red sandstone with the upper surface of the beds of the coal measures. And this is of considerable importance in the present investigation. It is well known that a bed of sand occurs at the bottom of the limestone beds, resting on the upper surface of the coal measures; and that this sand contains the great feeders of water met with in sinking through the limestone beds to the coal measures, The deposit of magnesian limestone, being of marine origin, must have been originally deposited horizontal; the bed of sand covering, perhaps, the surface of the coal measures on which the limestone was deposited. If the upper surface of the coal measures had been level, or nearly so, this sand would probably have been somewhat of an uniform thickness; but if the upper surface of the coal beds were left by their denudation in a rough, undulating, or broken state, then we might be prepared to find the sand of very uneven thickness, which corresponds, generally, with experience. Still we would suppose it to be somewhat continuous, and by filling up the hollows and forming a level surface, that the limestone beds would be deposited level upon it, or that the bottom of the limestone beds would be nearly level and uniform; and that, under those circumstances, there would be reason to suppose that the feeders of water

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would find their way from great distances, and in large quantities, when an opening was made to the sand; always supposing, of course, that such opening was made at a considerable depth below the level of the Sea, and that it had communication with this bed of sand.

But then, another important consideration arises, seeing that the elevation of the limestone beds has been supposed to have been produced by the upheaving or protrusion of the Penine chain; and that this elevation was contemporaneous with the elevation of the coal beds, and that at least some of the dykes of the coal measures have been produced by such upheaving; is it likely, therefore, that similar dislocations would take place in the beds of the limestone, or that the dislocations of the coal beds would extend through the beds of the limestone? As if so, and this is my object for going so fully into this investigation, if the slip dykes of the coal measures extended into, and dislocated the beds of the limestone; then such dykes or slips would form, as it were, isolated barriers to the water in the sand; and we should have, in some localities, accidental detached portions of the limestone, separated by such dykes, and within the area of which little water would be found.

In corroboration of this view of the case, we see, the patch of limestone resting against the uplifted side of the great Ninety-fathom Slip Dyke at Whitley, near Cullercoats, as shown in Section No. 1. We see also, that the line of escarpment of the limestone, in the vicinity of Ferryhill, following, as nearly as can be, the line of the Forty-fathom Slip Dyke; and we know that it was proverbial, at one period, that there was no coal underneath the magnesian limestone, subsequently ascertained to have been produced by the broken and interrupted nature of the coal measures in approaching the escarpments of the limestone, and showing, not that the coal strata, as it might have been expected, was effected by the deposit of limestone, but that the deposit of limestone was effected by the breaks and dislocations of the coal strata. And we also know, that basaltic dykes, (which in some places in their course, form slip dykes), traverse and cut through, without any deviation in their direction both the coal measures and the magnesian limestone indiscriminately. All these prove that the magnesian limestone beds, are disturbed by the dykes and dislocations of the coal beds.

Whether, however, the isolation of particular areas or districts of limestone, and the continuancy of the sand beds and water, was or was not occasioned by the irregular deposit of the sand and limestone upon the uneven or broken surface of the denuded coal measures; or, that

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such insulation has been occasioned by the subsequent disruption of the limestone beds themselves, we know that in some sinkings through the sand, much less thickness of sand, and much less water has been met with in some localities than in other localities; and that in very short distances apart, for instance at Haswell Colliery, (the particulars of which I trust we shall obtain when the question comes on for discussion,) we know that a sinking at one place, proved large feeders of water, and a thick bed of sand; while at a very short distance therefrom, a comparatively thin bed of sand, and small feeders of water were found.

It is necessary now to give a short description of the nature of the beds of this deposit. Immediately below the soft marl covering the superior surface, the upper beds are extremely cavernous and scarcely, stratified at all; they seem to be formed of large masses of porous rock, with caverns filled with marl and sand. The lower beds, however, are compact, stratified, generally thin, but sometimes of considerable thickness; and in some cases extremely hard and more compact, and more impervious to water, than some of the compact sandstones of the coal measures. At the bottom of these beds there almost invariably occurs, as previously stated, a bed of sand or sandstone marl. When met with in sinking, where dry, it is often extremely hard, and so consolidated as to require blasting with gunpowder; but, when saturated with water, it acquires all the characteristics of a quicksand; being held in suspension with the water, is drawn up the pumps while sinking; and unless prevented in sinking through it, the sand flows into the pit, and caverns are formed all around the shaft, for considerable distances therefrom, of a height equal to the thickness of the bed of sand. It is no wonder, then, that there are such difficulties in sinking through such a material; and the case of Murton, by Mr. Potter, is perhaps one of the most difficult ever met with, the details of which the Institute has been favoured with, by that gentleman.

Having had the management, conjointly with the late Mr. Buddle, and afterwards with the late Mr. George Hunter, of sinking two pits through this bed of limestone, which now form the Seaham and Seaton Collieries, belonging respectively to the Marchioness of Londonderry and the Hetton Coal Company; I beg to lay before the Institute the particulars of such sinkings, and I must here apologise for trespassing to such an extent by the preceding observations, which, however, I deemed necessary to explain the reasons why a different system of operations was adopted at the Seaham and Seaton winning, than at Murton.

[Sketch shewing the application of engine power at Seaton Winning. Plate III]

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I have already remarked that the upper beds of the limestone are very cavernous and marly, but that the lower beds are compact, the stone itself being extremely hard and impervious to water, except where broken or split by cracks or slips in the beds. After having had three borings made to ascertain the thickness of the sand, and after considerable discussion and consideration, as to the possibility of meeting with an insulated spot, protected from the general flow of water by surrounding slips or dykes, and relying on the practicability of tubbing back the water of each bed of the compact limestone, wherever a moderately good foundation for tubbing could be obtained, a system of tubbing was adopted, and which was carried out in the following manner, and with the following results.

It will be seen by the map of the district, Plate I, that this winning is to the dip of the Murton Winning, both as regards the limestone and sand, and also the coal measures; and as the water of the latter winning had been entirely tubbed back, and being only distant about two miles, there was great apprehension of meeting with large feeders of water.

Three boreholes were, therefore, put down, as previously stated, to endeavour to find a spot where the sand was not thick. Fortunately, one of the holes proved the sand only three feet in thickness, in consequence of which it was decided to sink upon this borehole.

The level of the top of the pits is about 240 feet above that of the sea, and the upper bed of limestone being, as before stated, very marly and cavernous, the water was found at the level of the sea, or at the depth of 38 fathoms.

Plate III. will show the arrangement of sinking determined upon. The pit was fourteen feet diameter; no pumping engine was erected, but the two winding engines were adapted for pumping, as shown on the plan. The cylinders were each sixty-six inches diameter, seven feet stroke, condensing engines, the rope rolls twenty feet diameter, and the fly wheel twenty-six feet diameter, and weighed eight tons. These engines were therefore 150-horse power each. To each of the engines, as shown in the sketch, a pumping beam was attached, thirty-six feet long, and of proportionate strength, to work a series of sets of pumps with a nineteen-inch working barrel.

Two staples, shown on the plan, each six feet diameter, as well as the pit, was first of all sunk to the level of the water thirty-eight fathoms, and securely walled. The depth to the bottom of the sand was ascertained to be sixty-eight fathoms, and supposing that probably eight

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fathoms would have to be sunk further; one set of pumps at one end of the pumping beam in the staples, thirty-eight fathoms, would therefore just balance the other set of pumps, in the pit, to the depth at which it was expected the water might all be tubbed back, viz., seventy-six fathoms; and supposing the engines to work at a moderate speed, say sixteen strokes per minute, would give nearly 2,000 gallons per minute.

All having been prepared to sink, the one set of pumps was put into one of the staples, and one set only of one engine in the pit, and the sinking was commenced on the 12th August, 1845. Water was met with in sinking below the sea level, and at a depth of seven fathoms below the thirty-eight fathoms or sea level, or forty-five fathoms from the surface, the first wedging crib, No. 1, was laid on the 3rd October. The water had at that time reached 720 gallons per minute; this wedging crib and tubbing stopped back 480 gallons per minute, leaving a feeder of 240 gallons per minute.

The sinking was then resumed, and at the further depth of four fathoms two feet, another wedging crib, No. 2, was laid on November 7; the water having increased to 540 gallons per minute, 510 of which were stopped back, leaving thirty gallons only to contend with.

Sinking continued, and at two fathoms five feet another wedging crib, No. 3, was laid on the 22nd November, the water having increased to 660 gallons per minute; 510 gallons were stopped back, leaving 110 gallons per minute.

Soon after this wedging crib was laid, the water increased, and on the 11th December, three fathoms three feet was reached, when the water was 660 gallons per minute, besides 300 gallons plugged back in the borehole; another wedging crib, No. 4, was therefore put in on the 22nd December, when the water was 960 gallons, and which stopped 870 gallons, leaving 90 gallons per minute.

The limestone now became exceedingly hard and compact, so much so, that the sinkers could only sink about six feet per week, and discharging a great quantity of water. At the further depth of three fathoms one foot five and a half inches, another wedging crib, No. 5, was laid; this had the effect of stopping back 660 gallons per minute, leaving sixty gallons per minute only to contend with.

After the last crib was put in, viz., on the 23rd January, it was found, on the 25th February, when the pit had been sunk three fathoms two feet further, the water had increased to 1,020 gallons per minute. Another wedging crib, No. 6, was put in; this wedging crib stopped

back only 480 gallons, leaving 540 gallons per minute to contend with— this crib being sixty-three fathoms from the surface, twenty-five fathoms from the level of the water, and five fathoms from the top of the sand. The limestone had now become less compact; a considerable number of fissures or guile is was found, which prevented the complete stopping back of the water; and the water increasing to 840 gallons per minute, serious thoughts were entertained of providing more pumping power. It was, however, determined to proceed to lay down another wedging crib. Accordingly, another wedging crib, No. 7, was put in, which stopped back 600 gallons of water, the depth below the other crib being two fathoms and three inches. This was done on the 6th March, 1846, leaving 240 gallons per minute to contend with.

On the 25th March, the water having increased from 240 gallons to 390 gallons per minute, another wedging crib, No. 8, was put in, one fathom one foot below the other, which had the effect of stopping back 270 gallons per minute, leaving from the tubbing 120 gallons per minute, and from the bottom 30 gallons per minute.

The last wedging crib being only 4½ feet from the top of the sand, which, on one side of the pit, as proved by the original borehole, was only three feet in thickness, and having only 150 gallons of water to contend with, preparations were made to pass through the sand. It was thought advisable, in doing so, to put down several boreholes, through the shell of strata which now intervened between the bottom of the pit and the sand, to test the quantity of water in the sand. This mode of proceeding was adopted, in order that, if the feeders turned out to be greater than the engine could draw, the boreholes could be plugged up, and further power might be applied—the other engine being, as well as two other sets of pumps, ready to put in, if occasion required. The result, however, of the borings of six holes put around the pit, proved that the water was only increased to 480 gallons per minute. This fact being ascertained, and the quantity of water being much within the power of one engine; it was determined to pass through the sand with one engine, as expeditiously as possible.

Accordingly, on the 28th March, 1846, the sinking was again resumed, the intervening strata taken out, the sand passed through, and a wedging crib, No. 9, laid on the upper bed of the coal strata, on the 11th April, 1846, three fathoms one foot below the last crib, without encountering any difficulty, the amount of the feeders of water not exceeding 480 gallons per minute, as shown by the boreholes.

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The foundation of this wedging crib not being of a satisfactory nature, though sufficient for the current occasion, as 360 gallons per minute, out of the quantity encountered in passing through the sand, viz., 480 gallons was stopped back. The sinking was then continued, without meeting with any more water of consequence, to one fathom three feet further, when another crib, No. 10, was laid down; and then six fathoms further, to an excellent foundation, where three wedging cribs were put in, as the base of the entire tubbing in the shaft. The tubbing was then carried three fathoms further down, to protect the main foundation cribs; and the sinking through the coal measure commenced, without a drop of water in the bottom.

The following table will show the quantity of water met with, the quantity tubbed back at each of the wedging cribs, and the quantity of water left to commence sinking again; together with the distances between each wedging crib:—

[see Table in original text]

It will be seen from this table that the total quantity of water which the engine had to contend with, at the different periods of the operation, was 6,240 gallons per minute; that the total quantity which the wedging cribs failed to stop back was 1,360 gallons per minute, or an

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average of 136 gallons per minute at each of the wedging cribs; and that the total amount of water which was tubbed back before entering the sand, together with the sand feeders, was 4,880 gallons per minute; and which would have been the quantity required to have been raised, or pumped to the surface, if no water had been tubbed back.

It now remains to be explained why so successful an operation was performed. It arose from two causes:—

1st.—The successful operation of being enabled to keep up, or tub back, all the feeders of water in succession in the several beds above the sand. And

2nd.—From the small quantity of water in the sand.

The first of these causes cannot be considered as appertaining to this particular locality only; its success depends entirely on the nature of the beds of limestone met with. The lower beds of the limestone were, however, much the same as those throughout the whole of the district; and, when free from fissures or gullets, forms just as good foundations for tubbing, as any of the beds of the coal measures. And it must be considered, also, that though a large quantity of water may pass through the foundation of one wedging crib when no counteracting pressure is brought against such leakage, during the time of sinking to another foundation; yet, when another wedging crib is laid, and a pressure is thus thrown against the leakage of the preceding one, such leakage is either altogether, or, probably, nearly stopped; and, therefore, though each of the foundations may be separately bad, yet, when brought to bear in support of each other, a large proportion, if not the whole, of the water may thus be stopped back.

I am well aware that the occurrence of fissures, broken or cavernous strata, may render such a mode of proceeding abortive, as at Harton Colliery, wedging cribs were put in throughout a depth of seventy fathoms in like manner; but which, the occurrence of a slip or fissure running downwards within the area of the shaft, rendered entirely abortive, until the strata became firm and compact. Still I am of opinion that, in many cases, it will be found to be useful to adopt the same system as that which has been so successfully pursued, in the case of the Seaham and Seaton Winning.

With regard to the second cause of success. It was found on entering the sand, and previously thereto, that though the limestone beds were stratified and comparatively compact, yet that they lay at a considerable

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angle; so much so, that there were only three feet of sand on one side of the pit, and fourteen feet six inches on the other. This distortion or dislocation of the beds was, no doubt, occasioned by one or other, or, probably both, of the causes which I have, in the previous part of the paper, endeavoured to investigate. It has either arisen from the irregular or uneven base or surface of the coal measures, on which the limestone and sand had originally been deposited; or it may have arisen from the effect of dislocation in the coal measures and superimposing limestone beds, when they were jointly raised from a horizontal position to that which they at present occupy; or it may be from a combination of both operations. Certain it is, that the free and uninterrupted flow of water, from the great ocean of sand and water, lying underneath the limestone beds of the district generally; was prevented, by the isolation of this particular spot of ground, from flowing freely into the perforation or pit sunk through them. And I may explain, in corroboration of this, that since the seam of coal was reached, it has been found that the pit was almost surrounded with slip dykes, which were found to cross the shaft in different places in sinking. All this tends, in my opinion, to the belief that, the lower beds and sand of the limestone, is effected by the slips and dislocations of the coal measures; and that, in this case, we were indebted to that cause for the success of the second part of the operation.

I may add, that since the first pit was sunk to the coal, another pit has been sunk, about 200 yards distant from the one, the subject of this paper, with a similar result. The following statement showing the quantity of water which was tubbed back at the different wedging cribs:—[see Table in original text]

[Plate IV. Sketch shewing the tubbing at Seaton Winning.]

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The circumstances under which the sinking of the second pit was pursued, were so precisely similar to those of the first, that it is quite unnecessary to give them; but they certainly corroborate the supposition that, it is perfectly practicable to so dissever or separate the various feeders of water, contained within the limestone and sand, as to accomplish a sinking through these beds, with an amount of engine power, very considerably less than would be required, if the aggregate feeders were obliged to be contended with.

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NORTH OF ENGLAND INSTITUTE of MINING ENGINEERS

MONTHLY MEETING, THURSDAY, MARCH 5, 1857, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

Nicholas Wood, Esq., President of the Institute, in the Chair.

The Secretary having read the minutes of the Council, the meeting proceeded with the election of the following gentlemen as members of the Institute:—Mr. T. G. Hurst, Backworth Colliery; Mr. Joseph Holdsworth, Edinburgh; Mr. Richard Matthews, South Hetton; Mr. William Prosser, Mineral Surveyor, Llanelly, South Wales; Mr. John Harris, Woodside, Darlington; Mr. Joseph Whitwell Pease, Woodlands, Darlington; Mr. James Willis, Crook, Darlington; Mr. John Trotter Thomas, Coleford, Gloucestershire; Mr. William S. Clark, Aberdare, Glamorganshire; Mr. William Horsley, jun., Seaton Cottage, Hartley; Mr. John Maude Ogden, Sunderland.

The President said, the only business before them was the paper by Mr. Thomas J. Taylor; but he begged to say that, before reading it, there was another subject to which he would take the liberty of calling attention, viz., the proposed Mining College, as he thought the time had arrived for taking active measures to ascertain whether or not they could accomplish its establishment. He had previously discussed the matter with some of the committee, and they thought the very melancholy accident which had recently happened in Yorkshire would tend to show, more than any arguments, the great use, and, indeed, the absolute necessity of such an institution. It was a fact, appreciable to every one connected with that district, that it would be extremely desirable if a larger number of persons, of superior education and more extensive

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practical knowledge, could be obtained for the management of the collieries. He, however, did not mean to insinuate that this circumstance was the cause of the present lamentable accident; but, notwithstanding, it was well known that, in seeking out for a suitable staff for the opening out of a mine, the greatest difficulty was experienced in obtaining parties qualified for such an office. It was quite clear to all conversant with mining operations, that there was a great want of better educated practical persons than at present existed—persons with more ability and experience to grapple with the increasing difficulties of their profession. Under these circumstances, they were of opinion, that the present time was a favourable opportunity for bringing the claims of the Mining College once more before the country, and to impress upon the Government that they ought to take the subject up, with a view of having it established in some part of the country. Without wishing in any way to interfere with the mode in which Government might deal with the subject, they thought that, in addition to what the Government might think fit to appropriate to such an undertaking, it might be desirable that a small tax should be levied upon coals, with the object of raising sufficient funds. If, for instance, they could get as much as one farthing a ton upon the quantity raised in one year, and which, according to the estimate of Mr. Hunt, was about 64,000,000 tons, they would at once perceive that a large sum from this source alone might be obtained towards the establishing of the College. But without discussing, at present, the particular mode by which the requisite funds should be raised, there could be no doubt as to the necessity for immediate steps being taken to organize some well digested plan to, in the first instance, submit to Sir George Grey, the Home Secretary, to ascertain what Government would do. He (the President) had had some conversation with Mr. Morton, the Government Inspector of Mines for the Yorkshire district, and he was glad to say that that gentleman fully coincided with him in reference to that district, in the great desirability and, indeed, necessity of a Mining College, to promote the education of parties intending to devote their talents and industry to mining operations. He also further understood Mr. Morton to say, that he would make a representation to the Government in favour of the object; and if he did so, he (the President) hoped that the other Government Inspectors of the country, if they were of the same opinion, would take the matter up in a similar way. There could, he thought, be little doubt that such a recommendation would have great weight

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with the Government; and if their views harmonized with those of Mr. Morton, a recommendation coming from such a body—standing, as it did, between the public and the coalowners—could not fail to influence the Government in the promotion of such an object. If the want of such an institution did really exist, it must be known to them especially; and that being so, it was incumbent upon the Government Inspectors of Mines to express their opinions upon the matter. In conclusion, he begged pardon for detaining them so long upon this subject; but his experience had led him to conclude that, unless the most strenuous and unremitting attention was paid to the subject, and its necessity constantly kept in view, they would not succeed.

Mr. Atkinson thought a meeting would be a suitable mode for bringing the subject before Government by the Inspectors; but he thought all would agree as to the propriety of not meddling with the locality in which the College ought to be erected. The point to which they must adhere was simply as to the necessity of the establishment.

Mr. Dunn suggested that, in addition to the establishment of the College, the question of a benefit fund might also be considered. Mr. Atkinson thought that was a separate question. The President considered it not expedient to mix the subject up with anything like a benefit fund; yet, as the College would be for the benefit of the public at large, the contribution should either be from the public at large, or from the general body of coal and mining interests of the country, and by those manufacturing and commercial establishments interested in the economical production of such articles, or from both united. What was at present proposed to be done was to give instructions to the committee, intimating that the members of that Institute wished them to forthwith take active measures to bring the subject before the notice of Government. Without any further observations he would, therefore, submit the following resolution to the meeting:—

"That, as circumstances of various kinds seem to indicate this as a favourable time for bringing the subject of the establishment of the proposed Mining College under the consideration of the Legislature, the Committee be now requested to take immediate steps to bring the same before the Home Department of Her Majesty's Government, by means of a deputation or otherwise, and to adopt such further means as may seem desirable."

The motion having been seconded and put to the meeting, it was carried unanimously.

The Secretary then read Mr. T. J. Taylor's Paper, "Suggestions towards a less Local System of Draining Coal Mines."

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SUGGESTIONS TOWARDS A LESS LOCAL SYSTEM OF DRAINING COAL MINES.

BY T. JOHN TAYLOR.

There are certain circumstances, the inconvenience of which is hardly experienced in the first working of the mines of a country, but which operate with more mischievous effect as portions of the mining field become progressively exhausted. I allude particularly to the injurious and often fatal consequences of suspended drainage. The cost of such drainage is always an inducement to discontinue it, if found practicable to do so; and thus it happens that, where an upper seam is worked out, it has become, or is fast becoming, almost a rule in our district to dam back its feeders; this being done with a view not merely to save the lifting of those feeders, but also to secure the immediate tract of mining ground which is being worked against the possible influx of water from other royalties whose drainage has been discontinued.

The entire process thus results in the creation of a deep lake overhead, beneath which the future mining operations of the country are to be conducted.

This, it is conceived, is a risk which ought only to be submitted to when it cannot be avoided, as in the working of coal under the sea, or under estuaries—a subject upon which it would be very desirable to have the experience of one of its vice-presidents, Mr. Anderson, laid before the Institute, especially as it has not been determined at what depth coal can be safely worked away beneath overlying water, where there is

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no protection from an impervious alluvial cover. Nor is it easy to assign the limit of security; for it will be recollected that a single fissure of the numerous ones which have been caused by disturbances in our coal fields may bring down the water, the condition being that such fissure is sufficiently open for the purpose, under the pressure to which the water is subjected. Where, then, are we to assign a point of security thus dependent, to a great extent, upon accidental circumstances over which we have no control? Possibly, where there are thick intervening shale beds, a certain extent of coal may be successfully worked; but is this immunity certain to continue? I am here assuming, as a principle, that all the coal is to be removed; for it is obvious that to incur a large sacrifice of mine for the sake of safety is an alternative which cannot at this day be entertained.

In the district eastward of Newcastle, which is intersected by the Tyne, and bounded on the north by the Main Dyke, and on the south by a supposed line which may be drawn at a mile or a mile and a half from the river, there are the following beds of coal, the depths of which are given as found at Wallsend, being a central part of the basin:—[see in original text Table]

Of these the High Main is nearly worked out within the basin; the Bensham has been partially, but not extensively worked and so little of the remaining seams has been extracted that they may, practically speaking, be considered entire.

The time has then arrived for working the lower beds after the exhaustion of the valuable high main. If we bar off the High Main, then the metal coal and yard coal cannot be safely worked. And it would be rash to affirm that even the Bensham pillars could be removed consistently with security. The right course is to keep the High Main waste free from water by lifting the feeders to the day; and in the case of Wallsend and Willington Collieries the adoption of this course has been accordingly recommended in a recent report written by the President, Mr. Forster, and myself.

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In the case cited it was requisite to make provision, not merely for lifting the proper colliery feeders, but also to prepare for the possible influx of water from what may be called the lake collieries—those, namely, which have the dammed-up water of the upper seam lying above their present workings. It became necessary, then, to provide against the consequences of a too close proximity to such dangerous neighbours, and, still keeping the principle of lifting the High Main feeders in view, it has been recommended to put in tubbing at the High Main, leaving in it an aperture to enable the High Main water to come home to the pumping engine, with a stop valve which may be closed in the event of a sudden rush of water, or of a more gradual increase to the extent of overlaying the engine power.

Such is the condition of a part of our coal field adjoining a great shipping port, and such are the expedients that must be had recourse to for the purpose of meeting a state of things which cannot be contemplated without both alarm and vexation. It might almost be imagined that the steam engine is not yet invented, and that the science of mining is retrograding instead of progressing.

No doubt the expense of contending with water, the miner's greatest enemy, is considerable, even to the overburdening of some individual collieries. But this is a question of distributive rather than of aggregate cost. I have before me several statements of the actual expense of lifting water from our mines, and find that it amounts to very nearly a farthing per ton of water upon a standard depth of ninety fathoms. This includes all current charges, but not interest or redemption of capital. The engines, boilers, and pump work are, of course, assumed to be in good working condition, with no more than an average liability I to accident and interruption.

We are accustomed to regard the position of a colliery as an isolated one, and are told that we must protect ourselves by barriers. But in reality we do not, and have not thus protected ourselves. In proof of this we may ask, why is the High Main seam being tubbed off in so many collieries of this immediate district? Certainly much more from an apprehension of an influx of water from adjoining collieries than for the purpose of being freed from that proper to the colliery itself. If the latter had been the only cause of alarm, there would have been few cases of the hermetic process described. Our actual position is, it seems, the worst that can be, for we have neither the barrier security nor the drainage security.

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But admitting, for the sake of argument, that efficient protection resides in an amended barrier system, let us inquire into the true character of that system. I am not sure that any member of the Institute has endeavoured to calculate the extent of barrier required to isolate the several royalties which make up the aggregate of our Durham and Northumberland coal field. But the result, when stated, will, I dare say, startle most of the parties now present as much as it has done myself. I have taken from Bell's plans plots in various parts of the coal field—some with very large royalties, others with those that are medium sized, but none that is too small to form by itself a fair working tract—and have found that, as an average result, each acre of coal field requires very nearly half a chain length of barrier for each seam. Now there are—as nearly, perhaps, as we can approximate to the fact—about 455,000 acres of coal field, representing 227,500 chains of barrier, and this number of chains is equal to 2,844 miles for one seam only.

Supposing barriers to average forty yards in width, this gives fourteen acres to a mile, and on an aggregate mean thickness of sixteen feet of coal throughout, the quantity contained in a mile of barrier is 7,200 tens, the rent value only of which, at 15s. per ten on the gross produce, is £5,400 per mile.

Such is the costly nature of the protection on which we profess to rely. I do not state the gross sum, because it is obviously to be spread over the entire term of existence of the trade; but the elements of the calculation are strictly applicable to ourselves. The gross annual quantity of coal raised in these counties—fifteen millions of tons—requires to produce it 2,500 acres of a four feet seam, the length of barrier corresponding to which is 1,250 chains, equal to sixteen miles; and, at forty yards wide, this is 224 acres thus yearly and irrecoverably sacrificed to the barrier system. The water, it will be recollected, is to be lifted all this time, and will continue to be lifted, except in rare cases; for, as already stated, it is not the feeders proper to a royalty that really give rise to the tubbing system, but the apprehension of encountering the general feeders of the district.

There are thus two accumulative causes of expense entailed upon the present system.

1st.—The costly barrier sacrifice.

2nd.—The expense of lifting water, which, as above explained, is not diminished by the barrier system, and of lifting that water in a divided, and, therefore, most expensive manner.

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Now, the object of the present suggestions is to draw the attention of the Institute to the subject, with a view to save, if practicable, the loss incurred under the first head, and also, by concentrating the application of drainage power, to diminish its expense. The discussion which is to take place in the ordinary course upon this paper will, at all events, elicit facts and opinions which may be highly useful.

It will be observed that the arguments for a less local system of drainage are not made to rest merely upon a danger or assumed danger from overlying or adjoining collieries, but that the subject is placed upon a much wider basis, the comparative cheapness, namely, of such a system, both abstractedly, and especially when taken in connection with the barrier sacrifice. The argument cannot, therefore, be met by the usual objection, that these and similar questions are ones of time and progress. On the contrary, the object sought to be attained is one of immediate economy, as well as of safety and right engineering practice.

I shall conclude by giving the outlines of a plan projected by myself some time ago for the drainage of the coal district between Newcastle and Tynemouth.

The aggregate feeders of this part of the basin are estimated at 4,060 gallons per minute.

It would be right to lift a part of this water in the rise portion of the basin, with a view to save depth, and consequent expense. For this purpose Tyne Main Colliery is well situated; and at this point 1,400 gallons per minute might be lifted, leaving 2,600 gallons to be lifted in the other portions of the basin.

Keeping the same principle in view, of not lifting the water from a greater depth than necessary, a second engine might be placed at—say Wallsend—to lift 1,300 gallons per minute, from a depth of say 100 fathoms. For this purpose an engine of 240-horse power would be required.

A third station would be the Howden Pit, Percy Main Colliery, which is very nearly the lowest point in the basin. Here 1,300 gallons per minute would have to be lifted from a depth of 135 fathoms, requiring an engine of 320-horse power; but with a view to provide for a possible, though not probable, increase of water, and also to enable the waste water to be lifted out in a shorter period, it is proposed to place two engines on this pit, each of 250-horse power.

These four engines would lift from the high main, below which the feeders are inconsiderable, and could, it is assumed, be kept down by

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means of the winding engines with water tubs. The engines would be placed on pits already sunk; and the expense of constructing them, with houses and pumping apparatus complete, may be estimated, including contingencies, at £32,000.

The rent value of an acre of Bensham Seam five feet high, allowing one-eighth for loss, and reckoning 20s. per ten on round, and 10s. per ten on half of the small produced, is £97.

Therefore the rent value of 330 acres of Bensham seam only (exclusive of other seams), would be equal to the cost of constructing the engines.

A barrier of forty yards around a single royalty of 900 acres comprises an area of between seventy and eighty acres, the rent value of which is between £7,000 and £8,000. It is calculated that, in the aggregate, about 114 miles in length of barrier, in one seam only, will be required to enclose the several royalties in this district; and supposing the barriers to be forty yards in thickness, the aggregate area of coal thus sacrificed is 1,660 acres, the rent value of which, in the Bensham Seam, is £161,020; and if this be doubled for other seams, the amount sacrificed is £322,040.

The foregoing calculations do not comprise any amount for lessees' profit.

On a consideration of all the circumstances, it appears equitable for the lessors to incur the cost of erecting the engines, the lessees afterwards keeping them in operation.

As regards the distribution of the expense amongst the lessors, the High Main seam may be regarded as exhausted in the district; but a large proportion of the Bensham, and nearly the whole of the other seams, remain unworked. As all have, therefore, within the limits assigned, a direct interest in the measure, it does not appear necessary to calculate minutely the quantity of workable coal in each individual case, but rather to simplify the subject, by assuming proportions corresponding with the surface extent of the respective royalties, unless a special reason be given to the contrary in any particular case.

A line drawn northward from Newcastle to the Ninety-fathom Dike, thence following the course of the Dike eastward, thence passing southward by the outcrop of the High Main to the Tyne, thence crossing the Tyne, and comprising within its southern boundary the royalties of Hilda; Jarrow, Hebburn, Heworth, Tyne Main, and Felling, comprises an area of above twenty-six square miles, or about 17,000 acres.

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The cost, therefore, to the lessors would be at the rate of 37s. per acre, on the respective extents of royalty. This would be, for a royalty of

400 acres.................... £740

600 „ 1,110

800 „ 1,480

The cost of keeping the engines going is estimated at £8,800 a year; which might be divided in the proportion of the vends of each colliery. The round and small coals vended from the district would probably be about 350,000 chaldrons yearly, upon which the above cost of £8,800 a-year is equal to 6.03d. per chaldron.

The foregoing is an outline of an undertaking which, if carried out, would, it is conceived, greatly benefit the district, as well as the parties directly interested. The particular details and development might, it is suggested, be worked out by the viewers of the lessors acting in concert; and if a satisfactory result be arrived at by them, a meeting of lessors (to whom it is thought the initiative properly belongs) might be afterwards held, to discuss and determine upon the entire project.

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NORTH OF ENGLAND INSTITUTE of MINING ENGINEERS.

Monthly meeting, Thursday, April 2, 1857, in the rooms of the Institute, Westgate Street, Newcastle-upon-Tyne.

Nicholas Wood, Esq., President of the Institute, in the Chair.

The Secretary having read the minutes of the Council Meeting,

The President called attention to a present of books from the Manchester Literary and Philosophical Society, for which he proposed a vote of thanks, and which was carried unanimously. The President then referred to a minute of the Council having reference to the proposed College for Mining and Manufacturing Purposes, and said that the Council were engaged in drawing up the draft of a bill to be presented to Parliament. In submitting it for the consideration of the meeting, he begged to state the Council were decidedly of opinion that it was desirable to make an attempt to have a bill introduced into Parliament, in the ensuing session, to impose a tax upon coals for the purpose of erecting and endowing the College. The subject would come before them in a more perfect shape at the May meeting, when the draft of the bill would be laid before them. He thought it was a good time to bring the matter forward, especially as the unfortunate accident at Lundhill Colliery had powerfully excited the public mind on the subject. The course proposed to be pursued after the bill was drawn out, was to call a meeting of the general body of coalowners who met once a year in London, and submit it to their consideration, with a view of obtaining their sanction and support, and which, if obtained, he hoped would accomplish the object. It was well known that the gentlemen who would constitute the meeting in question, represented the different coal

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districts in the kingdom, and hence their assistance would be essential to the success of the project. The Council also thought it desirable that a deputation should wait upon the Government, to ascertain if they would take up the subject, and introduce the bill into Parliament, or afford their aid and support in some other shape: it was essential to have their support, otherwise he feared it would be of no use applying to Parliament. The deputation would go to London early in May, and meet the body of coalowners, and also have an interview with the Government, in order to push the affair into practical operation. A letter, they would observe by the minutes, had been received from Dr. Robinson, as chairman of the College of Practical Science, Rye Hill, with reference to the proposed College in question, in which the objects of the Mining College were highly recommended, and which he would proceed to read.

The President resumed by adding, that it must give every member of the Institute the greatest pleasure to receive such a handsome letter of approval from such a body of gentlemen as Dr. Robinson presided over.

A short conversation ensued, after which a vote of thanks was proposed, and unanimously agreed to, to be conveyed to the Newcastle School of Practical Science, through Dr. Robinson; and the following resolution was also passed with reference to the bill intended to be presented to Parliament:—

Resolved—"That the Committee of the proposed College of Mining and Manufacturing Practical Science, be requested to draw up the heads of a bill for the establishment and endowment of the same, with the view of its being introduced into Parliament during the present or ensuing session, and that such draft be laid before the May Meeting."

The President next observed, they were aware that the late Bishop of Durham was a Patron of the Institute, but as he had retired, and another Bishop having been appointed—a divine of great science and learning— he (the President) took the liberty of calling upon him, in order to obtain his sanction to allow his name to be placed among the list of patrons. The Rev. Prelate most readily consented, and also expressed his willingness to promote in any way he could the establishment of the College. He explained, as well as he was able, to his Lordship what had been done; but as it was desirable that his Lordship should be fully acquainted with the proceedings of the Institute, he moved that a copy of the Transactions of the Institute from its commencement, be presented to the Lord Bishop of Durham.

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The motion was then put, and carried unanimously.

The President then drew attention to a large plan of a new mode of ventilating coal mines by Mr. George Hepple, which having been closely examined by the members present, a vote of thanks was passed to Mr. Hepple.

The meeting then adjourned.

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NORTH OF ENGLAND INSTITUTE of MINING ENGINEERS.

MONTHLY MEETING, THURSDAY, MAY 7, 1857, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

Nicholas Wood, Esq., President of the Institute, in the Chair.

The Secretary having read the minutes of the Council, afterwards read the draft of a bill proposed to be brought into Parliament for the endowment, and a memorial, drawn up by the Council, respecting the proposed College of Mining and Manufacturing Science, with the object of presenting the same to Her Majesty's Government.

After the draft of the proposed bill, and the memorial had been read, a brief desultory conversation ensued, which ended in the following resolution being unanimously approved of:—

Resolved—"That this meeting approves of the heads of a bill for the establishment and endowment of the proposed Mining and Manufacturing College, and also to the presentation from the Institute, of a memorial to Her Majesty's Government in favour of the same bill, it being understood that the details of the proposed bill are to be hereafter finally arranged."

The following gentlemen were then elected members of the Institute:— Charles Attwood, Tow Law Iron Works, Darlington; Joseph Bewick, Grosmont, near Whitby.

The President next called attention to the business of the day, viz., the discussion of papers in arrears, the first of which was by Mr. Potter, "On the Murton Winning" and as it had precedence of others he should be glad to hear any remarks from gentlemen present.

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Mr. Hall admitted that Mr. Potter had given them in his paper a very able report, respecting how successfully he had overcome every difficulty in their operations; but he still thought Mr. Potter had left out one important point, and that was, the cost of the scheme, the interest upon which was of great consequence in regard to future operations.

Mr. Potter replied that that was a financial question, and he was not prepared with details respecting it.

Mr. John Taylor then made the following remarks on the proposed mode of sinking through the sand at Ryhope:—

There are two pits, each fifteen feet six inches diameter, now in course of sinking at Ryhope.

The section to the bottom of the sand is as follows:—

	Fths.	Ft.	In.
Soil and clay....................	3	3	0
Limestone.......................	32	5	2
Sand............................	16	0	6

At seventeen fathoms the top of the water was reached.

It is proposed to put through the sand in the following manner:-—

1. All feeders of water met with in the limestone to be pumped.

2. Instead of piling, metal segments with inside flanges and bolt holes, to be used.

As this proposed mode is entirely at variance with the custom usually pursued, I will endeavour to explain the reasons for adopting it.

1. From an attentive examination of the sand underlying the limestone, I am inclined to think that, excepting under pressure, it is perfectly quiescent and impervious to water, indeed, it is well known that sand, not affected by pressure, forms a good barrier.

2. It is a well-known fact that large gullets are constantly met with in sinking through the limestone from which the feeders issue, and there is every reason to suppose that these gullets communicate with the sand. Assuming such communication to exist, it will follow that, if the feeders in the limestone are tubbed back, they will be met with in the sand, having a pressure according to the height of tubbing in the pit.

3. It will further appear that the effect of pumping all feeders to the top of the sand will be tantamount to bringing up a level for draining the limestone; and, in fact, the result will be, that the sand will be enabled to be dealt with as if at the surface.

It may be urged that no communication exists between the limestone

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and the sand, for if so, the level of the water behind the tubbing should have sunk as the feeder was drawn from the sand. But it seems to me that this argument cannot have much force, because, assuming a feeder of 1,000 gallons a minute to be met with in the limestone and to be tubbed back, then if 999 of this feeder pass into the sand, and be thence pumped, I contend that the level of water behind the tubbing will remain the same as before, inasmuch as the issue is less than the feed. But, even should the quantity of water drawn from the sand be very much greater than that in the limestone (without altering the level of the water behind the tubbing), it does not follow that there is no communication, because it might require a very long time before the feeder drawn from the sand could sensibly affect the level of the water behind the tubbing, as a very large surface would have to be drained before the level was affected to any extent.

With respect to the use of piles—

From the nature of the sand, one side of the pit being frequently as hard as flint, and the other soft loose sand, it will appear that the use of piles is scarcely practicable.

The great advantage of using the metal segments is the facility with which the soft side of the pit can be secured by bolting on segments, thus preventing wasting of the sand until the hard portion can be worked down to the same level.

It is proposed to hang from two wedging cribs, at five fathoms above the sand, the segments of tubbing referred to, bolting them on, and thus securing the pit as it is sunk through the sand.

Mr. Longridge asked Mr. Taylor the quantity of water?

Mr. J. Taylor replied, between 150 and 200 gallons per minute, at present, increasing as we sink deeper.

Mr. Hall asked how they found the beds of limestone lying above the sand? Were they uniform and stratified?

Mr. J. Taylor—The limestone is not uniform and unstratified. It did, however, seem to him to be an extraordinary thing that no improvement had been made from year to year in passing through the sand, while enormous expense had been incurred. He, for one, thought the time had arrived to make some change, and would be glad to carry into effect any practical suggestions the meeting might make.

Mr. Barkus thought it was apparent that, by tubbing back the

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water, it had the effect of throwing the feeders hack on the limestone.

Mr. Potter conceived it was a most important point to ascertain, if there was a direct communication between the limestone feeders and the sandstone feeders. He had no evidence of this, but found the reverse was the fact from his experience, as the feeders of water in the tubbing were not disturbed, but retained their pressure when the sand feeders were opened out below.

Mr. J. Taylor considered this a sort of negative proof. If, for instance, they pumped, say 1,000 gallons per minute of water of sand feeders, and the feeders of water behind the tubbing were 1,200 gallons per minute, then the water behind the tubbing would not be affected; the pressure would remain the same, and it did not in that case prove the non-existence of communication. Sand they knew formed a good barrier when not under pressure.

Mr. Potter—But through the sand there were communications by open fissures, and this formed a communication with distant feeders.

Mr. Dunn thought the feeders of the limestone likely to fill the gullets of the limestone, and so find their way into the sand.

Mr. J. Taylor might add, that we might suppose that the large gullets were made by the operation of water, and this rather implied a free communication, by means of such gullets, between one limestone bed and another. What he suggested was, to pump all the water found in the limestone, and not tub any of it back, and so go into the sand with no pressure of water thrown upon it by tubbing.

The President—But suppose, in sinking through the limestone, they met with a bed which was sufficiently compact to enable them to tub back the whole of the water above that bed; and then suppose they sunk farther, and met with three or four beds of limestone successively, and that they could tub back in each of those beds in succession all the water in those beds, as they did at Seaton, and could do so until they reached the sand; then would it not be advisable to pursue this system, and so arrive at the sand with no feeders at all, and then they would only have the feeders incident to the sand to contend with.

Mr. J. Taylor thought that would be highly prejudicial; for, instead of having only the sand feeders to contend with, he was of opinion the feeders above would find their way downwards through the gullets into the sand; and they would have, in addition, all the feeders above, with their accumulated pressures, to contend with likewise.

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The President considered that the superior feeders finding their way down into the sand was contrary to facts, as at Seaton they had two or three feet of sand, and comparatively little water, viz., 480 gallons per minute, though they had tubbed back in some of the upper beds upwards of 1,000 gallons per minute, and there was quite sufficient thickness of sand to allow any quantity of water to pass through it, if there was a connection between the feeders of the upper beds and the sand feeders.

Mr. J. Taylor said this was scarcely a case in point, as the thickness of the sand at Seaton was very inconsiderable.

The President—But at Seaton we had the fact, that the upper feeders were kept up, and had no communication with the sand feeders, and though the thickness of the sand was only three feet on one side of the pit, it was fifteen feet thick on the other side.

Mr. Greenwell thought that it was an important point, that in sinking through the limestone greater feeders were found than in sinking through the sand.

The President did not mean to say that such would be the case in every pit, as he had found it was not so at Harton Colliery; the water there followed them down to a depth of nearly seventy fathoms, but this was owing to a slip dyke running down the shaft. He did not mean to say, that they would in every case succeed in tubbing back the feeders of bed after bed of limestone, in separating the feeders, and in arriving at the sand with comparatively little water; the question was, is it advisable, where the beds of limestone are so compact as to admit of its being done, to tub back the upper feeders when approaching the sand? It had proved successful at Seaton, where the aggregate quantity of water met with was 6,240 gallons per minute; and where, in successive beds, they tubbed back altogether 4,480 gallons per minute, and they passed through the sand with 480 gallons per minute. If they had not tubbed back the 4,480 gallons per minute, he thought they would have had to contend with this quantity of water in passing through the sand. If, therefore, they put in wedging cribs at each bed of limestone, and the water remained with all the pressure behind the tub due to its depth; the inference was that the superior feeders did not find their way to the sand feeders below, more especially as in the case of Seaton the upper feeders were 1,020 gallons per minute, in one bed of limestone, and the sand feeders below only 480 gallons.

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Mr. J. Taylor was not inclined to go in with the President on the points alluded to, because, as the respective feeders of water are tubbed back at each wedging crib, it is only fair to assume (if it is admitted that there are gullets in the limestone), that a portion, at least, if not the whole of the previous feeder, finds its way down to the next wedging crib.

Mr. Potter begged to say that he found the feeders of water behind the tubbing at the Murton Winning sustained their full pressure behind the tub, and above the wedging crib, and did not apparently pass below to the sand feeders.

Mr. J. Taylor—The level of the water at the top not shrinking, was no proof that the feeders did not pass through; unless the whole of such feeders did pass through the level at the top would not alter.

Mr. Potter thought it an extremely difficult question to decide whether any or what part of the feeders did pass through; but his opinion was they did not, and that the sand feeder was an entirely independent one.

The President thought the question was not so much whether the tub held up the whole of the feeders, as whether the tubbing threw increased pressure upon the feeders of water in the sand. It was clear that when tubbing was used above the sand, there was an immense mass of water sustained by the tubbing, with great pressure ; and the question was, did the water, so held up by the tubbing, find its way to the sand, and with it the accumulated pressure thrown upon such water by the tubbing; and, if so, was it not advisable not to tub back at all, but draw the whole of the feeders to the surface, and so pass through the sand feeders with no pressure upon them at all.

Mr. J. Taylor thought that the success at Seaton might be owing to accidental circumstances. For instance, the sand might have been strong at that place, so that there could be no possible communication.

Mr. Dunn said that Mr. Taylor seemed to go on the assumption that the limestone beds were not tight, or did not hold up the water.

Mr. Thos. J. Taylor—It was possible that they were successful at Seaton in spite of the tubbing.

The President thought no one would argue that sand was impervious to water. When saturated with water it became a running sand, or what is called a quicksand.

Mr. Thos. J. Taylor—If water pressure were applied to it, then it would become a running sand.

The President said that, according to Mr. T. J. Taylor's theory, they ought to have had at Seaton a great pressure of water on the sand, a running or quicksand. Now, such was not the case. The sand was not so disintegrated as to become a running or quicksand: the pressure of water behind the tubbing did not appear to have acted upon the sand feeders. They, therefore, did separate one feeder from another. The facts at Seaton showed that they could separate the feeders of water in the limestone, from the feeders of water in the sand; and the whole of Mr. Thos. J. Taylor's reasoning rested on this point. If we could so effectually separate the feeders of the limestone, from the sand feeders that the former did not act upon the latter, then there could be no question that it was advisable to tub back the superior feeders; and that, as at Seaton it was advisable to tub back 4,880 gallons per minute, and pass through the sand with 480 gallons of water, rather than to pump 5,760 gallons per minute on a doubtful assumption, especially as in both cases the tubbing was to be put into the pit.

Mr. Thos. J. Taylor—Was the tubbing all put in before passing through the sand?

The President—Yes, within a few feet from the top of the sand, and nearly 5,000 gallons of water had been tubbed back in the several beds.

Mr. Thos. J. Taylor said, that the pumping of the limestone feeders was a question of expense as concerned those feeders. What they were discussing was, properly, an engineering question.

The President said, it was merely the additional cost of the wedging cribs of the tubbing to set off against the cost of engine power. They could, no doubt, raise the feeders of water by engine power; but the question, after all, was, if it was advisable, where practicable, to tub back, or to lift the water by machinery?

Mr. T. J. Taylor said, it was not entirely a question of expense, but as to whether they could shut off, or entirely tub back the feeders of water in the limestone.

Mr. Potter—If the feeders of water were not excessively large, and they employed adequate engine power to raise them to bank, there was then no difficulty.

The President conceived there were these questions involved in the case. The first was, with reference to engine power being employed; and secondly, as to whether they could tub back the water in the different

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beds of limestone, and prevent such water from having any communication with the sand feeders; and the third question was, which of the two modes is the most economical, always supposing, of course, the two modes were open to them. But, apart from economical considerations, he was forcibly impressed with the opinion that they could, in certain cases, tub back separate feeders of water in separate strata, as they continued the sinking, and that those feeders would not communicate with the sand feeders; and if so, then perhaps each case would present a different aspect, as regarded the economy of the one mode with that of the other.

Mr. Dunn thought, that, at Harton Colliery there was a slip dyke which passed down the shaft, and which prevented the tubbing being effectual.

The President said, if they had wished in this case to tub back the water, they could not have done so. There was, however, another consideration as regarded the two cases of Murton and Seaton, and that was, that the feeders of the former did not communicate with the other. He thought that the slip dykes of the coal measures extended into the limestone, and isolated the Seaton from the Murton Winning, and this proved that there were interruptions in the communication of the limestone generally, and if so, why not between the separate beds?

Mr. Thos. J. Taylor observed that there were cases before them where the sand had been successfully passed through with the feeders of the overlying limestone tubbed back. The Haswell case had, however, failed with such tubbing; while the Murton case, though successful, had been so only by means of an enormous expenditure, and an application of what might be termed an unprecedented amount of engine power. The question was, therefore, still undetermined; and the Ryhope case would throw further light upon the most desirable course of proceeding. In the meantime, they might inquire how far induction from such facts as had been ascertained would carry them. And, in the first place, they had to consider the texture of the sand itself, a specimen of which he held in his hand. He had ascertained that the difference between the dry and saturated specific gravity of the sand was as 2,081 to 2,238; while that of the ordinary coal sandstone was as 2,278 to 2,374; from which it followed, that the sand was something more than twice as porous as the common sandstone. Now, this increased porosity was really owing to the absence

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of the cement, by which sandstones obtain their customary tenacity. This sand is, in fact, held together by pressure, and, so long as it is undisturbed, might be called properly enough a sandstone. No doubt there was a variation in the texture of the sand at different places; but they still had sufficient evidence to establish its mineral character: its structure was laminar, and the beds, often very thin, had softer partings between them. Besides these numerous beds, which are frequently unconformable with each other, there are threads intersecting the "sand." Now, it could easily be understood that, when the softer partings are removed, the whole mass becomes incoherent, and being without cement, falls to pieces, and passes then, and not till then, into a state of sand. But no such effect would or could take place without a water action; and it may be added, that the same action operates to widen the threads already described, the beds being most easily acted upon where they are thus intersected, until they become large cavities in the shaft sides. Now, all this mischief is traceable to the action of water; and the question resolves itself into this—How are we to prevent such water action, or, if we cannot entirely prevent it, how are we to proceed so as to diminish it in the greatest available degree? It is clear, on a consideration of all these circumstances, and especially of the texture of the so-called sand itself, that water will not pass freely through it, if it can be prevented from wasting. This is a common character of sands, but it is more especially applicable to this case, where the mischief is the result of an action that takes place after the sand is bared. Now, it is manifestly not by bringing the greatest possible amount of water action to bear upon the sand, that we are to prevent its waste; yet we do this by coffering the limestone before the sand is passed through, the effect of such coffering being to keep the limestone water borne up to its highest level, and to assist by this pressure, if anything can be supposed to assist, the discharge of water through the interstices of the beds and the cross threads already mentioned. If we look to the limestone itself, we shall find (as regards this question) additional reasons for not coffering it. It has large gullets, and is, in all respects, a rock which admits the free passage of water; neither is it interstratified with alternate beds of impervious substance, but is continuous throughout, becoming, however, less open in the blue bed that usually lies at the bottom of it. In this limestone, then, we are bound to assume free channels of communication down to the sand.

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What, then, is to be the effect with a free communicating channel, and the greatest capable amount of pressure at the same time, but a state of things which is at a maximum for wasting the sand, and making it serve as an avenue to the limestone feeders, or a large portion of those feeders? If, on the contrary, the limestone is kept open, and its feeders pumped to bank, not only are those feeders withdrawn, but the pressure on the sand is diminished, at all events, immediately round the shaft, and the probabilities of waste ensuing are proportionally decreased.

The President said, reference had been made by Mr. Taylor, to the hardness of sand, when dry, but after all, the question rested upon this, whether the sand feeders and the limestone feeders were separate or connected. If separate feeders, then they could either draw all the limestone feeders with engine power, or tub them back, and in either case they would only have the sand feeders to contend with. But if the two feeders were connected, then the question assumed a very different aspect; drawing off the limestone feeders by engine power would then of course, relieve the pressure, whereas, tubbing back the upper part of the same feeders (as they are supposed to be) would only throw a greater pressure upon the sand, and so increase the difficulty. The experiment about to be made at Ryhope would be an important one.

Mr. J. Taylor thought the experiment would be carried out there most effectually, as they proposed to draw by engine power all the feeders down to, and including the sand feeders, and hence the experiment was important. It was well known that enormous expense had been incurred by the old system, and, if the experiment succeeded at Ryhope, it was of great importance to the trade. The difference between the systems was this:—At Murton, the feeders were tubbed back in going through the limestone, but they intended to draw their limestone feeders at Ryhope, and so pass through the sand without any pressure of water above. Mr. Potter had said that every wedging crib had tubbed so much water back, and, although that might be so, yet he (Mr. Taylor) had not experienced that such was the case. Mr. Potter replied that he did not say so.

Mr. J. Taylor—But Mr. Potter said there was no communication between the water behind the high tubbing—that it did not lower in level when the feeders below were tapped; still he (Mr. Taylor) contended that such a fact, of no difference in the level, did not prove the case, as the upper feeders of water might be larger than could pass through

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the gullets into the lower beds, and hence the level of the water in the upper tub would remain the same.

The President thought that this fact might not show that there was no communication between the two feeders, still it nevertheless did not prove the position of Mr. Taylor. Therefore, after all, it was merely a balance of opinion between parties, as to whether or not it was practicable to separate the feeders. But there could be no question, in his opinion, as to the Seaton case.

Mr. J. Taylor considered it was not against his opinion that if there was communication, the water in the high tubbing should retain its level; Mr. Potter stating that he drew the whole of the feeders off without any change.

Mr. Potter said they drew 6000 gallons per minute from the sand without its having any apparent effect upon the water behind the tubbing.

Mr. Dunn—Still Mr. Potter says that when they drew all the water from the pit, the tubbing was full.

The President-—They must remember that Mr. Potter, in his paper, says that the limestone was much broken, and was lying at considerable angles next the sand; therefore he still thought that the water which came out of the sand was connected with part of the feeders which came out of the broken limestone; and this might be, and yet there might not be any connection with the other feeders above. The feeders of the broken limestone might communicate with the sand feeders and not with the feeders where the limestone was more compact; and, therefore, he was inclined to think it possible that at Murton the feeders belonged to each bed, and not to the whole mass. Mr. Hall said that Mr. Taylor might probably think of trying his new mode of sinking through sandstone feeders, in consequence of the small depth at which the sand was met with at Ryhope, which was only 34 fathoms, with a pumping power of 500 horses; but it would be quite another thing at 80 fathoms, as at South Hetton and Murton.

Mr. J. Taylor—That even would not alter his views, but rather tend to strengthen them, as it was his opinion that the upper limestone feeders of water, when tubbed back, tended to increase the pressure in the sand, by coming down through the gullets behind the tubbing in greater force; this, therefore, would increase the difficulty.

Mr. Potter referred to the condition of the artesian wells, where the communication seemed to be from some feeders belonging the bed of stone.

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Mr. Boyd instanced the case of the different mineral water feeders of Cheltenham being entirely separated from each other in the different beds. By boring to a particular bed they got one description of mineral water, and by boring to another bed, either above or below, they got an entirely different description of mineral water; the feeders of water there in the different beds seemed to have no connection with each other.

The President thought Mr. Boyd's case a very strong one. In sinking through what is called the 70 fathom post on the Tyne, which was a very open gritly bed, almost all the feeders above the High Main Coal being in that bed, they did not generally get any water until they reached that bed, but when they tubbed the feeders back in that bed, they never got them again. It was the same at Harrogate, as at Cheltenham. The beds which contained the mineral waters were in the millstone grit formation, the strata lying at a considerable angle. When they bored down to one bed, they obtained a particular kind of water, and at another place water of an entirely distinct character was met with, so that, in fact, they could, by boring into the different beds respectively, obtain different qualities of water.

Mr. Dunn asked if it was the ordinary coal strata, and not limestone, would the same policy be pursued?

Mr. T. J. Taylor could not tell, as there was no such thing as solid rock in nature.

The President, in reference to a question by one of the members relating to the effect of boring, said it was possible to bore down in a shaft, and miss feeders of water. Such was the case at Killingworth Colliery. When the bore went down to the seam, they were led to suppose there was no water, having met with none in boring; but when they came to sink the pit they found a large feeder of water. It was a feeder which came out of a gullet, and which the boring had not tapped.

Mr. Marley adverted to boring in the sand at Castle Eden Winning, where, at a short way from the sand, they drove a drift, and put a borehole through, with the idea of ascertaining what feeders they were; but the result was, that they could not depend upon boring.

Mr. G. B. Forster, in alluding to the 56th page of Mr. Potter's paper, begged to correct an error relative to the accident at Eppleton. The accident was not occasioned by the want of timbering, or by the sinkings going on too fast. A good deal of walling had been put in, and it was supposed that the men had, contrary to strict orders, taken a

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crib bodily out, instead of drifting it, and that this had caused the sides to run in. The pit, however, was opened out again immediately, and sunk eighty fathoms further.

Mr. Greenwell asked if any water passed through the limestone and sand at Eppleton, and was it tubbed?

The President said, there was a large feeder of water of 2,000 gallons per minute, which was tubbed back, and the water remained at the present time.

The discussion on the above paper then terminated; after which a desultory conversation ensued respecting the other papers, when it was agreed to discuss them at the next monthly meeting.

The meeting then broke up.

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NORTH OF ENGLAND INSTITUTE of MINING ENGINEERS.

MONTHLY MEETING, THURSDAY, JUNE 4, 1857, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

Thos. J. Taylor, Esq., one of the Vice-Presidents in the Chair.

The Chairman, on taking his seat, said the first business to be transacted was the electing of gentlemen proposed for members at the previous Monthly Meeting.

The following gentlemen were then elected members of the Institute:— Mr. Alex. B. Cochrane, The Heath, Stourbridge; Mr. Chas. Cochrane, Ormesby Iron-works, Middlesbro'; Mr. Geo. Chapman, West Auckland Colliery; Mr. Wm. Grisdale Sawyer, Whitehaven; Mr. John Bigland, Bowden Close Colliery, Bishop Auckland.

The Chairman next called attention to rule IX., relating to the change of officers of the Institute at every Annual Meeting. That rule, from the want of sufficient formal notice, was not acted upon last year; and a special resolution was also passed authorizing the meeting to dispense with it. As it was a rule of the Institute that an annual election of officers should take place, he had drawn out a resolution to the effect that the requisite notices should be given for carrying out rule IX. at the ensuing Annual Meeting. The resolution having been read by the Chairman, it was put and carried unanimously.

The Chairman said, there was another subject he wished to call attention to. It would be remembered that he was requested to see Mr. Hutton respecting the collection of fossils which formerly belonged to

that gentleman, but which was at present in the custody of Messrs. Laws & Glynn. The object of the Institute was to prevent the collection leaving this part of the country, as there was another customer for them, viz., the Coal Exchange of London. He had had an interview with Mr. Hutton, who informed him that the fossils, although not quite perfect, were essentially so. The parties in possession of this collection were most anxious to dispose of them, so that the Institute could not delay in resolving what it should do respecting them at the next General Annual Meeting. With that object, and for the purpose of satisfying the parties in the meantime, he submitted the following resolution for their consideration:—

"That the subject of the purchase by the Institute of the fossils described in "The Fossil Flora of Great Britain" be brought before the General Annual Meeting in August next."

The resolution, on being put, was carried unanimously.

The Chairman next referred to the papers standing over for discussion. He said the first was that of the President, "On Underground Conveyance;" and the second his own, "On a Combined System of Drainage for Mines," and as this was a proper time to enter upon the discussion of them he would be glad to hear any observation.

Mr. Reid considered that as the President was not present, they could not do much with the subject of his paper without him.

After a short conversation, it was agreed to defer the discussion of the President's paper; upon which the meeting entered into the subject of Mr. Taylor's paper, viz., that of combined drainage.

Mr. Reid thought they ought to get an Act of Parliament on the subject. He had pointed out to the Council certain means, which were in practice on the Continent, by which disputed points might be considered in relation to damages. In Prussia such a course was adopted. All disputed points were brought forward and considered, and in case the outlines of royalties were of a tortuous description, they gave and took the barrier lines. Damages were awarded as compensation.

Mr. Dunn—Yes; if two or three parties combined they might get an Act of Parliament for general drainage.

The Chairman—Agreed; an Act of Parliament here was equivalent to the power of the Crown abroad.

Mr. Reid stated that Mr. Taylor in his paper alluded especially to barriers and tortuous lines, and these he considered came fairly before them for the public benefit. He might mention that in Prussia if a barrier was tortuous, a line was drawn by which the dispute was regulated.

Mr. Barkus said, in reply to Mr. Reid, that the continental system of arranging barriers could not be acted upon successfully in Northumberland and Durham, where the upper seam had been worked, and barriers left under the boundaries of the respective estates, in accordance with the terms of the leases granted to the several lessees. Many of such barriers have been reduced and rendered ineffective previous to their abandonment, and a general communication has arisen in the High Main Seam from such untoward causes. Any arrangement of barriers to be left in the under seams must be made to accord with those in the upper seam, otherwise the division of districts would be imperfect. The mischief arising from inundation appears to be still extending, as I am told the pumping engine at Gateshead Park has been discontinued.

The Chairman—The object he had in view was to dispense with the barriers altogether.

Mr. Berkley—Suppose the barriers were once broken, there would be no compensation to parties fifty years after.

Mr. Dunn—On the Continent, if the Government Engineer saw a case of necessity, the Government would compel the party to carry it out.

The Chairman—Still, the Governments on the Continent could not do more than an Act of Parliament realised in this country.

Mr. Reid—If judging rightly, he conceived that Mr. Taylor's paper recommended that all parties should unite and do for themselves what was done by the Government of other countries. If the President of the Institute had been present he might have given them some information, as no one was better acquainted with the matter in hand than he was. He thought a sufficient case might be proved by showing the great quantities of coal wasted; and that in itself might make a good preamble for a bill.

Mr. Dunn conceived that if it were for the general good no opposition whatever would succeed. In Staffordshire, and other parts of the kingdom, the value of the coal mines was deteriorated by the barriers. He thought that if they began to drain that district they might bring down engines, houses, canals, railways, &c.

Mr. Marley begged to draw Mr. Taylor's attention to a remark, the

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true meaning of which, he did not doubt, could be at once explained. It might be inferred from a passage in the paper written by Mr. Taylor, that the safety of life in the mine was not sufficiently looked to.

The Chairman thanked Mr. Marley for the observation made by him, and stated that the entire tendency of his remarks was in the opposite direction; so much so that the very system recommended by him was calculated to do away with one cause of the loss of life—that arising from inundation. What he meant by a non-sacrifice of mine for "the purpose of safety" was, that in our day, where such effective means were available for working, and especially for draining mines, it was unnecessary to sacrifice mine for that purpose.

Mr. Atkinson begged to call attention to the subject of photography, which he thought might easily be adopted in reference to the plans of collieries. The correctness and fidelity of this art was such, that if applied to such purposes, it might tend to the safety of lives from inundation.

The Chairman was of opinion that the subject opened out a wide field, and was worthy of a separate paper, which he suggested to Mr. Atkinson the expediency of writing on the subject.

On a few words from Mr. Reid, it was agreed to adjourn the discussion. After which Mr. Marley's paper "On the Cleveland Ironstone" was read, and the meeting adjourned.

[errata.

On Map, No. 2—Outline of the Geological Formation of Cleveland—for "Specton Clay" read Speeton Clay.]

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CLEVELAND IRONSTONE. OUTLINE OF THE MAIN OR THICK STRATIFIED BED, ITS DISCOVERY, APPLICATION, AND RESULTS, IN CONNECTION WITH THE IRON-WORKS IN THE NORTH OF ENGLAND.

By Mr. JOHN MARLEY.

To the members of this Institute, this ironstone cannot but be an interesting subject, whether they be mining engineers, coal owners, iron masters, or simply a part of the public personally disinterested, as I believe that nothing has been discovered, within the last twenty years, having so direct an influence on the landed, railway, and mineral wealth, in the North of England, on the South Durham coal field, and on the iron trade generally, as the discovery and application of this large ironstone district.

I suppose it may now be taken as an admitted fact, that the prosperity or depression of the iron and coal trades regulates, in a very material degree, the prosperity or depression of nearly all other commercial pursuits in the same locality.

Having been early connected with the development of the northern part of this district, I have agreed to put the most material facts in connection therewith on record, on the assumption that the same may be useful in preserving an account of the early proceedings, (as it is anticipated it will become one of the most important iron districts of the kingdom), and, at the same time, be laying before the members of this Institute a correct account of the discovery and application of this ironstone, more especially as connected with the northern part thereof; and in doing so, I shall principally confine myself to a general outline, leaving

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the details of the respective special districts to be dealt with by others in future papers. Therefore, before entering upon the more immediate subject of this paper, it may be well to draw attention to the iron-works in the northern counties prior to the discovery, and to the application thereof, in the north part of Cleveland, as the requirements of the iron-works then in existence had a most influential bearing on the same. A general map, showing the relative position of the iron-works in the north, with the various coal, limestone, and ironstone districts, is herewith given, see Map No. 1.

1st. The Lemington Iron-works.—Belonging to the Tyne Iron Company, are the oldest smelting works in the North of England (of modern times). These works, consisting of two furnaces, were erected about the year 1800, for the purpose of smelting ironstone to be got from the coal measures in the neighbourhood of Walbottle, Elswick, and adjoining places on the river Tyne.

They had not been many years in existence before the local ironstone supply was found inadequate, and the partners, in looking for an extraneous supply, began to use, and have for upwards of fifty years continued to use (with Scotch and other ores), ironstone from the Yorkshire coast, being the clay ironstone nodules collected from the beach at various places, beginning with Redcar on the north and ending with the Old Peak on the south, but, in so doing, I have no doubt they got many blocks of this main stratified bed, which had fallen off the cliffs, particularly in collecting nodules at Kettleness, where part of this seam forms the beach, so that, in all probability, these works were not only the first erected, but also the first to use (although unknowingly), this bed of ironstone. Indeed some blocks, seen at these works, have been since recognised by parties as being from this bed. A Mr. Wilson, one of the former partners of these works, is, I believe, entitled to some credit for early recognizing this regular stratified bed on the coast. The first shipment to these works of this bed of ironstone, as such, was in the months of March and May, 1837, from the Whitby Stone Company.

2nd. Birtley Iron-works.—These works, consisting of three furnaces, and belonging to the Birtley Iron Company, were erected about the year 1827 or 1828, and were intended for the smelting of local ironstone to be got from the coal measures at Ouston, Birtley, and in the immediate district. About the time of the erection of these works, Mr. Benjamin Thompson, then the managing partner of this Company, sent a Mr. Jos. Bewick, sen., of Hylton, near Sunderland, to examine the Yorkshire

[No. 1 Map or Plan shewing the position of the coal, limestone and ironstone with the Iron Works in the North of England]

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coast from the Tees to Flambro' Head, with the view of procuring an extraneous supply (in addition to the Scotch stone), as a mixing stone, and which examination he made about 1827 or 1828, and completed two surveys thereof, as well as examined portions of the interior of the country, but from the nature of beach shipping, and want of railway communication, they were deterred from any further proceedings at that time. However, in May, 1833, the Act for the Whitby and Pickering Railway received the royal assent, and the consequent making of that railway caused this ironstone to be again looked after, and thus it was that on the 18th of May, 1836, a trial cargo of fifty-five tons (of 22½ cwts. each ton), of this ironstone was sent from Grosmont, six miles south-west of Whitby, by the Whitby Stone Company, and brought to these furnaces, and thus these iron-works were the first to have, knowingly, used this ironstone, although they did not get a second cargo until the 30th May, 1837, viz., of 128 tons of 22½ cwts. each.

3rd. Ridsdale Iron-works.—Although these works have, as yet, never been in connection with the Cleveland district, yet, as they may now possibly become so, from the increased railway facilities, I think it better to include them in this paper. They were erected by parties in connection with, or at one time forming part of, the Derwent Iron Company, about the year 1835, and afterwards belonged to Messrs. Forster & Co., and are situated on the North Tyne. They consisted of two furnaces, and were intended for clay ironstone, to be got from the carboniferous limestone measures. But, although making good iron, they were, from their isolated position, heavy cost of transit by carts, in addition to the cost of the local raw material, completely debarred from getting other ores to them, or their own manufactured produce away, except at great expense, and hence were laid in at considerable sacrifice. But, shortly, the Border Counties Railway will give facilities of transit to and from, in consequence of which it is possible these works may again be proceeded with, as both hematite and other extraneous ores may then be got to the place by rail.

4th. Hareshaw Iron-works.—The same remarks apply to these works as to the Ridsdale. They consist of three furnaces, and were erected about 1836. They were also originally begun by the same parties as the Ridsdale, and afterwards belonged to Messrs. Woods, Parker, & Co.

5th. Wylam Iron-works.—These works were first erected by Mr. Ben. Thompson, about the year 1835 or 1836, and primarily intended for the smelting of coal measures ironstone, but, although only one furnace, it

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was found that the local supply was inadequate, even with occasional cargoes of Scotch ironstone. Now, as previously named, this ironstone, i.e., the main Cleveland bed, was first examined by Mr. J. Bewick, sen., in 1827 or 1828. He was, in consequence, again sent by Mr. Thompson in 1838, and in which year he began at Kettleness, on the coast, where part of this bed of ironstone forms the beach, and shipped ironstone for these works from thence, and in the following year, viz. 1839, they, in addition, got ironstone from Mrs. Clark, at Grosmont, (Mrs. Clark's mines being wrought then, and now, under the management of Mr. Bewick, jun.) After these works had been out of blast for a short time they were taken by the present firm of Messrs. Bell Brothers, about the year 1844.

6th. Consett Iron-works.—Consist of seven blast furnaces belonging to the Derwent Iron Company, and were erected about the year 1839 or 1840, for the smelting of local coal measures ironstone. An extraneous supply had to be sought for these furnaces, from the carboniferous limestone measures, on both the rivers Wear and Tyne, as also partially from Whitby, but they depended principally on the local supply until 1851, i.e., after the opening out of this ironstone in the north part of Cleveland.

7th. Walker Iron-works.—These iron-works, situate on the Tyne, and belonging to Messrs. Losh, Wilson, & Bell, originally consisted of only one furnace, being the first blast furnace that was specially erected for this bed of ironstone (in connection with Scotch, and other ores, for mixing), viz., about the year 1842 or 1843, and which ironstone was purchased from the aforesaid mines belonging to Mrs. Clark, in the Whitby district, the first cargo being sent in June or July, 1843, since which time these works have been increased by one extra furnace, built for the Whitby district ironstone in 1844, and by other three for the north part of Cleveland, about 1852, making now a total of five furnaces.

8th. Stanhope Iron-works.—These works, consisting of one furnace, were first begun in 1842 by Messrs. Willis and Rippon, but never by them finished, they were afterwards taken by C. Attwood, Esq., for the Weardale Iron Company, in 1844, and put into blast in 1845. They were intended entirely for the Weardale carboniferous limestone measures, locally called "vein" or "rider" ironstone, and, I believe, have not used any of this Cleveland ironstone.

9th. Crookhall Iron-works.—Were erected about the year 1845, consist of seven furnaces, and also belong to the Derwent Iron Company. Similar remarks applying to them as to Consett.

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10th. Tow-Law Iron-works.—Were erected about 1845 or 1846, consisting of five furnaces, and belong to the Weardale Iron Company. Were intended as a more permanent carrying out of the Stanhope Ironworks scheme, and for similar ores, with the extra advantage of coal measures ironstone as a mixing stone.

11th. Witton Park Iron-works.—Belonging to Messrs. Bolckow and Vaughan, consisting of four furnaces. Were intended for a mixture of ironstone, to be got from the coal and carboniferous limestone measures, with this main bed as a mixing stone; the latter got principally from the aforesaid Mrs. Clark's mines, near Whitby. They were erected in 1845, and put into blast early in 1846.

Having now given an outline of the iron-works erected up to and with 1846, it will be seen from the tabular statement appended hereto, that only eleven furnaces were erected during a period of about 36 years, i.e., before the application of the discovery of this ironstone by the "Whitby Stone" and "Birtley Iron" Companies, in the year 1836, and that after this ironstone was used by the said Birtley Iron Company, in 1836, the Tyne Iron Company in 1837, and the Wylam Iron Company in 1838, we have only a period of about six or seven years before the first furnace was built, by Messrs. Losh, Wilson, & Bell, at Walker, especially for this ironstone, within which period an additional number of eight furnaces were erected, thus showing, up to and with 1842 or 1843, only nineteen blast furnaces in existence in the North of England; and, although this ironstone from the south part of Cleveland was then more or less used by all the iron-works that could have access to the same by rail or otherwise, we have no further works specially erected for this stone, except one additional furnace at Walker, in 1844, all the remaining furnaces having been erected more or less independent of it. But with the combination of this main or thick bed of ironstone, from the south part of Cleveland from 1842 and 1843 to 1846, a period of only from three to four years, we have eighteen more furnaces erected, or nearly as many more, making then a total of still only thirty-seven furnaces for the whole of the north-east part of England, and some of them permanently abandoned or temporarily out of blast.

I now come to the more immediate subject of my paper, viz., the discovery of this ironstone; and on this point many have been the claims made by various parties, with various merits, some attributing it to the Romans, others to the monks; and within the last ten years to various individuals, all wishing to give the discovery a degree of antiquity,

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whatever they could do as to the merits of the application. But, in treating on this point, I am afraid I shall not be able to do justice to all, therefore should any parties not be named to whom credit may be due, let me at once say that it will be from want of knowledge thereof, and not by intention on my part. That the Romans or monks, or both, have been at work very little doubt can be entertained, and in illustration I give the following quotations. 1st, Professor Phillips says,* "ironstone abounds on this coast, and has been formerly shipped in large quantities to Newcastle. Inland, iron-works, established by the monks, were formerly carried on near Rievaulx Abbey, and further up in Bilsdale, and in the valley of Hackness." And next, J. W. Ord,† after remarking as to inland iron-works at Bilsdale, and former shipments of ironstone having been made to Newcastle, gives the following note:—"Bransdale, Rosedale, and probably some other of the dales, contain quantities of ironstone, although at present in disuse. The vast heaps of iron slag, and numerous remains of ancient works, prove that much iron must formerly have been produced there. There are also appearances in these dales of charcoal having been prepared largely for these purposes; but when the works were carried on, no record remains to shew. However, an *inspeximus* dated at York, February 26th, 2nd of Edward III. (1328), recites the grant of a meadow in Rosedale, called Baggathwaite, to the nuns, by Robert de Stuteville, originally given by that family, A.D. 1209, whence it is evident that iron was worked in Rosedale at a very early period." Therefore, before giving my views on this point, it will be well to state, first, that this main bed of ironstone is between the upper and lower lias formations, and besides which there are numerous thin clay bands of ironstone, commonly called in this district "dogger bands," as also intermixed largely in the shale are "nodules" of ironstone; and upon the top of the main alum shale or upper lias, is a seam of ironstone now known as the top seam, (although not the highest geologically) generally lying from 40 to 45 fathoms above the main or thick bed, as also there is a third seam lying still higher, i.e. geologically, being in the oolite formation. Having stated this, I proceed to give my reasons for thinking that it is very questionable whether the Romans or the monks ever smelted any part of this main bed of ironstone, because in the various remains of slag and refuse left by them in Bilsdale, Bransdale, Rosedale, Furnace House in Fryupdale, Rievaulx Abbey, and other places, no traces of this main seam of

* Illustrations of the Geology of Yorkshire, 1829, by John Phillips, F.G.S.

† History and Antiquities of Cleveland, published in 1846, by J, W. Ord, F.G.S.L.

ironstone have been found, although " dogger band" and " nodules" have been so found along with the charcoal and slag. The quotations just given, afford some idea of the antiquity of smelting from the other beds. The Rievaulx Abbey district is in the oolite formation, and in several instances in the different districts, the slag remains can be identified with, and are in close proximity to the "dogger bands" in the ironstone seam known as the top seam, which I have never found to be the case with the main seam. I therefore conclude that the operations of the Romans and monks, as also the shipments spoken of to Newcastle, all belong to the "dogger bands" in the so-called top seam, and to the "nodules," except as named about the shipments to Lemington, in my remarks on those works.

I have been informed that in 1790, a gentleman from Whitby, being at Skelton, either discovered, or thought he had discovered iron ore in that estate, and sought by correspondence during that year, with the late Mr. Wharton, or his agent, to take it on lease; and again in 1798 and 1800, but the late Mr. Wharton would not listen to any proposal. The late Mr. Rutter, land-agent, had in his possession, as recently as 1850, three original letters of this correspondence, but, which, I have not been able to see.

In 1811, the late William Ward Jackson, of Normanby Hall, had large samples (6 or 8 cart or wagon loads) of this ironstone from near Upsal, in his property, sent to some iron-works on the Tyne, but the answer brought back by the men, was to this effect—"Tell your master it is good for nothing." This stone must have gone to the Lemington iron-works, as Messrs. Losh, Wilson, and Bell, to whom it is said to have been sent, had no blast furnaces until 1842. This may be said to be the first application (if not the discovery itself) of this ironstone, anyhow, the first of which we have any authentic account. In the same year, viz: 1811 or in 1812, the late Thos. Jackson, of Lackenby, opened out and laid bare the full height of this ironstone in Lazenby Banks; he then trying to draw attention to it as ironstone. This place now forms part of the Eston ironstone mines, and thus, Eston and Normanby can lay claim to the earliest application, if not discovery of this stone.

Coming to more recent dates, I find that Mr. J. Bewick, sen., in 1827 or 1828, (as previously named) had twice examined the coast from the Tees to Flambro', as well as part of the inland country, and reported to Mr. B. Thompson, then of Birtley iron-works, the existence of this main seam of ironstone, and in a private lecture delivered in the winter

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of 1854, at Grosmont, by Mr. J. Bewick, jun., he states, that "the only reason why operations were not then commenced, was the fear that a sufficient number of ships would not be obtainable for beaching purposes, and which, subsequent experience has shown was well founded; public railways then being very little known, the ironstone in the interior of the country was not thought of, without which it could never have been worked."

In 1828, the Rev. George Young, A.M., in writing on the Yorkshire coast,* makes several remarks on the ironstone in Cleveland, but without giving any value to this main or thick bed. After stating that the ironstone holds a conspicuous place in the ironstone and sandstone division, he says, "It appears to be partly calcareous, partly argillaceous, and has been ascertained to yield 15 per cent. of iron, being collected for an iron-foundry at Newcastle." He further says, "the beds are seldom more than 9 or 10 inches thick"—thus, clearly showing, that here the main seam was not meant. The thick, or main seam, is however pointed out in the section given, in describing the Boulby cliffs, viz:—"6.—Main bed of aluminous schistus or alum-rock, 200 feet. 7.—Imperfect seams or flat nodules of hard blue limestone, mixed with alum-shale, 10 feet. 8.—Hard compact alum-shale, 30 feet. 9.—Ironstone in beds, or rows of nodules, interstratified with the shale, 15 feet; "the latter being evidently the main seam. He further speaks of several bands of ironstone, and says, that estimates have been made of the proportion of iron, being "from 30 to 60 per cent.," an estimation which he remarks, "is perhaps beyond the truth"; so, that although he may be said to have faintly identified the main bed, he still attributed no commercial value thereto.

In 1829 Professor Phillips' work, already referred to, was published, from which I give the following quotations, showing that, although he thoroughly identified this thick bed, and gives it the true geological position, he places no value thereon. The first extract is from his "Tabular View of the Series of Yorkshire Strata," viz.:—[see in original text]

* Geological survey of the Yorkshire Coast, 1828, by the Rev. Geo. Young, A.M., assisted by Mr. John Bird.

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which rocks he more minutely describes afterwards, as follows, viz.: [see in original text]

In No. 14, the ironstone known as the top seam is found, and in No. 16 the main thick bed. He afterwards identifies both seams, viz.:—"At Kettleness, from the sandstone rock, just above the alum works, to the lias scars beneath, we have the following section:—[see in original text]

The 4 feet being the so-called top seam, and the last mentioned 20 feet being the main seam.

Further on in the work, Nos. 16 and 17 are again described as follows:

"16. Ironstone and marlstone series consisting of— [a] The ironstone bands, which are numerous layers of firmly connected nodules of ironstone, often separate, and enclosing dicotyledonous wood, pectines, aviculae, terebratulae, &c, twenty to forty feet. [b] The marlstone series, consisting of alternations of sandy lias shale, and sandstones, which are frequently calcareous and generally full of shells. The lower beds are usually most solid and project from the cliffs in broad floors, covered with pectines, cardia, dentalia, aviculae, gryphaeae, &c.; thickness variable from forty to one hundred and twenty feet.

"17. Lower lias shale, more solid, less fissile, and generally of coarser and more sandy texture than 15," (being the upper lias shale), "with a different sprite of organic remains, amongst which plicatulae, gryphaeae, and pinnae, are perhaps most characteristic; thickness exposed in Huntcliffe less than two hundred feet, at the Peak three hundred feet, but the bottom is nowhere seen."

Having now given a sufficiency of extracts from Professor Phillips' work to show his knowledge of the true position, it now only remains to give another as to the value he put on the ironstone in the "Eastern

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part of the county," viz.:—" The principal repositories of this mineral are above the grey limestone, and below the upper lias or alum shale. It is at present of no value except as ballast."

Before leaving this work, however, I ought to say that the sections given therein are of the greatest utility in tracing this ironstone formation on the coast, as is also, generally, Professor Phillips' Map of the Geology of Yorkshire, published in 1853, (since the application of the discovery of this ironstone); and while making allusion to the latter it may not here be out of place to call attention to the fact of some landed proprietors having been much misled by the upper and lower lias formations beings tinted alike, and thus drawing conclusions that as the lias was shewn on their estates, this main bed of ironstone was there also, whereas it turned out they only had the lower lias, and that this main bed of ironstone was not in their properties. It may be worth while to consider the propriety hereafter of distinguishing the upper and lower. I have made an attempt to do so in the outline Geological Map of this district which I attach hereto (see Map No. 2).

In May, 1828, the year previous to that in which Professor Phillips' work was published, Mr. Charles Attwood, ironmaster, now managing partner in the Tow-Law Iron-works, was by accident detained in Northamptonshire, and while so, discovered part of a wall, built of ironstone, of a somewhat similar kind to this, in a ploughed field, but after search in proximity thereto, he could not discover any quarry or hole, whence it could have come. He observed that the stone was oolitic, and although his other pursuits at the time drew his attention from the Northampton stone, in the summer of the following year, viz., 1829, when on his way to the Hambleton Hills, and not far from Sutton, under Whitestone Cliff, his attention was again attracted by seeing what he conceived to be a similar ironstone to that seen in Northamptonshire, and at the same time recollected seeing somewhat similar pieces at Lemington Iron-works, amongst the stone collected from the coast. In August or September of the following year, viz., 1830, he, in company with his brother-in-law, Mr. William Matthews, a Staffordshire ironmaster, was again in this district, proceeded past the limestone quarries to near Boltby, and in that neighbourhood found a similar ironstone (now known as the top seam) samples of which Mr. Matthews kept and labelled, with the prognostication that when the railroad system became developed, then Cleveland would become a great iron district, and thus this subject was allowed by both to rest until the winter of 1841, or spring of 1842, when Mr. Atttwood's attention being again directed to

[No. 2 Map. Outline of the geological formation of Cleveland]

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the iron trade, he procured one of the original Geological Maps of the late W. Smith,* and from it, and from the sections of the coast in Professor Phillips' work already mentioned, had hand sections and maps made ready for a tour of discovery, with a view of finding the same ironstone as near to the railway at Stockton-upon-Tees as possible. These maps Mr. Attwood has kindly allowed me to examine, which maps, of course, from their sources, contain sufficient materials to have led Mr. Attwood to the right places, if his tour had been followed up, as the geological formation at Eston and at Roseberry are prominently and correctly marked thereon. However, although, the time was arranged for this visit, the tour was abandoned, in consequence of a Mr. Walton, from Weardale, calling on him with specimens of the "vein " or "rider" ironstone, and pointing out the advantages as then appeared, of Stanhope furnaces being partly erected, and actual existing railway communication; and hence, on the 23rd day of July, 1842, he turned his back on Cleveland, and made his first visit into Weardale; and thus, as far as he was concerned, lost sight of the subject until Mr. Vaughan, of the firm of Messrs. Bolckow and Vaughan, waited on him in 1850, for the purpose of selling part of this ironstone. When told of the quantity and prices, before knowing the locality, he produced the maps in question, and pointed out Roseberry and Eston, as, in his opinion, the locality from which it must come.

About the year 1832 or 1833, this ironstone is said to have been examined and reported on by one of our members, Mr. T. Y. Hall, and Mr. W. A. Brooks, C.E., (*see Vol. II, pages 115 and 116, of this Institute's Transactions,*†*)* and reference is there made to the "Nautical Magazine," of May, 1833. But on referring to this magazine, I find from one of the articles in it,§ that Mr. Brooks only is named, (although Mr. Hall was concerned with him,) and that he, Mr. Brooks, had been reporting on the project of Docks and Harbour of Refuge at Redcar, and that the only allusion there made to ironstone is as follows: "The adjacent rocks contain large quantities of ironstone," and then, after alluding to "Upleatham freestone," "cement manufacturing," and to the "supply of coals by canal," &c, suggests the feasibility of a "cannon and anchor foundry," to supply these articles " 30 per cent. cheaper than at other places." I presume it must be a mistaken reference by Mr. Hall, as only

* Geological Map of Yorkshire, W. Smith, Mineral Surveyor, 1821.

† The Extent and Probable Duration of the Northern Coal Field, &c, by T. Y. Hall, 1853

§ Observations on Port William, at Redcar, on the south side of the Tees Bay, coast of Yorkshire, projected by W. A. Brooks, C.E., Stockton-on-Tees.

quotations are given, in the "Nautical Magazine" of May, 1833, otherwise from anything therein given, no wonder that so "little notice was taken" of this ironstone. I have not, as yet, been able to procure a copy of the report alluded to.

In a lecture* delivered in March, 1853, Dr. Merryweather says, "It is now about twenty years since" he and his friend, the late Mr. Richard Moorsom, at that time President of the Whitby Literary and Philosophical Society, "took a geological walk," (which would thus be about the year 1833,) and their "object was to seek for minerals and mineral waters," as well as to get to the summit of the basaltic ridge which crosses the middle of Godeland, on their way up the Whitby and Pickering Railway, to Beckhole. They "also examined minutely the bed of Godeland Beck, near to the south side of the church that has since been erected there, and found it composed of a firm mass of marine fossil shells." He says, "I little thought at that time that this was to turn out the oolitic ironstone, which is at present causing such a sensation." In congratulating Mr. H. Belcher on account of having promoted the building of the above mentioned church at Grosmont, he says, "Mr. Belcher has not only unintentionally raised his own monument, to transmit his worthy name to future generations, but he has planted it on the very rock of iron from which the first modern workings of the oolitic ironstone in the north of England took place." Some exception ought to be taken to this, so far as the shipments from this bed of ironstone, along with the nodules taken off the coast, are concerned, as also the samples from Normanby, by the late W. W. Jackson, in 1811.

In 1845, Dr. Merryweather seems to have taken an active part in endeavouring to get a railway from Whitby to Stockton; and in 1846, as appears from the lecture above referred to, formed one of a deputation to the directors of the York and North Midland railway, to assist in getting what they called the "Whitby and Tees railway, with a branch from Stokesly to join the Great North of England at Cowton," and in setting forth its advantages, says, "there is one feature connected with the dales which is of the first importance, that is, the ironstone with which they abound." They succeeded in getting the Act for the railway from the Whitby and Pickering railway to Castleton; which railway, has not however been made. This ground is now occupied by the North Yorkshire

* A Lecture on Gold and Iron, and Iron-ore, with especial reference to the Ironstone of the vale of the Esk, of Staithes, and Cleveland, delivered before the Whitby Literary and Philosophical Society, by George Merryweather, M.D., on Tuesday, March 29th, 1853: with a report of the speeches.

[Diagram of the strata at Rockliff]

and Cleveland railway, which is opened from Picton to Stokesly, the link between which and Grosmont still being incomplete.

About the year 1834, I understand one of the principal estates in the Rosedale Abbey district changed proprietors, (which district has lately caused no little interest in Cleveland, as well as out of it, and of which, more hereafter) the east side of Rosedale was purchased by Dr. Penfold, (now Captain Vardon's property) and on which occasion, an agent of Lord Ward's, from Dudley, was brought over to examine this estate for ironstone, but his report was that it was limestone and not ironstone.

Coming next to Louis Hunton's paper,* read before the London Geological Society, on 25th May, 1836, we find a complete section of the strata at Rockcliff, near to Lofthouse alum-works, from which I give the following extracts, viz:

"Section of the upper lias and marlstone at Rockcliff (Easington heights), local dip, S.W., one foot in ten feet."

[see in original text Table]

* Remarks on a Section of the upper Lias and Marlstone of Yorkshire, shewing the limited vertical range of the species of ammonites and other testacea, with their value as Geological tests, by Louis Hunton, Esq., 1836. Also quoted from very largely, with section, in J. W. Ord's History and Antiquities of Cleveland, 1816.

The main bed of ironstone is here definitely shown, and called 25 feet thick. The nodules are also alluded to as having been smelted at Newcastle.

The next subject worthy of notice, is the Whitby and Pickering Railway, which has played an important part in the development of this ironstone. The royal assent was given to this railway in May, 1833; and to the various examinations of the Esk Valley, with the view to the making and opening of this railway, may be traced the first practical application of the discovery of this ironstone in the south part of Cleveland. An account of the scenery on this railway, as well as a description of the railway itself, was written in the year 1836, by Henry Belcher,* solicitor, Whitby, who was not only secretary to the railway company but also an earnest promoter of the railway, and to whose various excursions, occasionally accompanied by Dr. Hubbersty, of Cambridge, we owe this application of the discovery, they finding and directing the attention of the Whitby Stone Company to a portion of the main seam of ironstone, cropping out to the surface in the side of the Merk Branch of the Esk or Godeland Beck, in the Egton estate, belonging to the late Mr. Elwees, at Grosmont, six miles, (by railway,) southwest of Whitby, near to the church; and which six miles of this said railway were opened on the 8th day of June, 1835, the whole line not being publicly opened till the 26th day of May, 1836. About the same time we have a public company formed, for the purpose of developing traffic for this railway, (and without any special view to this ironstone, but primarily for freestone and whinstone), called the Whitby Stone Company, consisting of twenty-four members, viz., Messrs. Robert and John Campion, Henry Simpson, John Chapman, and others, with the said Mr. Henry Belcher, as secretary, and it was by this company that, on the 18th day of May, 1836, (eight days prior to the public opening), the first small quantity of the fifty-five tons previously named were sent from Grosmont to Whitby, and shipped for the Birtley iron-works. With regard to this first shipment the experiment was anything but certain in its results. A second trial quantity was sent off in March and May, 1837, by the same company, to the Tyne Iron Company, who condemned the stone most strongly, saying "they were ashamed to see such refuse on the Quay!" Nothing daunted, however, they got the Birtley Iron Company to try it again, and on 30th May, 1837, sent 128 tons (22½ cwts. each), of which they received, this time, a more favourable report,

* Illustrations of the Scenery on the line of the Whitby and Pickering Railway, with a short description of the district and undertaking, by Henry Belcher, 1836.

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which said, "if we can get it at a payable rate we shall be induced to try it," and hence it was, that in January, 1838, the first contract was made for 30,000 tons, and they used it with their local ironstone and Cornish ore, first beginning in small quantities, then using 33⅓ per cent., and next 95 per cent. of this ironstone. After using about 10,000 tons of this contract the Birtley Iron Company entered into further and permanent contracts. The Whitby Company had 10s. per ton (22½ cwt.), for the first cargo, and 9s. per ton for the second, delivered at Pelaw Staiths on the Tyne, for the Birtley Iron Company, the prices now being somewhere about 7s. to 8s. per ton, 22½ cwt. I subjoin a section of the ironstone strata in the Esk Valley, having reference principally to the mines, wrought by the said Whitby Stone Company, viz.:—

General Section of Strata in the Vale of the River Esk, from Cooper's Cut, via Grosmont, to Beckhole.* Rise of strata 1 in 45, N. 78 E.—[see in original text]

* Per Mr. J. Waddington, manager for the Whitby Stone Company, Whitby.

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Thus showing the aggregate of the ironstone in the above section to be 47ft. 3in.

In 1838, Mr. Bewick, sen., began to work, and shipped the main bed of ironstone from the sea-beach, at Kettleness, for Wylam ironworks. This ironstone is now being wrought by Mr. John Watson, of Lythe Hall, near Whitby.

In 1839, Mr. Bewick, jun., commenced to work the main bed of ironstone on behalf of Mrs. Clark, near Grosmont, for Lemington iron-works, and for general sale, and it may be as well here to give another section of the Esk Valley district, having more especial reference to Mrs. Clark's mines, as follows:—

1. Soil, &c.	Ft. In.
2. Sandstone, (varies in the thickness and quality)	58 6
3. Ironstone seam (called the top seam of Cleveland) is here coarse and silicious, varies much in thickness and quality, (in Mrs. Clark's property, is from 8 to fifteen feet thick)	11 6
4. Upper lias shale, including cement seam, varies to 170 feet	130 0
5. Strong coarse shale being the dogger and jet rock*.....	29 0

[see in original text Table of the Cleveland Main, or Thick Bed Ironstone Series.]

* The sale of manufactured jet articles in Whitby alone, is said to be about £50,000 per annum.

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The Avicula bed is so called from the fossil shell avicula cygnipes (or young swan) being prevalent in it.

The Pecten bed is so called from the number of the pecten fossil, or common scallop therein contained.

The method of working in this district used to be, to get about one half in the first working, but of late they have adopted a mode similar to that of our northern coal mines, and so find it advantageous to take only about one-third in the first working.

The Pecten and Avicula seams together yield from 18 to 20 thousand tons (22½ cwts.) per acre.

The general vend from Mrs. Clark's mines has been about 30,000 tons per annum, but in 1856 only about 20,000 tons.

The seam known as the top seam was opened in April, 1852, and about 200 tons vended, (i.e. from Mrs. Clark's property) and then abandoned on account of being so very silicious.

In 1839, Mr. D. Nesham, of the late firm of Nesham and Co., of the Portrack Lane Iron-works, at Stockton-on-Tees, became identified with the Cleveland ironstone. Happening to be in company with the late H. Vansittart, Esq., of Kirkleatham Hall, he had his attention directed by that gentleman to some ironstone near Coatham, and after examination, he shipped a small cargo from that place, about 150 yards from the flagstaff, to the Devon iron-works, Alloa, near Stirling, for trial; and, in answer, received a letter advising him not to be at any further expense about it, as it was not worth trying, there being no iron in it. He replied thereto, leaving himself in the manager's hands (a Mr. Leslie Meldrum, I believe). And so, on Mr. Nesham having occasion to be in that district about 1850, he, on enquiry, found his cargo deposited in the ballast heap; of course, it had never been tried. (This ironstone is alluded to in Messrs. Walker and King's report, hereafter named.) During, 1839, 1840, and 1841, however, he prosecuted many examinations of Cleveland, in connection with a Mr. Alexander Byrne, of London, and a Mr. Scale, of Aberaman, South Wales; and in order to be certain, got arrangements made for the first refusal of the respective royalties with the late Mr. H. Vansittart, the late Sir J. H. Lowther, the late Martin Stapylton, Esq., and the late Sir William Pennyman, but never became assured of its value, although the parties were extensively engaged in analyses, with a Mr. Maugham, of London, and in personal inspections, (as appears from the correspondence which then passed, part of which I have had the opportunity of perusing, by favour of Mr. Nesham.)

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Coal, hematite, and peat seem to have also engaged their attention, although at last they give up the hematite idea. In one letter Mr. Scale says, "The Whitby stone may extend within a few miles of your town" (i. e. Stockton). Mr. A. Byrne, in his anticipations of iron-ore, near "Stockton, Stokesley, and

Yarm," speaks of "a mighty company" to be established, and a railway "from Stokesley to Hartlepool." One rather wide idea, however, he names, in one of his letters dated 14th March, 1840. He reports that he has seen Dr. Buckland at Oxford, who "is of opinion that iron ore of a better quality than you now work at Whitby exists in great abundance near Stokesley, and all across for several miles, from Whitby to Whitehaven." He also states some of the ores from the north of Cleveland, analyzed by him, to contain "30 to 40 per cent. of iron, 25 per cent. of lime, no sulphur, no manganese, no magnesia, nor in fact anything bad, being a very rich flux stone of the oolitic order," and says, "if you can get plenty of the stone at a cheap rate, you have a treasure with which to compete with any market in the world." Other ores are named as "35 per cent. of iron and 26¼ of lime." Mr. Nesham's transactions in the iron trade not having been very profitable and the result of his examinations doubtful, he gave up all claim to the royalties.

In 1840 the Messrs. Bewick made further examinations of the coast, and, amongst other places, discovered the ironstone at Skinningrove, and at the same time examined part of the interior country, and in so doing found it at Slapewath, near Guisbro'; traced it westward past the Guisbro' old alum works, and judged as to other places where it might be found; but want of railways, and a fallacious view (as now proved) of the quality of the stone at those places, caused it again to be allowed to rest.

In 1840 (the same year in which Messrs. Bewick made their last tour) the Whitby Stone Company were also bestirring themselves, and sent deputations to the north part of Cleveland to explore; and on the 7th, 8th, and 9th of July, 1840 (after Mr. Scale and others had reported) Mr. Nicholas King, of Whitby, (manager of the Whitby Stone Company prior to the entry of the present manager, Mr. John Waddington, in November, 1836,) with Mr. James Walker, solicitor, of Whitby, made their examination, and their report thereon bears date Whitby, 10th July, 1840* On the first day they examined the Huntcliff and

* An error hereon appears in Mr. Waddington's speech, printed along with a lecture on Gold and Iron, and Iron-ore, by George Merryweather, M.D., 1853, wherein this report is put as having been made in 1837.

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Redcar district, and allude to a "2 feet bed of ironstone at East Coatham," "of 37 per cent. yield," "but only 10 to 15 yards broad," and "200 to 300 yards long" (this being the bed shipped from by Mr. Nesham). On the second day, however, viz., 8th July, 1840, they state that they found "on the Knowles," "midway on Hillside, near Lazenby, near Eston Nab," "ironstone in large quantities," "not less than 8 feet deep, but the quality is hard, harsh sort, and very unlike good ironstone—coarse." And on the same day the report shews, they "next examined the Knowles on the south side of that ridge in Mr. Jackson's estate," and found "indications of a similar stone, but not opened out." They also had an interview with the late Mr. Rutter, land agent to Sir J. H. Lowther and others, and report that he informed them of "ironstone 6 yards thick, in a well near West Coatham," but that after examination they were satisfied that the 6 yards rock could not be ironstone. They also had samples of ironstone bands shewn them by Mr. Rutter, from Roseberry Topping, but thought them "very unlike ironstone." The third day they devoted to the Hartlepool district, and the acquiring of information as to "coals and coke suitable for ironmaking."

Now, here is an actual re-examination of those parts of the present Eston and Normanby ironstone mines which are alluded to in 1811 and 1812, and by parties fully acquainted with the Whitby ironstone, and their report closes with "quality is hard, harsh sort, and very unlike good ironstone—coarse".

This ironstone also rises and crops out before arriving at Redcar, and does not "dip down towards Redcar" as stated in this report.

Somewhere between the years 1844 and 1846 I understand the "pecten" portion of this main band of ironstone was seen in the hills near to lngleby Greenhow, by Mr. J. Waddington, of Whitby, but was thought worthless.

In 1846 Mr. J. W. Ord published his work, already named, and in order to show his view of the then value of this ironstone I quote as fellows:—"It is at present of little value except as ballast, and is scarcely of sufficient importance to encourage speculation." He gives several quotations from other works, to indicate the presence of ironstone, and amongst others he states that "just above the Alum rock in Roseberry Topping is iron ore," this being the position this main bed of ironstone occupies there and elsewhere.

Having now brought the different examinations to the year 1840, and it being difficult to assign the discovery specially to any one, (although

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it and the application may be said to have been in 1811), I would next draw attention to the fact that the whole of the iron-works already named, with the exception of Walker iron-works, were originally intended for the smelting of local ironstone, and that such local ironstone, either from quality, quantity, or cost, and more particularly the latter two, invariably failed to answer the required end, so that all had to look elsewhere for additional and cheaper supply, and some parties took royalties, even at high rates, after the year 1837, in the Whitby district, and others in Scotland. Hence a similar remark equally applies to Messrs. Bolckow and Vaughan's Witton Park iron-works, notwithstanding their central position for ironstone, from the coal measures and carboniferous limestone measures, as also the "vein" or "rider" stone from both Teesdale and Weardale, and in course of which, in addition to getting ironstone from the Whitby district, this firm collected several thousand tons off the coast, between Redcar and Skinningrove, in the spring of 1848, and brought the same by beach shipping to Middlesbro', and thence per rail to these works; and, arising out of this operation, we have the first practical application of the discovery of this thick bed to the north part of Cleveland. One Mr. James Burlinson, of Bishop Auckland, was engaged in the collecting and shipping of these nodules, and was succeeded by the Messrs. Roseby, of Witton-le-Wear.

Mr. A. L. Maynard, one of the lessors of the ironstone at Skinningrove, called Mr. Burlinson's attention to this bed of ironstone in his (Mr. Maynard's) estate, inland, as a stone which some had thought contained iron. Mr. Burlinson, after examination, applied to Mr. John Anderson, railway contractor, of Middlesbro', for money or other assistance to open out and test it. In the meantime, Mr. S. F. Okey was sent by Mr. Burlinson's solicitor, (Mr. Bowser, of Bishop Auckland,) to examine it thoroughly, but his report was not sufficiently flattering to warrant any further proceedings being taken by them. On the Messrs. Roseby succeeding Mr. Burlinson, and being informed of these matters, they observed that some portions of the ironstone in course of shipment were from this seam, and had fallen off the cliffs, and which stone had got worn by the action of the waves of the sea into something like the shape of nodular balls, as well as oxidized into proper colour to pass inspection with the other stone, and finding such to be the case, were not long in tracing this main or thick bed, (here running from twelve to eighteen feet thick in the cliffs), and securing agreements for leases for working the same, under the Earl of Zetland,

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A. L. Maynard, Esq., and some others; and they made arrangements and commenced work on 7th August, 1848, preparatory to shipping this ironstone to Messrs. Bolckow and Vaughan's works at Middlesbro', for their Witton Park iron-works. To show the prejudice with which the first cargo was treated by the then furnace-manager, it is a fact that he had teamed the first few waggons of the stone into the refuse heap as "freestone stuff," before receiving instructions from Mr. Vaughan thereon, and reported unfavourably on the first trial. Thus then on the 26th August, 1848, the first shipment of fifty-six tons (22½ cwts. each), of the main bed of ironstone, was made from Skinningrove in the north part of Cleveland. The Messrs. Roseby not having the means of carrying the matter out, entered into arrangements with Messrs. Bolckow and Vaughan as to Mr. A. L. Maynard's agreement for lease, in consideration of money advances. Mr. John Anderson, railway contractor, of Middlesbro,' in his evidence on the Shildon Tunnel Branch before the House of Lords, in 1854, taking credit for this ironstone being opened out with his money, he having advanced the Messrs. Roseby fifty pounds for getting the trial cargoes. It was in consequence of Messrs. Bolckow and Vaughan's advances that I was first called upon by them on the 22nd day of September, 1848, to examine this main bed of ironstone, and which led my attention to be directed to it.

The Messrs. Roseby not being able to fulfil their contracts, the mines of Mr. Maynard (Skinningrove) came into the hands of Messrs. Bolckow and Vaughan, about July, 1849, and were worked by them unto the 19th day of October, 1850, inclusive, when they were transferred to Messrs. Losh, Wilson, and Bell, who have continued to work them, and ship stone from them to their Walker iron-works, as required. Messrs. Roseby shipped from here 747⅝ tons, (22½ cwts.), Messrs. Bolckow and Vaughan about 5,418 tons, (22½ cwts.), Messrs. Losh, Wilson, and Bell's highest quantity per annum being $6,025\frac{5}{22\frac{1}{2}}$ tons, and for 1856, about 5,500 tons of 22½ cwts. each.

This ironstone here rises in direction N. 45 E., and the following is a section of the main seam, as now in course of working, viz:

Shale roof.	Ft. In.
Dogger band of ironstone	0 6
Top block of ironstone	5 0
Small ironstone parting	0 2
Bottom block of ironstone	5 6
	11 2

Messrs. Bolckow and Vaughan having thus in 1848, begun to use the

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Skinningrove ironstone, and finding it so much better in yield than the Whitby ironstone, although, from the same bed, their attention was turned to the Eston and Upleatham hills, not from any geological reasoning at first, but from their proximity to Middlesbro' and to railway communication, as Mr. Bolckow then said, if found there, this stone would really be of use, as, having railway communication, all the drawbacks of beach shipping, which were great, would be avoided. In the latter part of 1848 and early in 1849, trial drifts were made in the Upleatham hills, in the Earl of Zetland's grounds, as well as in those of the trustees of Lady Hewley's, at Eston, and in the late George W. Jackson, Esq.'s property at Normanby, by Messrs. Campbell, and Stephen Forster; which trials, I examined first early in 1849, but the seam then discovered was only the seam now known as the "top seam" of Cleveland. This seam is the most irregular in Cleveland, both in thickness and quality, and is here divided into thin bands, very different from Fryupdale, Grosmont, Rosedale, and Thirsk districts, as will be seen by the sections given. This seam may be said to vary from only a "type" to 20 feet thick, and in some places, not even a "type" is found. The section taken in Lady Hewley's, I give as follows:—[see Table in original text]

which varies very much from the section of this seam, given hereafter as taken in S. Stapylton, Esq.'s property.

The section taken in Upleatham grounds is as follows:—[see in original text]

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From the examination of these drifts, and the strata in the hills, I was of opinion that this main bed of ironstone (or Skinningrove seam, as it was then called), would be found at Eston; I, therefore, on Messrs. Bolckow and Vaughan's behalf, as far back as March, 1849, entered into correspondence with the agent for the late G. W. Jackson, Esq., for leave to search for the ironstone, and enter into leases, but the latter said it had formerly been well tested in his father's life-time, (viz. the late W. W. Jackson, Esq., in 1811), and would not listen to it. He told me he would "not assist me to ruin Messrs. Bolckow & Vaughan, and spoil the estate," and thus it was not till early in 1850, that negociations were so far advanced with the adjoining proprietors, viz., the Trustees of Lady Hewley's Charities, that they engaged Mr. T. E. Forster, Mining Engineer, of Newcastle, to examine, report, and advise terms, which he did, I accompanying him to the drifts in the seam now called the "top seam," in his examination (without happening to come on this thick seam exposed), and it was under these terms that, on the 8th day of June, 1850, the re-discovery of this bed was made in the Eston Hills, being effected in the following manner. Mr. Vaughan and myself having gone to examine the hills for the most suitable place for boring, we decided to go up the hills to the east, adjoining Sir J. H. Lowther's grounds, and so walk along to Lady Hewley's grounds on the west. In ascending the hill in Mr. C. Dryden's grounds, we picked up two or three small pieces, we, therefore, continued our ascent until we came to a quarry-hole, from whence this ironstone had been taken for roads, and next on entering Sir J. H. Lowther's grounds to the west, a solid rock of ironstone was lying bare, upwards of sixteen feet thick. I need scarcely say that having once found this bed, we had no difficulty in following the outcrop in going westward, without any boring, as the rabbit and fox holes therein were plentiful as we went. We also examined the place in Lackenby Banks, squared down in 1811 or 1812, by the late Mr. Thomas Jackson, of Lackenby. The period from the 8th June, 1850, until the middle of August following was occupied in completing arrangements for opening out this ironstone, and the first trial quarry was begun on the 13th of August, 1850; a temporary tramway was soon laid down, and by the 2nd of September, 1850, the first lot of about seven tons was brought down in small tubs to the highway side, from thence carted to Cargo Fleet, and thence by rail to Witton Park Iron-works, being about twelve weeks after actually seeing the ironstone, and by this method 4040 $\frac{7}{20}$ tons, were sent away

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by 28th December following, viz., 1850. And now was completed what really may be said to be the commercial discovery of the Eston ironstone, or *bona fide* application of the original discovery, whenever the discovery did take place.

Before entering on the latter part of this paper, I may here observe that the existence of this ironstone having now become a public matter, numberless have been the accounts of its previous discovery, amongst others, Mr. S. Blackwell, in a lecture* before the Society of Arts in London, in 1852, says, "the iron ore in this formation was first known and worked at its northern extremity, in the neighbourhood of Middlesbro'. A workman noticed a considerable deposit of iron, which took place from a spring, issuing at the base of one of its beds. Upon calcining a piece of the rock, its character was at once evident. He communicated his discovery to the proprietors of the extensive iron-works of Witton Park and Middlesbro', who immediately recognised its importance." This account will be seen to be far from correct. The real merits of the case are, that the existence of this stone has been long and well known, though not its value. For instance, Sir J. H. Lowther's carriage roads at Wilton Castle are made of it, and have been for years. It may and does seem strange that it should have lain over so long; although, even after it was opened out, we have many instances of even ironmasters, on inspection, throwing it away as no better than a sandstone, as it is stated in the Geological Survey for 1856†, "It would easily pass muster for an ordinary sandstone with only its external surfaces, more or less rusted by the peroxidation of iron." The application of this discovery was speedy; competition for royalties arose on all sides, notwithstanding which, I am glad to be able to state, that the Eston tract, secured by Messrs. Bolckow & Vaughan, (after their persevering efforts, they being the first parties to open out the north part of Cleveland), will bear comparison with any in Cleveland. At the same time, to show that it is not free from its "troubles" I append Plan No. 3 to this paper, being a cross section of the Eston range of hills. I next give a section of the strata as shewn under the Eston Nab, in S. Stapylton, Esq.'s royalty; as follows:—

* Quoted in the afore-mentioned "Lecture on Gold and Iron," by Dr. Merryweather, 1853.

† Memoirs of the Geological Survey of Great Britain, and of the Museum of Practical Geology. Part I: The Iron Ores of the North and North-Midland Counties of England, 1856.

[No. 3 Plan. Cross section of the Eston Range of Hills and of the main seam of ironstone, at the East End of the Eston Mines Royalties]

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[see in original text Tables of strata details]

At these mines there is no sulphur or pyrites hand on the north side of the hill, except at a small point to the extreme west.

The first surveys and levels were completed for the present Eston Branch Railway, on the 17th day of August, 1850; which said railway was commenced in the October following, and by December, 1850, was so far completed, that 136 $\frac{17}{20}$ tons of ironstone were sent over it, being carted to the same from the tramway previously named, thus making

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a total from these mines in 1850 of 4177$\frac{4}{20}$ tons; but it was not until the 4th of January 1851, that the first locomotive passed along this line prior to the public opening of this railway and the mines, which took place on the 6th day of January, 1851. The event then celebrated was considered, and has since proved to be, an important one for the district. The proceedings of this public opening were all duly recorded by the newspapers of the day.

The first instructions relative to these mines were that 1000 tons of ironstone would be required weekly, but before the permanent rails were laid down, these instructions were changed to 1000 tons daily, and even this was found unequal to the requirements, as during the year 1851, 187,950$\frac{15}{20}$ tons were wrought and vended; and during the following five years, ending with 1856, 1,719,507$\frac{12}{20}$ tons were vended, of which, during 1856, there were 568,156$\frac{11}{20}$ tons shewing a large increase over 1851; the quantities during 1856 running from 10,000 to 12,000 tons (20 cwts) per week. The greatest day's-work, week's-work, and fortnight's-work being respectively thus, in 1856:—

Greatest day.................... 2,325$\frac{19}{20}$ tons

Greatest week................ 12,312$\frac{14}{20}$ tons

Greatest fortnight................ 24,136 tons

Up to the end of 1856 the total vend since the commencement is nearly two million tons. Thus, will be seen the great magnitude to which these mines have attained. The mode of working adopted, is as yet the "board and pillar;" the sizes of the pillars now being from 14 to 16 x 30 yards, and the boards 4 to 6 yards, the general height taken away in mining, varying from 14 to 16 feet, the pillars next the outcrop not being so large. The greatest cover actually explored under being about 65 fathoms. A few small experiments in taking out these pillars have been tried, and have been so far successful, obtaining fully 80 per cent. These being, however, only experiments, and a further test being required before any particular plan be adopted, at present the pillars are left large on that account. Many thousands of tons have been and can be quarried. The present mines are as yet carried on by drifts or adits.

The Eston Branch Railway is two miles in length from the Middlesbro' and Redcar Railway, (its junction thereon being three miles from Middlesbro'), and to this branch railway the ironstone is brought in

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waggonetts down self-acting inclines of 400 and 600 yards long, each waggonett carrying about 31½ cwts. These mines and the works in connection will shortly have the advantage of an independent communication with the shipping in the river Tees, by the extension of their branch railway under the public railway, and thence by a jetty into the channel of the river. A private Act of Parliament had to be got for these mines and the said railways, the principal lessors lands being in Chancery, viz., that of Stapylton Stapylton, Esq.

Having now brought this matter to the time of practical results, I will next give a short sketch of the principal mines opened out since 1850.

The first, therefore, in order of time, are the Upleatham mines, in the Earl of Zetland's property, and under lease to the Derwent Iron Company. They obtain an outlet on the Middlesbro' and Redcar Railway, by a tramway about four to five miles in length, (leaving the main line about seven miles from Middlesbro'), and although this tramway is only about two feet wide, part of it is wrought by miniature locomotives, and the remainder by hauling engines. The vend from here has, I believe, been up to about 1,000 tons per day, that of 1856 being only 171,360 tons (20 cwt.).

The following is a section of the main thick bed (having already given one of the so-called top seam), viz.:—

Shale roof, dips South 5 East about 2 inches to the yard.

	Ft. In.
Main ironstone bed, having an occasional parting about 3 feet from the top, and a regular parting about 2 feet from the bottom	13 0
Blue shale...	5 0
Ironstone...	2 2
Shale proved to.......................................	40 0

No pillars, properly speaking, have been taken out (except five or six adjoining the outcrop), and, therefore, not to be taken as any criterion, the pillars varying from four to five yards x ten, twenty, and thirty yards respectively, the boards being from six to seven yards. The whole of this ironstone has been got by quarrying and drifts or adits.

The next and important application of this ironstone discovery, was the obtaining of the Act of Parliament for, and consequent making of, the Middlesbro' and Guisbro' Railway, with branches to Hutton-Lowcross, or Codhill mines, and to Roseberry Topping, it being opened in 1853; and by way of shewing the rapid increase of the mineral traffic,

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which is nearly all ironstone, I subjoin the following abstract from the Railway Company's accounts, (Roseberry Branch not being yet made), viz.:—

	£ s. d.
Receipts from minerals from 11th Nov. to end of 1853	329 18 1
For the year 1854	4224 5 7
Do. 1855	8594 11 1
Do. 1856	12916 11 3

being a total since the opening of £26,064 16s. 0d. from minerals only, other traffic receipts having increased each year also.

The principal mines opened on the line of this railway are, first, the Hutton-Lowcross, or Codhill mines belonging to Messrs. Joseph and Joseph Whitwell Pease. A section of this ironstone and the per centages thereof, as at these mines, were furnished me in 1853, by one of the promoters of the Middlesbro' and Guisbro' Railway. This I subjoin as an example of the difference between the appearances at the outcrop and the interior section, especially as regards such parts as have become oxidised or crusted, and as a proof that the analysis of such ought not to be the only criterion of value, although the stone, in its natural state, may be improving as the workings advance, which I believe is the case here.

"The section of the main bed was taken in the West Gill, viz.:—

	Ft. In.	
1st block of iron-stone	16 2	(Average of nine specimens taken out at intervals of about 2ft. vertical height, 41.7 per cent. of iron.)
2nd do. do.	2 4	Called shale, but yielding 39.2 per cent. of iron.
3rd do. do.	1 6	Called bottom band, 31.5 per cent. of iron.
	20 0	

The average of the whole seam equalling 40.6 per cent. of metallic iron."

I next give a correct section of the strata at these mines, and, following it, a section of the average of present workings, viz., 6 ft. 1 in. of good ironstone, with an average of 33.09 per cent. of metallic iron, as per analysis hereafter given. The section is as follows:—

[see in original text Table listing section of strata at Hutton-Lowcross, or Codhill Ironstone Mines.]

[see in original text Table listing section of strata at Hutton-Lowcross, or Codhill Ironstone Mines - continued.]

The average working section of this main bed being as follows :—[see Table in original text]

The ironstone here has been quarried to a very large extent, as well as being wrought by means of day drifts or adits. No pillars have been removed as yet, the sizes being about 4 x 24 yards, and boards 4 yards laid out to 6 yards. The ironstone from these mines is brought by a short self-acting incline plane, on to the Codhill branch of the Middlesbro' and Guisbro' Railway, and the workings during 1856 have been about 220,000 tons, of which 217,253 tons (20 cwts.) have been vended.

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On the 26th December, 1856, a small blower of inflammable gas made its appearance in these mines, from a large gullet only 340 yards in from the surface, with 13½ fathoms of cover on. It left altogether in four days, and in no other place in these mines has any gas been discovered. There was a large bog on the surface, which, it was thought, might have something to do with it.

The next mines opened on the line of the said Middlesbro' and Guisbro' Railway are the Normanby mines, adjoining the Eston mines on the west, belonging to Messrs. Bell Brothers, and are on the estate of the late W. W. Jackson, Esq., from which ironstone was taken in 1811. They, consequently, partake of the character of the Eston mines in many respects, but at the outcrop to the west are not of the same thickness, and are dipping to the north, south, and east, being similar to one end of a boat at the west. The following is an average section of the main bed, viz.:—

	Ft. In.
Dogger or top band of ironstone ..,..............................	2 6
Sulphur or pyrites..	0 2
Main block of ironstone..	8 0
Bottom ditto	0 9
	11 5

The vend from these mines in 1856 was 131,575 $\frac{17}{20}$ tons.

These mines are all wrought as yet by quarrying and drifts or adits, and by a short private branch railway, the ironstone is taken on to the said Middlesbro' and Guisbro' Railway.

The next and last opened mines on the line of this railway are the Belmont or Belman Bank mines, Guisbro', belonging to the Weardale Iron Company, and are held over an immense tract of surface. They are connected with the main line by a private branch, but as yet have not been opened out to any great extent. The following is an average section of the main bed, viz., full rise N. 70 W.

[see in original text Table of average section of the main bed]

The vend for 1856 was 73164 $\frac{10}{20}$tons.

The next district I wish to draw attention to, is the sea coast—and

[No. 4 Plan. Section of the Sea Coast from Hartlepool to Whitby]

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to this paper I append a section from Hartlepool to Whitby, marked No. 4 Map. Beginning at the Hartlepool end, we have ironstone first at Redcar, viz.: nodules that have been collected off the rocks. Further along the coast towards Whitby we find the same class of nodules at Saltburn, Huntcliff, and all the way to Skinningrove, where the Skinningrove mines stone is shipped by a jetty. Between Huntcliff and Skinningrove the main bed only once approaches the shore, but has not been wrought. Going still further in the same direction we come to the Earl of Zetland's sea coast stone, at Lofthouse Alum Works, which was first shipped in 1849 and 1850, i.e., both nodules and the main thick bed— first by the Messrs. Roseby, and afterwards by the Derwent Iron Company. From Lofthouse to Boulby, several parties, since 1849, have shipped from the main bed, but nothing of any importance. At Boulby, the ironstone is under lease to the Marchioness of Londonderry. This royalty has been taken with the view of promoting iron-works at Seaham Harbour. The ironstone a little north of the alum works has been drifted into, but nothing wrought, the drifts and workings being closed over with a slip of the cliff.

I give the following section, taken a short distance to the north of these drifts. [see in original text]

The main bed of ironstone is first split with a shale parting, a little to the north of these alum works. The ironstone will have to be got away from here by beach shipping. There is a pit or staple already which could be applied as a drop, it being now used for lifting the coals from the beach for the alum works.

The next ironstone place on the coast is at Staithes, and is now under lease and in course of being wrought by the Messrs. Palmer, of Newcastle-on-Tyne, and the stone is taken from here by beach shipping.

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The section of the strata here found, (and by which it will be seen that the main bed is now very much intersected with shale and divided), is as follows, viz.:—

[see in original text Table of Section of the strata in the Signal Cliff at Staithes.]

Aggregate of ironstone, including the shaly partings in No. 10, is 13 ft. 10 in.

I now come to a somewhat extensive place, viz.: Rosedale Docks and mines. The ironstone workings at this place have as yet been confined to the so-called top seam, and the stone was formerly lowered on to the beach shipping jetty by a self-acting incline plane, but is now dropped down a shaft by a self-acting drop about 22½ fathoms, and thence by a short tunnel to the spouts at the docks newly constructed, which are about three acres in extent, and by the side of which they were, at my last visit, busy sinking two shafts to the main bed of ironstone.

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I next append a section of this Rosedale Cliff, as follows, viz.:—

[see in original text Table of Section of the strata in the Rosedale Cliff, at Rosedale Docks (on the coast between Staithes and Runswick Bay).]

Now, sinking in blue shale, and with Staithes as the data, has eight fathoms one foot more of the last-named shale, and then on to the dogger band of six inches, lying 3½ feet above the main bands. In this sinking inflammable gas, in small quantities, has been met with. Since my visit to this place, I understand the main seam has been got at the depth expected, or a total of about 43 fathoms 3 feet 5 inches from the bottom of the seam, known as the top seam; and, assuming the main seam to be the same as at Staithes, it will make an aggregate of ironstone beds here of 18 feet 6 inches.* The plant at present is such that 70,000

* Since this paper was read I have been favoured with the following section of this main seam of ironstone, as sunk through, viz.:— [see Table in original text]

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tons per annum, it is estimated can be vended, if necessary ; but, in 1856, the vends from here and Staithes were only about 23,500 tons. The propriety of changing the name of this place is, I believe, at present under consideration, in consequence of Rosedale Abbey district often being confounded with it.

Immediately to the south is a small place vending ironstone from the so-called top seam of Cleveland, belonging to Messrs. Seymour, Thompson and Co., their vend during 1856, being 12,500 tons.

Still further south, we come to the Victoria Docks and Ironworks, on the north of Runswick Bay, at a place called Wreck Hill, not far from Hinderwell, and belonging to a Leeds company, called the Victoria Iron-works Company. At this place, which is situate within ten yards of the sea, two blast furnaces are in course of erection, the machinery and necessary apparatus being, I understand, so far ready that, if all go well, they are to be in blast in the autumn of this year. The extent of royalty here is about forty-three acres, and of docks about one-eighth of an acre—the latter not finished. There being no railway or inland communication, the sea is their highway and railway, and sole inlet and outlet, not more than seven months shipping being calculated on as practicable; and everything required (except ironstone) having to be imported.

The seam, known as the top seam of ironstone, is here apparently not so good as at Rosedale (coast), the following being the section, viz.:—

Soil, &c.	
Freestone.	Ft. In.
Irony shaly sandstone..................................	9 0
Ironstone dogger band................................	0 3
Very coarse irony sandstone.......................	1 3
Shale..	2 6
Main band of the seam, known as top seam .	1 4

Alum, shale, &c, about 40 feet to sea level

Below this, the company have sunk a shaft about twenty-six fathoms further down to the main seam, and, I understand, with the following as a section:—

	Ft.	In.
Dogger ironstone band................................	1	2
Shale	1	9
Top block, ironstone	1	11
Shale..	1	9
Bottom block, ironstone.................................	3	10
Shaly parting..	0	0
Shale	1	0
Ironstone..	1	0
	12	5

The strata seems to be rather dislocated here.

Continuing along the coast round Runswick Bay, we then come

[No. 5 Plan. Section of the Sea Coast from Whitby to Flamborough Head.]

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Kettleness Alum-works, the point where the main bed forms the beach, and, as already named, is now in course of working by Mr. John Watson, being first begun by Mr. J. Bewick, sen., in 1837.

The next point worthy of notice is Sandsend, where, at the alum works, the top seam (so-called) has been tried and abandoned within the last few years. It varied, in about half a mile, from one-and-a-half to four feet thick, but of inferior quality.

To the south of Sandsend we come to the Raithwaite mines, belonging to the Eskdale Ironstone Company, worked out of the low cliff on the sea side, and vended by beach shipping.

It is only a small place, the section being as follows:—[see in original text]

The quality here varies considerably, being very silicious, and part of the seam is thrown aside as useless. In the analysis, hereafter quoted, it will be seen how capricious in quality this so-called top seam is here. The vend for 1856 being 5916 tons.

There being no further mines, we now come to Whitby; but, before leaving the coast, let me first remark that as there are no mines on the south side of Whitby, although nodules have been collected off the beach at the Old Peak, I have not thought it necessary to detail the coast any further, but have appended a section from Whitby to Flambro' Head (see Map No. 5), which brings us to the chalk formation.

It is at the port of Whitby that the Esk Vale, and Whitby and Pickering Railway ironstone, has been shipped, not only by the Whitby Stone Company, and Mrs. Clark, (the latter's shipments being previously named), but also by the Birtley Iron Company, who shipped during 1856 about 10,000 tons (22½ cwts), besides a few small quantities by small proprietors from the neighbourhood of Sleights Bridge and other places on the said railway; amongst others the Eskdale Iron Company vended 5438 tons. The Whitby Stone Company's maximum vend per annum being about 40,000 tons (22½ cwts.), and for 1856 about 20,000 tons (22½ cwts.).

It was the "pecten" portion of the main bed that was first sent from this vale by the said Whitby Stone Company, this is said to be easier to

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work in the furnace than the "avicula" band. In the latter bed in this vale small balls of sulphur pyrites are sometimes met with, and have occasionally been collected and sold at 21s. per ton.

Before closing my remarks on Whitby, I may state that ironworks have often been contemplated in that locality, and by different parties, Mr. Hunt, of the Birtley Ironworks, offering to take shares about the latter part of 1840. About 1843 or 1844, the late George Stephenson, C.E., was sanguine as to the success of ironworks in that neighbourhood, but I understand that when the papers were laid before his son, Robert Stephenson, Esq., M.P., he was not so sanguine, owing to his having at that time great expectations as to the results of the Weardale iron-ore just then being opened out. However there is now something more like certainty as to the erection of blast furnaces in the district. At Beckhole, eight miles from Whitby, on the Whitby and Pickering Railway, a company has been formed called the Whitby Iron Company (limited), to work mines and make iron. The mines at Beckhole have been opening out during the last eighteen months and are as yet in the seam so-called the top seam, which varies here from 4 feet to 14½ feet thick, and thus irregular. I subjoin a section, viz.:—

1. Soil and clay, &c.

2. Freestone

3. Coals 6 in., and fire clay 12 in.

4. Freestone.

5. Shale about 8 ft.

		Ft.	In.
	Ironstone........	5	0
	Coarse irony sandstone	1	3
6. Seam known as top seam	Ironstone	7	6
(at its greatest height)	Shale.....................................	0	3
	Ironstone................................	0	6

14. 6

The company purpose also sinking down to the "pecten " and "avicula" beds, the so-called top seam being wrought by drifts or adits.

There are other three or four small ironstone workings between Beckhole and Grosmont station, all in the so-called top seam of Cleveland. It is near the Grosmont station where the North Yorkshire and Cleveland Railway is to join the Whitby and Pickering Railway, and from which to Stokesley this line is incomplete.

There is no doubt that the main bed of ironstone will exist on nearly the whole length of this portion of the railway in some form or quality, but it is lying under level except at the head of some of the branch

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dales, where it is exposed to the surface. I examined some of Mr. J. S. Pratt's ironstone, sunk to in Fryupdale, on the 10th day of January, 1856, and found that it was the seam known as the top seam. As no ironstone is as yet working in this part of Cleveland, I do not consider it necessary to do more than give the following section* made from the I various outcrops in Fryupdale and beside the river Esk, viz:—

	Ft. In.
1. Soil, &c	
2. Freestone..	55 0
3. Seam, known as top seam......................................	12 0
4. Soft jet rock..	4 0
5. Cement rock..	20 0
6. Alum rock..	160 0
7. Hard jet rock...	18 0
8. Shale..	60 0
9. Pecten band, portion of main seam.............	6 0
10. Shale...	30 0
11. Avicula band, portion of main seam.......................	4 4

The analysis of the stone from the top seam will be given hereafter.

The "pecten," Mr. Pratt states at 32 per cent., and the "avicula" as richer. The North Yorkshire and Cleveland Railway is only opened out from Picton to Stokesly, with also the Whorlton Branch, but a few miles before arriving at Stokesly from the south we come to Ingleby Manor Mines, leased under Lord Delisle, by the Ingleby Mining Co., who have been engaged proving the stone; but from the want of the completion of the public railway, as well as of a private branch from it to these mines (which will be about three miles in length) no ironstone has as yet been vended. I append the following section of the strata at these mines, viz.: Burton Head at Ingleby Manor Mines—full rise nearly north.

[see in original text Table]

* Furnished by J.S. Pratt, Esq., and made by his mine surveyor, Mr. Joseph Greenhough.

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[see in original text Table of Cleveland Main or Thick Seam.]

From the above section it will be seen that a third seam comes into view for the first time as a working seam, and is higher geologically than the seam called the top seam of Cleveland, and, therefore, I have called this seam the "Ingleby" top or third seam. The top band of this seam has somewhat the appearance of some parts of the other two seams, and partially as regards the shell or crust having a greater per centage of iron than the bulk. In one of the analyses given, attention is directed to the oxide of manganese, said to be an important element in the manufacture of steel.

The second seam, known as the top seam, has not been seen or sought for here, and when I made my examination of these mines, I was unable to account for the three freestones; but, on comparing the strata in one of the Eston borings (see Diagram), I found they agreed geologically, and satisfactorily proved the true position of the third seam. Whether any type of this third seam may exist in the said Eston boring is uncertain, but, after comparing notes with John Bell, Esq., of the firm of Bell Brothers, who has examined the Cleveland district more minutely than almost any other ironmaster, it appears he has discovered types of the "Ingleby" third seam both at Crainimoor and at Carlton, to the west of Ingleby Manor mines, the result of which I give by the annexed sketch. (See Diagram.)

The "Ingleby " top seam, therefore, evidently decreases to the west, and is only typified in the hills in that direction; and, vice versa,* the so-called top seam at Swainby is evidently decreased in the above hills to the

* This seam is now being sought for at Kildale on the south and east by Messrs Bell Brothers.

[Outline of a borehole situate to the west of the line of cross section of Eston Hills;

Ideal cross section of the hills from Burton Head to Swainby]

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east, and there only typified. The main or thick bed, as will be seen by the section, is much divided here, and about two months ago a blower of gas was met with in it, issuing from a very small fissure in the 2 feet 6 inches shale, which, when first lit up, continued to burn for some time, but the flame was of a bluish colour—this being the third place in this district in which there have been indications of gas. In all probability it comes from the jet rock, where such rock is in a state of perfection, as the rock is so highly bituminous and sulphureous that (as named in Mr. Louis Hunton's paper, before-mentioned), when a small heap was once calcined "at Loftus Works", "the melted bitumen and sulphur flowed in flaming streams."

It may be as well here to remark, that the ironstone proprietors on the line of the North Yorkshire and Cleveland Railway will get more immediate access to the blast furnaces in the Middlesbro' district, by the branch railway called the Middlesbro' and Guisbro' Branch, joining the Middlesbro' and Guisbro' Railway near Morton Grange, and the North Yorkshire and Cleveland Railway near Potto. The length of this branch will be about five miles, but it is not yet made.

On the 23rd June, and in the following month, 1851, I examined the main bed of ironstone at Carlton, and found the following section, taken in a staple sunk on the flat ground to the east of the quarries of the old alum works, viz.:—

[see in original text Table]

From none of these hills, however, are there as yet any opened mines after leaving Ingleby Manor and going west, until we come to Swainby district, which is opened out by the Whorlton Branch Railway from off the North Yorkshire and Cleveland Railway, being about 2¼ miles in Length.

These royalties, I understand, are held by lease from the Marquis of

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Aylesbury, to Messrs. R. W. Jackson, C. Barrett, and R. Watson, and the portion opened out is subleased to Messrs. Holdsworth, Bennington, Byers, & Co., and are called the Swainby mines. These mines only commenced to vend ironstone about the 3rd of March this year, and are now vending about 120 tons per day—200 tons per day as yet being their maximum vend. The seam wrought is the main seam, as will be seen by the following section of the strata at the mines, viz.:—

[see in original text Table of Section of strata in the hills at Swainby Mines.]

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The seam, which above is shewn 23 feet, where cropping out at the top of the dale southwards, has decreased to as follows:— [see in original text]

Again, near to Mr. Pattinson's farm, on the late Mr. Mauliverer's property, the seam supposed to be the so-called top seam is 30 feet below the 24-feet freestone in the above section, and at 220 feet below the said freestone is the main seam, as follows :— [see in original text]

Proceeding along this range of hills to the west and south, and passing Osmotherly, where trials have been made for this ironstone by one of the proprietors (but it is as yet completely closed, there being no means of transit), we come to the villages of Kirkby Knowle, Boltby, Thirlby, and Felis-Kirk, &c, or what may be properly termed the Thirsk district.

On the 23rd day of October, 1851, after having opened out the Eston mines, Mr. Vaughan and myself made a tour into this district, commencing at Thirsk; but our attention being directed solely to the main bed, we passed over the so-called top seam, not knowing then of its existence as a working bed of ironstone, and came to the conclusion that if the lias was its full thickness here, the bottom or main bed would lie very deep, so that we made a very cursory examination of the hills until we got to Osmotherly, where the old alum works gave a more definite character to the strata in which lies the ironstone we were seeking. In October, 1852, Mr. Vaughan and myself were again asked to visit this district with Mr. C. Bradley, of Richmond, which we did, and made an examination of the seam now known as the top seam of Cleveland, in a drift in the property of C. H. Elsley, Esq., at Kirkby Knowle —the seam being about seven feet high. We then decided that it was not the main bed of Eston or Cleveland, but a higher seam, which is now proved to be correct. Since 1852, and up to the present time, several openings have been made in this district in the Rev. C. Johnstone's property, at Thirlby, Dr. Verity's at Boltby, and at Mount St. John's, near Felis-Kirk.

I re-examined part of this district in April last, and the so-called top

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seam is exposed in several places in the properties named. Having had placed in my hands a general section of the strata made, I understand, by the said Dr. Verity, I cannot do better than give it in this place, as it will be of great importance in further examinations of the district. (See Diagram.)

Dr. Verity here indicates the position of the Northamptonshire ironstone, alluded to in this paper as having been seen by Mr. Attwood. The latter part of this section is corroborated by Professor Phillips (whom I had the pleasure of meeting at Rosedale Abbey the day before I was in the Thirsk district). He kindly furnished me with a section, which is as follows:—

[see in original text Table of Measured Section of strata at Felis-Kirk.]

And, in writing me, he states that "great care was taken in making the section," and that he believes it" contains the Eston measures in a reduced state," and considers the "marlstone is unequivocally exposed in the fields immediately north of the section, and is seen in the road-cutting" and hence draws the conclusion that, although the so-called top seam of Cleveland, Boltby, and Rosedale (called dogger and inferior oolite in his work already named), may be here worth working, that the Eston or main bed is not so. These conclusions, of course, depend altogether on the marlstone being correctly identified.

Dr. Verity's section not only gives us a seam to tally with the "Ingleby" top or third seam, but several others in the higher geological formation, as well as one below—the second seam above the so-called top seam apparently agreeing with the "Ingleby" top seam. Want of time in my last visit prevented me examining this district in such a manner as to test the accuracy of the section with regard to the upper seams. In passing Kennicow limestone quarry, I found several ironstone bands, but none sufficiently good to be worthy of special notice. Three yards of the limestone seemed to contain a large per centage of iron also.

This ironstone district is still closed for want of railway communication, although by some it is considered the most likely to supply the West Yorkshire district iron-works, with the so-called top seam as a mixing stone.

[Section of the Strata from Hambleton Training Ground to the ark Beck at Thirlby and the Church Yard at Felis-Kirk;

No. 6 Plan of Rosedale Abbey;

Cross section of drift & shafts near the magnetic quarry at Rosedale Abbey]

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The only special district to which I think it necessary now to allude, is the Rosedale Abbey district, the ironstone from which has attracted a large amount of attention, on account of the large per centage, immense deposit, and magnetic properties. In this district, as by the quotations already given, iron-making must have taken place upwards of 600 years ago; and it also appears that, about 1834, it was reported on; but it was not until the spring of the year 1853 that attention was directed to it as an ironstone. About 1851, East Rosedale district being in want of material to mend the public roads, an arrangement was obtained for carting this magnetic iron ore (as it is now called) at 6d. per load, from the present quarry, for that purpose. The roads so mended, were observed by Mr. W. Thompson, a collector and shipper of ironstone at Staithes, who had occasion to be over in this district seeking for jet. This he soon communicated to Mr. George Park, of Whitby, Mr. Hartas, of Wrelton, and to Messrs. Sheriff, Mason, and others connected with the railway company. Hence the matter was soon before the public, and the district has perhaps been most examined of any part of Cleveland, by parties interested in the iron trade. The attention of the parties opening out this ironstone, viz., Messrs. Leeman, Sheriff, and Hartas, as lessees, has been principally confined to the place known as "The Quarry," and the drift and pit near thereto, shewn on the Plan attached hereto, called the No. 6 or Rosedale Abbey Plan. The principal lessor on the west side of Rosedale, is H. B. Darley, Esq. The quarrystone is entirely unproved as to its extent or thickness; it is lying in a conglomerated state, as though it were a disjointed and isolated batch, forming concentric rings in the hill-end, and not uniformly stratified in any one direction, nor at any regular points, either vertical or horizontal. The depth in the quarry may be called 35 to 60 feet, and not yet at the bottom of the ironstone, from which quarry the ironstone led away as an experimental stone has been taken. The analysis of this stone will be given with the others—the bluish black being the richest. Looking at the Plan, not many yards to the south, a drift is shewn, and also two pits, one sunk and the other not completed, I examined the ironstone proved between the pit sunk and face of the drift, which appears more stratified, but not really so,—in one instance there is a cheek or slip, running nearly parallel to the drift, hading at an angle of 45° to the south. The particulars of the strata and the stone proved will be best understood by the annexed sketch. (See diagram.)

The quality of this ironstone, both from this drift and the quarry

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adjacent, varies in itself, the bulk of the drift ironstone being non-magnetic (so-called). It will be observed from the Plan, that no cross drift in behind the quarry has been driven, so that, as yet, no correct idea can be formed as to the relative position of the two. However, on the road from Hutton-le-Hole, at the point marked A on the said No. 6 Plan, a seam of ironstone, coarse and silicious, is cropping out, but also in a confused state, and is at a much higher elevation than "The Quarry " ironstone, viz., about 65 fathoms, and although the ironstone itself is very much different to that in

"The Quarry", it seems a question of considerable importance, whether it is not the regular seam meeting first with the disturbance, in approaching from the north, and this view is to some extent confirmed by the regular freestone strata capping the hills on the west side of Rosedale, in the continuation of Rosedale Vale northwards, where, about two miles up, we come to the drift called "Sheriff's Drift" (shewn on the Plan), where a seam of ironstone is drifted into for about 40 or 50 yards, and the following is a section:— [see in original text]

This ironstone is about 41 fathoms more in elevation, than the ironstone at the quarry, but is about 24 fathoms lower than the point A on the plan at the outcrop.

The analysis of this ironstone will be given, shewing the different value it has from the so-called magnetic "Quarry" ironstone. I have no doubt that this seam is the same as the seam at the point A on the Plan, as also the same as that found on the east side of Rosedale, in Captain Vardon's property, of varied thickness, as well as the same seam as that at Grosmont, Fryupdale, Swainby, and Boltby, as the top seam of Cleveland—the nine inches of coal in the pit sunk agreeing with Beckhole, near Grosmont, in particular; so that the only doubtful point is as to the portion from the outcrop at A to the so-called magnetic "Quarry," the most feasible solution being, that it is a disjointed patch of the regular seam, known as the top seam, and not a vein, as has been said; and, with all due deference to the parties

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who have had more opportunity for examining this district than I have I propose leaving the extent of the magnetic and extra per centage tract as an unsolved problem, as it may vary from one or two acres to any indefinite extent, not being at all proved to the south.

About two miles south-west of the magnetic "Quarry," near to a place trailed Loskey Bridge, on the road to Hutton-le-Hole, a trial pit, called the "Hutton Pit," has been sunk so far, to test the stone, but without any definite result. Near to the said Loskey Bridge is a soft blue sandy rock, thought to be an outcrop of this stone, and is about 20 fathoms lower in elevation than the magnetic "Quarry." Whether it is the outcrop or not is very doubtful. This ironstone is not a true magnetic— that is, it will not attract iron itself, but is attracted by the magnet before calcining. I cannot make out, from the results of the experiments, that the iron from here, is better in any of its qualities than the iron from the main seam of Cleveland, and if so, the commercial value of this district, will resolve itself into a pure question of calculation, at the same time involving many elements, the item of railways being the principal one.

The ironstone for experiments has now to be carted upwards of ten miles to Pickering, at from 6s. 8d. to 7s. per ton, and thence via Malton and Thirsk to the northern iron furnaces. The Derwent Iron Company have got about 2,000 tons of this stone, the result of a portion of which, in quantity, was from 48 to 49 per cent. About 200 tons and 450 tons have been sent to two firms in the Middlesbro' district for experiments, besides small quantities to Masbro' Iron-works, and to South Durham Iron-works near Darlington, making an aggregate of from 3,000 to 4,000 tons vended. The nearest railway is the Whitby and Pickering Railway, having the South and West Yorkshire Iron-works in view; but this route is, I believe, abandoned, the promoters being wishful to get on to the North Yorkshire and Cleveland Railway, either by Fryupdale, Danbydale, or, as is said to be most feasible, by Ingleby Manor mines, and so join the railway there, thus making about 14 miles to the North Yorkshire and

Cleveland Railway, and thus have (by the intended junction of the North Yorkshire and Cleveland Railway with be Middlesbro' and Guisbro' Railway) direct access to the centre of the North Cleveland iron furnaces. But before much outlay is incurred for the transit of this ironstone, further tests ought to be applied as to the extent of stone of equal quality to "The Quarry" ironstone.

Before following up the account of the iron-works built since 1846, it now only remains for me shortly to refer to some of the various analyses

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made at various times, of the ironstone from the different places, and in so doing, I would wish to caution speculators in ironstone mines from placing too great confidence in such analyses, however chemically correct they may be as to the identical piece of ore subjected to examination They alone are not sufficient data on which to open out or condemn ironstone mines, particularly in Cleveland, as so much depends on the getting of fair average samples of the ore, and applying such analyses, mathematically correct, to the bulk of the stone; as also in respect to the difference of such at the outcrop, to that in the solid, arising from long exposure to the air and other causes; as also the difference in the shell or crusts from the internal bulk—in the latter item alone varying in some cases from 10 to 15 per cent. of metallic iron.

If, however, we perform our analyses upon a large scale—say a few hundred or thousand tons in the blast furnace—we subject it to a practical test, the objections as to good or bad workmanship applying equally to the chemical test as to this. On the other hand, I believe chemical analyses have been and are too much neglected in iron making, and would, probably, if more generally applied in regular work to all the materials used, be the means of important results as to quality.

The analyses I have tabulated, as far as is practicable, having been made in various ways by various parties. Where they have been published, reference is made thereto for description of process and other details. The various works may be consulted advantageously, and, although the results are very various indeed, they are, in all probability, chemically and practically correct with regard to the actual specimens experimented on, and, at the same time, are perhaps in many instances wide of the real results of the bulk of the mines.

I first give analyses of the main or thick bed.—(See Table annexed.)

The practical calculation is that three tons of the north part of Cleveland main seam will make one ton of iron, and that it requires nearly four tons of Whitby main seam to one of iron. Notwithstanding the foregoing analyses, the main bed of Eston ironstone has often exceeded Dr. Maugham's estimate of 35 per cent. from the blast furnaces, I have no doubt up to 37 per cent. Of course allowance ought to be made for the difference there is between the pig iron from the blast furnace and pure iron. I now give the analysis of the seam called the top seam of Cleveland.—(See annexed Table.)

The foregoing analyses clearly shew the truth of the remark as to the irregularity of quality of this seam.

I next give the analyses of the "Ingleby" top or third seam as follows:-

[Analyses of the Bed or Seam, known as the Top Seam of Cleveland Ironstone;

Analyses of the Main Bed or Seam of Cleveland Ironstone]

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[see in original text Table of Analyses of “Ingleby” top or third seam]

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The top hand of this seam averaging two feet two inches is the main feature of these mines, and what effect it will have on the quality of the iron, by its use as a mixing stone, is as yet untested by actual proof, considerable weight being placed thereon by the lessees, on account of the large per centage of manganese named by Mr. Herapath.

The only other analyses I have now to allude to are those named in Mr. Crowder's first paper, in April, 1856, as to (Scugdale) Swainby, viz.:— [see in original text]

Mr. Crowder calls attention to "the three top and two bottom beds" being similar" to Hutton-Lowcross and other places, whilst the middle beds are very poor in iron and rich in lime," having formerly been tried for a true limestone. From the section already given, Nos. 1 to and with No. 7, being from the seam known as the top seam, and No. 8 or Scarthnick being the same as the present working seam, and identical with the main bed of Cleveland.

I now continue the account of the erection of the blast furnaces since 1846.

The iron-works having now the advantage of an almost unlimited supply of ironstone by rail from the north part of Cleveland, with the extra incentive of high rates for pig iron during most of this period, the erection of blast furnaces increased very fast, and in the following order, (beginning where we left off,) viz.:—

12th. Bedlington Iron-works.—Belonging to Messrs. Longridge, and consisting of two blast furnaces. The first was erected about 1849, and the last in 1854, and were intended for a mixture of local coal-measures ironstone with Cleveland (Whitby) stone. They have been out of blast since September, 1855.

13th. Middlesbro' Iron-works.—Belonging to Messrs. Bolckow and Vaughan, consist of three furnaces, and were erected about 1852, for Eston ironstone.

14th. Eston Iron-works.—Belonging to Messrs. Bolckow and Vaughan, consisting of six furnaces, were erected about 1853, for Eston ironstone.

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15th. Cleveland Iron-works.*—Consisting of three furnaces, were erected in 1853 and 1854; belong to Messrs. T. L. Elwon and Co., and were intended for Eston ironstone.

16th. South Bank Iron-works. — Consist of three furnaces, were erected in 1854 and 1855, and belong to Messrs. Bernhard Samuelson, and Co., and were also intended for Eston ironstone.

17th. Tees Iron-works.—Consist of four furnaces, were erected about 1854, and belong to Messrs. Gilkes, Wilson, & Co., being intended for Hutton-Lowcross and other Cleveland ironstone.

18th. Darlington Albert Hill Ironworks. — Belong to the South Durham Iron Company, and consist of three furnaces. Two were erected about 1854, and one in 1857†, for Hutton-Lowcross and other Cleveland ironstone.

19th. Ormesby Iron-works.—Belong to Messrs. Cochrane and Co., consist of four furnaces, and were erected in 1854 and 1855, for Hutton-Lowcross and other Cleveland ironstone.

20th. Clarence Iron-works.—Belong to Messrs. Bell Brothers, consist of three furnaces, and were erected in 1854 and 1855, principally for Normanby ironstone.

21st. Stockton Iron-works.—Belong to Messrs. Holdsworth, Benington, Byers, and Co., and consist of three furnaces, erected in 1854 and 1855, for Swainby and other Cleveland ironstone.

22nd. Wallsend Iron-works.—Belong to Messrs. Palmer and Co. (lately to Messrs. Carr & Co.), and consist of two furnaces, and were erected in 1854 and 1855, for the so-called top seam ironstone from the coast.

23rd. Felling Iron-works.—Belong to Messrs. Pattinson and Bell, consist of two furnaces, and were erected in 1854 and 1855, for Normanby and other Cleveland ironstone.

24th. Bradley Iron-works.—Belong to Messrs. Richardson and Co., consist of four furnaces, and were erected in 1854 and 1855, partly for local ironstone as well as Cleveland ironstone.

25th. Norton Iron-works.‡—Belong to Messrs. Warner & Co., consist of two furnaces, and were erected in 1856, principally for the Swainby and North Yorkshire and Cleveland Railway ironstones.

*Since this paper was read, an arrangement has been made, by which these iron-works have become the property of Messrs. Bolckow and Vaughan; and Messrs. Elwon, Malcolm and Co., have commenced the erection of new iron-works, near Eston Junction, to consist of two or three furnaces, and to be called the Clay Lane Iron-works.

† Has been put into blast since this paper was read.

‡ The "Big Ben" bell of Westminster Parliament Houses, was cast at these works.

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26th. Washington Iron-works.—Belong to the Washington Chemical Company and Messrs. Bell Brothers, consist of one furnace, and were erected in 1856, for Normanby and other Cleveland ironstone.

27th. Haltwhistle Iron-works.—Belong to Mr. Joseph Beasley, jun., from Birmingham, consist of one furnace, and were erected in 1856, for local clay ironstone and brown hematite from near Alston; still, by railway communication, they may be considered to belong to the northeast part of the North of England.

Thus, it will be seen that, from 1846 to and with 1851, a period of five years, we have only one new furnace erected, viz., at Bedlington, in 1849. But it is to be remembered that it was during this period that a severe financial crisis existed, as also that the price of pig iron was very-low during part of this time;* then, from 1851 to the present year 1857, or say a period of only six years, we have the large number of forty-eight more furnaces erected, and nearly all for Cleveland ironstone; making now a total of eighty-six blast furnaces, besides the following ten† furnaces, either in course of erection or under arrangements for the same, as well as others said to be contemplated, viz.:—

28th. Brenkburne Iron and Coal-works.—Consisting of two furnaces, are situated six miles from the North-Eastern Railway, north of Morpeth, in Northumberland (and come into the list under the head of North of England), and are intended primarily for local ironstone from the carboniferous limestone measures, similar to Ridsdale Iron-works.

29th. Victoria Iron-works (Wreck Hill, near Hinderwell).—Have been already alluded to, being on the sea coast, and are intended to consist of two furnaces.

30th. Jarrow Iron-works.—Belong to Messrs. Palmer & Co., and are intended to consist of two furnaces for the (sea coast) Rosedale ironstone.

31st. Middlesbro' New or Tees-side Iron-works.—-Belong to Messrs Snowdon and Hopkins, and consist of two furnaces, being intended for Cleveland ironstone.

* The price of pig iron (No. 1) on the Clyde, from 1840 to and with 1855, is as follows:-—See "Chart of the Properties and Prices of the Metals chiefly used in the Arts and Manufacture," &c, by William Johnston, metal merchant, Glasgow. [see in original text Table of price per ton of pig iron (no. 1) on the Clyde]

†Since this paper was read Clay Lane Iron-works have been begun, thus making eleven new ones, and thirty-three in all.

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32nd. Beckhole Iron-works.—These works are intended to consist of two furnaces, and have been already alluded to as belonging to a public company called the Whitby Iron Company (Limited).

It now only remains to notice a few of the most prominent results in the district; and the first is a most direct one, on the Stockton and Darlington Railway, raising that railway from its somewhat depressed state of 1850, to one of extreme financial prosperity at the present time. The following extracts from the Company's accounts (including Wear Valley, Redcar, and Weardale Extension Railways) will shew the extraordinary increase of traffic, viz.:[see Table in original text]

The increase of ironstone, limestone, coke, and coals for iron-works, will be seen to be as marked as the decrease of coals and coke for export, the aggregate increase being very marked within the last five years: and the aggregate tonnage of all kinds being about 3½ million tons in 1856. Of course this extension of traffic applies, in a modified extent, to the other railways and means of transit in the district.

On the South Durham Coal-field this great extension of iron-making cannot but have had, and will continue to have, a most wonderful effect, when we consider that there are eighty-six blast furnaces altogether, of which seventy-three are at present in blast, to which the supply of Cleveland ironstone is equal to sixty-five furnaces, leaving only eight furnaces in extent to be supplied from other sources. And out of these sixty-five furnaces about two-thirds are drawing their supply of coal from the South

* Sent from Middlesbro' to Witton Park Iron-works.

Durham coal-field. These seventy-three blast furnaces will produce about five hundred and eighty-four thousand tons of pig iron, or upwards of half a million per annum, requiring for such production about three million tons of coals or coke. And in the capacity of either coals or coke, we have from this coal-field nearly one and three-quarter million tons of coals consumed yearly for pig iron making. But, in order to shew more strikingly this consumption of coal, it may be stated that the seventy-three furnaces in blast are consuming coal equal in extent to 600* acres at least, of four-feet seam per annum, of which I estimate 350 acres to be got from the South Durham Coal-field—equal to the drawings of at least fifteen moderately-sized collieries. Also, taking different yields from the various districts into account, we have not less than 1,690,000 tons of ironstone vended from this Cleveland district yearly†, being equal to about forty-six acres of a seam, five yards thick, of ironstone; and thus a square mile of such a seam would supply the sixty-five furnaces for about fourteen years.

Further, these seventy-three blast furnaces are consuming at least 379,600 tons of limestone yearly, for fluxing; so that these items combined will shew the extent to which the professional members of this Institute must be interested in the said Cleveland district.

It is neither necessary nor essential to this paper to compare the present production and make of iron with that of former periods. For the sake of contrast, however, let us take one or two years, viz., in 1820, the consumption of iron in England was only 400,000 tons or 184,000 less than the quantity now made from these seventy-three blast furnaces; and even in 1840 it was only 1,000,000 tons, or not twice the make by the said furnaces. In 1854, the make of pig iron in the British Isles was 3,069,838 tons—the North of England thus furnishing nearly twenty per cent of the whole.

I now wish to draw attention to the last result that I think worthy of notice, and that is an important one, viz., the value of coals and coke, when delivered from the South Durham coal-field into the Cleveland iron making district, which is so great that trials are going on with he

* This equals near 8¼ acres per furnace per annum; but with the coals consumed in production and transit of such to the furnaces, even ten acres per furnace per annum may be considered a fair estimate.

† Instead of commenting on the shipments and prices of the pig iron from Cleveland I have thought it better to append Messrs. Pauls, Buck, & Co.'s Circular dated 14th January, 1857, minus their list of furnaces. (See Appendix A.)

view of finding the continuation of that coal-field under the lias formation. It is not my intention to express any opinion hereon, beyond admitting its possibility, and giving a few facts in connection therewith: as, if coal of suitable thickness, quality, and depth from the surface, be obtained, I need hardly say its importance cannot well be overrated.

Both a sinking and borings have been made within the last eighteen months at Coatham, near Redcar, to the depth of about thirty-two fathoms, but, although rumour said a four feet seam of coal was found in the first boring, (on which, if there, the usual value of lessors' interest, stipulated for by a mining engineer of experience, was quadrupled), such seam, if ever there, disappeared on the approach of the sinking and further boring. These parties stopped boring in April last, being then, I understand, about thirty fathoms down, but no coal has been found, only shale and thin limestone beds.* At Kirklevington, (near Yarm), Lord Falkland has bored to a depth of upwards of 100 fathoms, in which he has gone through various beds of sandstone, and is said to have gone through the magnesian limestone, and now to be boring in the lower new red sandstone, having previously passed through two or three thin coal seams of two to three inches thick. These two places represent the present trials. As regards the former, W. W. Smyth, M.A., in the "Geological Survey, 1856," (already quoted from), has a foot-note as follows,—"It is intelligible that the discovery of neighbouring coal should be regarded as a desideratum ; but it says little for the spread of sound knowledge in the district, that at the present time a trial for coal should be in operation at Redcar, where people, more sanguine than prudent, are founding their hopes on the very shales, loaded with lias fossils, which, as has been pointed out to them by a geological neighbour, distinctly warn them to desist." The warning here alluded to I presume to be that of Professor Phillips, in his work, already mentioned, of 1829, and from which I now quote:—"the opinions of working colliers on this point have too often been preferred to the legitimate deductions of science, and even yet persons will, perhaps, be found willing to credit the delusive tale of finding good coal by going deeper. But the warning must be given though it be disregarded, and from all the natural exhibitions on the coast, as well as from the result of every experiment inland, I am compelled to state, that any hope of discovering seams of coal more than eighteen inches or two feet

* In 1778, a boring was made at Coatham, by the late Sir Charles Turner, to the depth of forty or fifty fathoms, but no coal was found. (See J. W. Ord's History of Cleveland, 1846)

in thickness, in any part of the strata above the upper lias or alum shale, is entirely unsupported by reason and experience. That the coal measures of Durham and Western Yorkshire exist (covered by magnesian limestone and red sandstone) beneath the lias, is probable, but the practicability of reaching them by pits, even in Cleveland, or near York, is very questionable, and the expense of the experiment may be ruinous." Still as I have said before, it is possible to find the South Durham coal measures, but, of course, below the lias. I quite agree with the Professor's remarks as to no thick coal seams being above the lias, but, notwithstanding the remarks just quoted, nothing has yet been shown to prove that the South Durham coal-field does not lie within reasonable depth below the lias. Others have bored on the coast, amongst them are, Zachary Moore, about 1740, and Lord Dundas in 1794. (See J. W. Ord's work of 1846.)

At Dinsdale, on the Tees, in 1789, several trials for coal were made, two of the borings being carried to the respective depths of sixty-six and seventy-four fathoms, of which thirty-two fathoms of the lowest beds met with consisted of white and grey sandstone, without any mixture of the red strata. The deepest Dinsdale boring, viz., Woodhead, is the one from which Middleton Spa now issues, being from a blue stratum lying under gypsum, at the depth of about 19½ fathoms.

At Entercommon, near Smeaton, three miles south of Dinsdale, a boring was made to the depth of 111¾ fathoms, with a similar bottom to the two at Dinsdale, and fifty fathoms, near the surface, of red sandstone with a few bands of hard stone.

These last particulars I take from the works of the Rev. G. Young, and G. C. Greenwell, respectively; from the latter of which I transcribe a section of the strata at Oughton, near Hartlepool, viz.:— [see in original text]

Mr. Greenwell, in his work just quoted, in order to make the likelihood

* A copy of this account in my possession makes this 4 ft. 6 in. more, and thus the total 88 fathoms 0 ft. 11 in.

[Ideal cross section from Castle Eden to Eston Nab;

No. 7, Section from Hartlepool to Castle Eden & Seaton.]

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of coal being found in Cleveland greater, supposes that the red sandstone and coal measures may become conformable at this point; and without calling this in question, I think other reasons may be given why the finding of coal here may be possible, and in order to give data for judgment hereon, I have appended hereto an outline section of the coast from Hartlepool to Castle Eden (see Map No. 7), and thence northward to Seaton pit, the latter part of the section being taken from the paper of Mr. Wood, President of this Institute,* and I also give the following sketch in illustration of the possible effect of an assumed heaving of the primary rocks in the vale of the Tees. (See Diagram.)

On the other hand, if no change in the disposition of the new formations, with the coal and other older formations, either by dislocations, upheaving, or otherwise, after leaving Castle Eden, then Professor Phillips is likely to be correct; but, of course, the whole, as said before, is, until proved, ideal, and only a possible fact. In conclusion, I must not omit to notice the expected greater facilities of importing hematite from the Ulverstone and Whitehaven districts by the now expected railway from Barnard Castle to join the Lancaster and Carlisle Railway, viz.†, the South Durham and Lancashire Union Railway, and with a very small per centage of which hematite, and reasonable care on the part of the proprietors of blast furnaces, there can be no doubt of iron of the best quality, and at a reasonable rate, continuing to be made in the district.

* On the Magnesian Limestone at the Seaham and Seaton Winning, read before this Institute. (See Vol. V. of this Institute's "Transactions.")

† The Royal Assent has been given to the Act for this railway since this paper was read.

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[Appendix. Tabular Statement of Blast Furnaces]

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(APPENDIX A.)

PAULS, BUCK, AND CO.'S CONTINENTAL REPORT.

Middlesbro'-on-Tees January 14th, 1857.

Sir,

We beg leave to lay again before you a Yearly Report of the iron manufacturing of this district, principally with respect to pig iron; this is a task which affords us the more pleasure as we have to state a further considerable increase in the iron trade of this place.

The annexed statistic tables of the past year, compared with those of 1855, exhibit an increase both in the production and exportation, new markets having been found for the produce of this district. In the course of last year three new furnaces were put in blast, which, together with those in existence before, have been working, with some slight exceptions throughout the year. Our makers have used every exertion to improve still more the quality of the iron, and we may state that their endeavours have been attended with very great success, inasmuch as the foundry pig iron of this district has now almost entirely displaced Scotch iron in the foundries of South Yorkshire and Lancashire, and is now used extensively in all parts of the Kingdom. It has also found a good reception on the Continent, and large orders are now in makers' hands for foreign shipment.

The fluctuation in prices was not so considerable as in previous years, and the difference between the highest and lowest range did not exceed 7s. per ton. The high rates of discount were of beneficial influence to the trade, so far as they checked speculative business, and prices, therefore, ranged in accordance with the proportions of production and legitimate demand.

Against the moderate stock of 25,800 tons, there are sold already about 19,000 tons for delivery in Spring, and a brisk business is expected this year, whilst our makers, with large orders on hand, have already raised their demands. Most of our founders have to execute very extensive contracts, which will call forth a great demand for local consumption. It is also of great importance that the Belgian markets have lately been thrown open to the trade, by a considerable reduction in the import duty of that country.

Our rolling mills were in full operation during last year, and the dullness of the trade of Staffordshire and other districts did not extend to our district. At prices ranging from £8 10s. to £9 per ton, extensive rail contracts have been executed. Common bar iron has not been sold under £8 per ton, and "best" not under £9; many sales were however effected at higher prices during the first part of the year. There have also been concluded of late, some important contracts for the supply of rails, which will occupy the rolling mills of this place for a considerable time.

The increasing importance of Middlesbro' in the export trade, and great improvements that have lately been made in the river, attract a larger number of vessels to our port which renders it daily easier to effect prompt shipments at moderate rates.

We are, Sir,

Your obedient Servants,

PAULS, BUCK, & CO.

[see in original text Table of Present quotations.]

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[Table of shipments to foreign ports of pig iron of the Cleveland district during the year 1856.]

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[Table of Comparative table of foreign shipments.]

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NORTH OF ENGLAND INSTITUTE OF MINING ENGINEERS.

ANNIVERSARY MEETING, THURSDAY, AUGUST 6, 1857, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

Nicholas Wood, Esq., President of the Institute, in the Chair.

The Secretary having read the minutes of the Council, the following gentlemen were elected members of the Institute, viz:—Mr. Anthony Seymour, Newcastle; Mr. W. Routledge, jun., Shincliffe Colliery, near Durham.

The Secretary next read the Annual Report of the Institute.

The President then moved that the Report read be received and adopted, which was carried unanimously.

The following resolutions, founded on the Report, were then consecutively put and carried:—

First,—"That the Fossils of the Coal Formation, delineated in Lindley and Hutton's Fossil Flora, be purchased by the Institute for the sum of £150, together with a copy of the "Transactions" of the Institute up to this date, as previously agreed upon with Mr. Laws, the present owner of the fossils. The said sum of £150 to include the cabinets containing the specimens and any documents or drawings that accompany them."

Second,—"That the Copyright of all papers communicated to and accepted by the Institute, become vested in the Institute, and such communications are not to be published for sale or otherwise without the permission of the Council."

The Secretary then read the Report of the Finance Committee.

The President, after the report was received and adopted, congratulated the members on the prosperous state of the Institute, both with respect

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to the increase of its members and funds. In regard to the latter department, he thought the financial position of the Institute was principally owing to the indefatigable exertions of the Treasurer, who, hitherto, had performed his duty in a most efficient and satisfactory manner. As a mark of their high estimation of their excellent Treasurer, he begged to move a vote of thanks to Mr. E. F. Boyd, the Treasurer, for the able manner in which he had conducted the business of the Institute; and also to the Financial Committee for the satisfactory report they had presented.

The thanks of the Institute to Mr. Boyd and to the Finance Committee respectively, was then moved and carried unanimously.

The Secretary having read a letter received from the Natural History Society, soliciting the co-operation and assistance of the Institute in obtaining a more eligible building than the present for the exhibition of their collection of Natural History, &c,

The President observed, that he thought it desirable that the Institute should co-operate with the Natural History Society in obtaining suitable rooms for the exhibition of their specimens. It would be obvious that as soon as the Institute came into possession of Mr. Hutton's collection of fossils, it would require some place to exhibit them; it, therefore, seemed that the proposition of the Natural History Society formed an opening by which both parties might be accommodated. If the meeting thought right they might refer the letter to the Council, who would take such steps as they thought proper, and then report upon the subject at the next meeting.

After a few observations from one or two members, it was agreed to refer the letter to the consideration of the Council to report thereon.

The President then presented to the Institute Thorp's Diagram of the Yorkshire Coal-field.

The President next observed that, before he closed that part of the proceedings of the meeting, he thought it necessary to make a few remarks on the present state, and future prospects of the Institute. In the first place, it must be highly gratifying to every member of the Institute to witness the rapid progress it had made since its commencement. No one, he flattered himself, could doubt the eligibility and great usefulness of such an institution. In regard to the several papers read during the year, he thought they did great credit to those members of the Institute who produced them; but it could not escape observation, that although the papers were excellent, yet there was a paucity in the discussions of them, and this had often been the subject of remark both here and elswhere.*

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It, therefore, must have occurred to the members of the Institute, that the discussions upon the several papers were by no means followed up with that advantage and usefulness which ought to take place at their meetings, and amongst so many members of such acknowledged practical ability. He, for one, could not satisfactorily define the reason of this, although it appeared consequent on the thin attendance at the Monthly Meetings. The thin attendance might be attributable to gentlemen reading the papers at home after they were printed, and, satisfied with their individual cogitations of them, did not think it worth while attending the meetings for their discussion at the Institute. The custom, as they knew, was to read papers, and at the succeeding meeting to discuss them, but those discussions have not always followed in their order. Some members, on the other hand, might consider the discussion upon one paper not sufficient to induce them to come. It had, however, occurred to him that, perhaps, it would be better if they did not meet so frequently; and that once in two months, when they would have a paper read, and also a discussion of the paper read at the preceding meeting, would have the tendency to improve the attendance at their meetings for discussion. If they adopted that plan then they could have a paper read at one meeting, and discussed at the following. He sincerely regretted, at those discussions, the absence of the old and experienced members of the profession. Some papers, of course, to them, might contain matters of everyday occurrence, and to them of no apparent importance; but, to the younger members of the Institute, the attendance of members of standing and experience at their meetings, and especially any observations from them, could not fail but to encourage and benefit the younger and less experienced members of the profession. If they could therefore add to the general interest of the meetings that would, he trusted, tend to draw together a large attendance of the younger members of the Institute. He, therefore, would propose to the meeting before it separated, a resolution as to the expediency of having their General Meetings only every two months instead of every month, as at present. There was another subject to which he would also briefly allude, and that was the proposed Mining and Manufacturing College. The Committee, to whom they had entrusted the management of the undertaking, had been unceasing in their efforts, and, although not so successful as they could desire, yet they have, he was happy to say, made some progress towards its establishment. Some members of the Committee had had meetings with Lord Granville and Sir George Grey on the subject, and had presented

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a memorial to the Government. The last meeting was highly satisfactory, as both Lord Granville and Sir George Grey expressed themselves satisfied it was extremely desirable that a proper system of education should he extended to the profession generally, and especially to the practical managers of mines. It was represented to the Hon. Baronet that there were twelve thousand practical managers of mines and only twelve Inspectors, and that it was obvious it would be of infinitely greater advantage that these twelve thousand managers should be thoroughly instructed and educated, than that so large a sum as about £14,000 should be paid annually to twelve inspectors. In making this remark, he did not in the least mean to depreciate the services of those gentlemen appointed as inspectors, because he believed, in the discharge of their duties, they had been extremely useful, and especially in enforcing the rules connected with the working of mines; yet, after all, they ought not to lose sight of the twelve thousand practical operatives, and practical managers of the mines, who, in many instances, are so lamentably deficient in education. The Government, he was glad to say, he thought, were impressed with the necessity of promoting a better system of education, and had sent Dr. Playfair to attend a meeting of the Committee in

Manchester, in order, if possible, to strike out some practicable result. Since that meeting a report had been drawn out by the Committee, and they only waited the reply of the Government to the report which would be made by Dr. Playfair, and of some other enquiries which were suggested at that meeting. They must, therefore, have every confidence in the Committee. He thought it his duty to state what had been done up to the present time, and he only begged to add that he hoped they would, at no distant period, arrive at a successful result.

Some conversation next ensued relative to the propriety of altering the day of the General Monthly Meetings from Thursday to Friday; and also of diminishing the General Meetings from every month to every two months. After a brief discussion, the following resolution was proposed by the President, and carried:—

"That, in order to induce a better attendance at the General Meetings, it is resolved that those meetings shall take place every second month,—say in October, December, February, April, June, and August; and that any paper read at such meetings be discussed the meeting next succeeding."

The President remarked that, amidst the numerous panaceas for the prevention of accidents which he had received, there were not many which

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he thought worth the notice of the Institute. One plan was from Dr. Hawkins, whom he had invited to come and explain it; and the other was sent to him by a gentleman of the name of Arundel, who had the management of some coal mines near Leeds, which he (the President) must say was simple and useful. It, however, contained nothing new to the Mining Engineers of this district, as it was merely following out the system of splitting of the air; which system had not been carried out to the extent in Yorkshire as it had been in Northumberland and Durham. The President here briefly explained the system from the plan; after which he proceeded with the reading of his paper on the "Accident at Lundhill Colliery."

Mr. Elliot, at the termination of the paper, begged to propose a vote of thanks to the President for his past services to the Institute. In doing so, he briefly eulogized his character and great abilities, and observed that, whether they looked upon him as the President of the Institute, or in any other capacity, Mr. Wood was ever ready to lend his influence and devote his valuable talents. In regard to the Institute, his attention and unwearied exertions to promote its welfare and prosperity were known to all its members; and he had only to propose the motion to receive the unanimous and spontaneous thanks of the meeting. (Applause.)

Mr. Potter having seconded the motion, it was carried by acclamation.

The President, in acknowledging the honour done him, said he was extremely obliged to them. He could assure them that he had at heart the great objects of that Institute, and no exertion of his should be wanting to bring it to a successful result. What had already been accomplished could not fail but to be highly satisfactory to every member of the Institute. The several papers produced and read at the Institute displayed great ability and experience, and had placed the Institute in a high and enviable position; and all that was required for the future was, for every member to exert himself to ensure a further Measure of prosperity, so that the Institute should be the means of imparting instruction and knowledge to the profession at large, and to the country generally. (Applause.)

The meeting then separated.

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AN ACCOUNT of the EXPLOSION OF FIRE-DAMP at the LUNDHILL COLLIERY.

By NICHOLAS WOOD, President.

On the 19th of February, 1857, an explosion of fire-damp took place at Lundhill Colliery, near Barnsley, in Yorkshire; which, for the loss of life, has been hitherto unprecedented in the trade, comprising no less than 189 persons. Having been called upon to assist in recovering the bodies of those persons, and in restoring the ventilation of the colliery, I have thought an account of the circumstances attendant upon the explosion, of the means adopted to recover the bodies of so vast a number of persons, and of the system of ventilation generally practised in that district would be useful to the Institution, and I therefore take the first opportunity of laying before it such of the facts as have come under my observation, together with such observations thereon as these facts have elicited.

The Lundhill Colliery is situated about five miles west from Barnsley, and is in the centre almost of what is called the Barnsley district, the pit being sunk to the main coal or Barnsley seam.

The following is a section of the strata sunk through in the downcast shaft at the Lundhill Colliery:—

[see in original text Table of Strata sunk through in the 11½ feet shaft, Lundhill Colliery.]

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[see in original text Table of Strata sunk through in the 11½ feet shaft, Lundhill Colliery. – continued]

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[see in original text Table of Strata sunk through in the 11½ feet shaft, Lundhill Colliery. – continued]

It will be seen that the pit is sunk through three beds of workable coal, viz.:—

	Yards	Ft.	In.
The Wathwood, or Milton Field coal	46	0	10
The Abdy coal	75	1	7

And the Barnsley or main coal 213 2 4½

The thickness of the Melton Field coal being about three feet ten inches, the Abdy coal two feet ten inches, and the main coal eight feet two inches—the latter seam being that which is generally worked in this district) and the following are sections of such seam, taken from different parts of the working:—[see Table in original text]

The bed of Low soft coal is taken away along with the lower beds of the section in the face of the banks at Lundhill; the Top soft coal forming the roof in the first instance, but being taken down at the back of the chocks and props.

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At other collieries in this district it is customary to have both beds of Top soft and Low soft coal as a roof in the banks, taking them down behind the chocks.

The "Clay seam" is a bed of soft coal containing pyrites, and is a characteristic of the Barnsley bed.

It is necessary to attend to the strata immediately overlying the Barnsley bed of coal, as this will be seen hereafter to have had some influence as regards the explosion; especially with respect to the manner in which the working of this coal has been carried on at this colliery, and at some other collieries in the district.

The bind, or blue metal laying above the coal, is usually about eighteen feet in thickness. About two feet six inches above the coal is a band of ironstone from two to four inches in thickness, and about one foot six inches above this is another band, from half an inch to two inches in thickness.

The whole of this bind falls in the goaf sooner or later, but the hard rock or post "stone bind," "cank stone and boulder stone," and "strong stone band" in the section, altogether above sixteen yards, has rarely, if ever, been seen to fall in the ordinary working. Though Mr. Brown, the present underground manager, says, "I saw one case during the re-opening of the pit where a small quantity had fallen down."

Two pits, or shafts, have been sunk to the Barnsley bed of coal, one used as a downcast, eleven feet four inches diameter, and the other used as an upcast, nine feet three inches diameter from the surface to the Abdy seam, and ten feet diameter from thence to the coal. There is also another pit sunk to the Abdy seam, on which is a pumping engine to pump the water from that seam; but there being little water in the Main coal, it is drawn to bank in tubs. The depth of the downcast pit is 216 yards 2 feet, and of the upcast 214 yards 2 feet 7 inches, the latter being a little on the rise of the coal, and thirty-three yards distant from the upcast.

The ventilation of the colliery was effected by these two pits, a furnace being placed at the bottom of the upcast shaft, the end of the furnace bars being fourteen feet from the outer circle of the upcast shaft.

An arch of about fourteen feet in width was carried from the shaft for some distance, and the furnace was placed within this arch, and also arched over. The furnace was eight feet four inches in width, the furnace bars being eight feet in length, making sixty-six feet eight inches, area

[A plan of Lundhill Colliery Workings shewing the Ventilation previous to the Accident]

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of furnace; and there was a space, or travelling road, one foot four inches in width, on each side of the furnace, within the large arch, and of two feet six inches above the furnace arch.

Plan No. 1 shows the workings of the colliery and ventilation, up to the time of the explosion; the arrows showing the direction of the ventilation; the single lines the stoppings; the crossed single lines the doors ; and the double lines the regulating stoppings.

The colliery, as will be seen from the Plan, has been worked on a system of banks, or benks, and board-gates. One main road, water level from the downcast, has been driven north and south from the downcast shaft nearly water level, to be used as an intake for the air, and roadway for bringing out the coals, which were drawn to bank only at the downcast shaft. Subsequently, or to some extent concurrently therewith, a second level has been driven on the dip side of the above main level, which, when completed, will, of course, form the water level, and also give two intakes for the air to the north and south extremities.

Parallel with these levels, and to the rise thereof, two other levels are driven, the one next the intake levels forms the general return air drift, from the north and south extremities to the upcast shaft; and the other level is that from which the banks are set out, as will be seen by the Plan. These levels are respectively called, the horse levels, the middle level, and the bank level.

Double or two board-gates are set away from this last level, at intervals of about every 110 yards, to the west or rise, which are driven in advance of the banks, arid which are used as roads to bring out the coals, and as air passages to ventilate the banks. A pillar of coal of eight yards is left between the two board-gates, and a pillar of eighteen yards on each side of these board-gates, leaving, consequently, about fifty-four to sixty yards for the width of the bank.

The whole width of the bank is not, however, taken away at once. A width of eighteen to twenty yards is taken away at first, (a), and continued until it reaches the first holings or slits out of the board-gates on each side, when another width of six yards on each side is set away, (bb), and this is likewise driven up to the first holings, meanwhile (a) reaches the second holings. Another width of six yards on each side (cc) is then set away and driven in like manner, (a) having then reached the third holings, and (bb) the second holings; and lastly, another width of six yards (dd) is set away on each side. The total width, it will be seen, is the original width of twenty yards (a), added

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to three widths of six yards on each side, or thirty-six yards (bb) (cc) (dd), making fifty-six yards altogether. It need scarcely be stated, as it will readily occur, that as all those banks are driven at the same rate of speed, the faces of them will be echelon, the leading banks being successively, the distance between two slips or holings a-head of each other. The twenty yards banks are called the "leading banks," and the successive six yards banks are called the "following-up banks." And the Plan will show the state in which they were in on the day of the explosion.

There is another operation practised in the working of this bed of coal which also requires notice, viz., the packing to secure the workmen from the sudden falling of the bind or shale heretofore noticed.

It is the practice to build pillars, (of such stones as can be procured,) from the bottom to the roof of the coal, to support the roof; these pillars or packs being three to four feet in width. Three rows of these packs or pillars are built in the twenty yards bank; and one row or pillar, in each of the six yard following-up banks. Considering the height of the seam, above eight feet, and the difficulty of obtaining stones, these packs were not very perfectly built, however, with them and the chocks and props of timber, the workmen were very well protected, and very few accidents happen. But it is understood that the falls from the roof in the goaf, generally throw over these pillars laterally, before the face of the bank has advanced very far.

It will be seen from the Plan that the general system of ventilation consisted of one division, or split of the air only. One current proceeding from the downcast along the main water levels to the north, and conveyed by stoppings in the holings, and doors in the board-gates, to the last holing next the face of those levels, then into the west side of each bank successively, then across the face of the banks and into the north board-gates up to the face, and down the south board-gate to the first slit into the next bank; and working south in this manner until it reached the north board-gate immediately north from the upcast, and so down that board-gate to the furnace and upcast shaft. The other current proceeding from the downcast, in like manner, along the south water levels to the face, and working north across the banks, and board-gates successively, to the same board-gate immediately north from the upcast, joining the north air there, and passing with it to the furnace and upcast shaft. Both currents of air passing over the furnace (except what found its way on each side, and over the furnace), to the upcast shaft.

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It has not been clearly ascertained what aggregate quantity of air passed through the mine, but it has been stated at from 50,000 to 60,000 cubic feet per minute.

Such were the state of the workings of the colliery, the system of ventilation, and the mode practised of working the coal, when the dreadful accident occurred.

It will, however, in the first place, be advisable to ascertain the state of the mine, as nearly up to the time of the explosion as could be obtained, from those who had last been in the mine, and who had escaped, and the following is the account given by the respective parties.

William Corbridge said—I went into the pit bottom on Thursday morning about four o'clock; as fireman, I commenced on the south level, and went round all the south west side, from one end to the other. I went round both the boards and the benks and all round the workings on the south and west sides, till I met Illingworth, the other fireman, in the centre or furnace board. I found all the places I visited safe and in good working order. Illingworth and I met at the furnace boards. He is dead. He started his examination on the north levels and all the north west workings till he met me at the appointed spot in the centre boards. We met there near half-past five o'clock. I met

Illingworth at half-past five in the morning, and was employed till dinner time in going round and examining the workings on the north side to see to the air being right and putting up brattices. The last I put up was in the north levels. Then I was looking to see if they were getting the benks right, and seeing that the men were attending to their duties. I did not see brattices put up in any other part. To my judgment the brattices were properly placed, and were in sufficient quantity. They were all in what we may call good working order. On the endings they were not quite so near to the face as the rule requires the brattices to be; but they are not wanted so near. Some were not so near as twelve feet in the slits, as we don't think it necessary, though the rule requires it. As a fireman I thought the pit in good working order then. No complaints have been made to me about the bratticing being too far off.

There was an air-gate on the north side which had fallen in, part of the air current passed up the place which had fallen. It had fallen so bad that a person had to crawl to get over it to get through. There had been a fall on the second benk on the north side. They had commenced driving up in the same manner a new air-gate. This was also so fallen in that it would have to be crawled over. It was crushed in for about twenty yards same as the other. I saw a blower about a week before the explosion, it was just getting into a blaze when I got there. I have seen hundreds of such blowers in this pit as well as others. I examined the goafs and found no gas in them. I went in as far as I could, some three or four feet and some half-a-dozen yards.

John Warhurst said—I never saw the pit in better condition than that morning. I visited every part of the pit, and there was not one place that would fire at my lamp. I tried the goaves, they were all clear and right. I carefully examined the goaves on the day before the explosion with a safety lamp; they were quite clear. It would be in

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the night when I examined them. I did not see gas in any place during the examination. I did not find a place where it would fire in my lamp from one end of the pit to the other. The flame of the lamp did not shew fire at all. We had no Davy lamps at work on that day in any place. It is very seldom we have occasion for Davy lamps. It was always in the boards where we had occasion to use the lamps. I do not know of any place in particular where we had to use lamps. We have not had occasion to use lamps in the straight board-gates for more than six months. We have had occasion at some odd times, when there was a feeder or blower, to use them. We have had feeders and blowers of gas sometimes. We have had them in the second board.

William Lodge, of West Melton, who was working in the benk or upper level on the north side, from forty to fifty yards from the fourth board-gate, said—When I got to my work there was chalked "Be careful" on my stool or buffet. I took my naked candle and went four or five yards. There seemed to be very little air stirring. I says to my trammer, John Earnshaw, "We will fill this corve of slack, and then you shall go and fetch John Warhurst." He went, and Warhurst came to me. I said to him, "How is this here? What's the matter?" I told him I did not like the place. He took his lamp and tried the sulphur. I was fearful of danger—in one respect of being burnt. I continued to work in the pit until half-past 3 o'clock on Thursday morning of the explosion. Warhurst told me it was safe to work without bratticing. I was then working with a candle. He sent me in a Davy lamp by my trimmer, and he accompanied him to the place where I was working. My next turn would have been Thursday night. I was satisfied when Warhurst put his lamp up to the roof there was no danger. The lamp did not lift any way. I have seen the gas fire in a slit on the south level, between the horse road level and the benk level, near to No. 3 board-gate, but not in any other place.

Joseph Swift, an elderly man, said—I am a miner, and have worked at the Lundhill Pit for about 17 months. I was working night shift in the pit on the night of the 18th of February. I was at work at the fifth board on the south side, and left the pit at about half-past 2 o'clock in the morning. I had no reason to complain that the pit was in a bad state, because it was not. I had no complaint to make against any one.

George Burrows, Lundhill, collier, deposed—I worked in the dip-board at the Lundhill Colliery. During the night of the 18th of February, I was working in the pit. I left about 4 o'clock in the morning. Where I worked there was no gas, and all was in very good order. I have not any complaint to make about the workings. I think the sulphur in the old workings has been out of the reach of the fire-triers.

John Thompson, of West Melton, collier, said—I have not seen any gas in the part where I was at work. There was not any brattice there. The benk was good. We always worked with candles in that benk. I have worked there six months. There was a fall at the other end of my benk on the Monday before the explosion. The falls in my benk have been gradual, and not large. When falls have taken place I have not observed much gas.

John Robinson said—I left the pit on the morning of the 19th about 3 o'clock. The pit was as safe as ever it was that night, ever since I commenced working in it. I have seen gas in the board-gates.

Edward Simmonds said—I could not tell that the state of the pit was different from other days. I cannot form an opinion as to the cause of the explosion.

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David Rollings—I was working in the Lundhill Pit on the day of the explosion, on the north side of the first board-gate. I was driving the left hand board-gate. I left the pit about fifteen minutes before the explosion, with Leonard Thornton, Charles Murgison, and others. Nobody had said anything to me about the pit being dangerous. When I came out of the pit I think it was in as good a state as ever I saw it. I always considered the pit as safe as if I was at home. Before the explosion I should be between 400 and 500 yards from the pit bottom. I had worked in this board-gate since the fore-end of January. I have not seen any gas in this board-gate. I am a judge of gas.

William Hubbishaw, collier, said—I was working about 200 yards from the shaft on the north side when the explosion took place. William and John Donkin and Joseph Simmonds were working with me. Simmonds went away from us toward the shaft. We remained where we were nearly four hours. I kept putting my hand up, and I found the air so hot that I did not think it safe to move. Then we got up and got hold of each other, and made the best way we could to the bottom of the shaft. I remember getting about twelve yards from the bottom, when my senses left me. I do not know how I got out. Where we were working the pit was safe, but between the third and fourth board there was a wind-gate which had been in a bad state for three or four months. It was so fallen in to that degree that they could only just creep over it. When Thomas Haliday was there, and he worked there before me, it had fallen in then. It is nearly three months since I went there. I worked in that place six weeks or two months, and it remained in that state all the time. I left it in that state, and have not seen it since. This air-road, to my knowledge, was tumbled in six weeks ago. It had tumbled in to that degree that there was not a free passage.

By Mr. Morton—There would be from twenty to thirty yards of this air-road which had fallen in. For that distance a man would have to creep over it. I have made complaints about this place. Mr. Coe knew all about it. I have seen him come up to it and go back twice rather than go over. He could have crawled over it. He has gone over to measure the work of the men. I have not made any complaint to Mr. Coe or the deputies about the air-course having fallen in. I knew that the rule with regard to the air-courses being five feet by six feet was broken, but did not complain to Mr. Coe or the deputies that I knew. They knew about it. The full quantity of air could not go up this air course, nor the half of it. I made complaints about six weeks ago to young Coe and Warhurst, about the packing being behind, and they told me there were plenty worse off than me. Mine was a following-up benk, and I have been twenty yards up without a pack being put up behind me, and then six yards were put one day, and four yards the next.

John Dunstan, miner, was called and said—I live at Jump, near Hoyland. I was working in the farthest leading benk on the north side, on the Tuesday night before the explosion. I did not work on Wednesday night. I was working at the top of the leading benk. The way out of our benk into the fourth board-gate was partly stopped up. I have not been down the air-gate for nearly three months. They could creep up and down this air-gate for six weeks after the roof fell in, but since then it has been so that nobody could get up and down. The proper place for the air to come to me was up that place which had fallen in. The air had to come round by the fourth board-gate.

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We had very little air in our place. What did reach had to come through the stones. We had very little wind in our place. Sometimes it would blow the candles a little.

By Mr. Morton—Before this fell in we had a good wind. It will be about six weeks since the air was stopped in this way. I cannot say whether the fire-trier came to me on Tuesday night. They allowed me to work with candles in the face of this benk. The fire-trier did not tell me on Monday or Tuesday, or any other time, to work with safety lamps. I am sure that this air-gate is now fallen in, and has been so for six weeks at least. I have tried but I could not get through by crawling.

William Beevers, one of the fire-triers, deposed—I was on the night shift on the south side, on the night before the explosion. I began my round on the south side of the pit about five o'clock on the evening of the 18th. I commenced going on the south level to the pit board. I examined the workings for the men who were coming on the shift. Warhurst and I met that night about half-past five o'clock, in the first board to the shaft. I delivered my report to him that all was right in the levels on the south side. They were free from gas. I can speak positively to this. I left the pit on Thursday morning about three o'clock. Every thing appeared safe. No complaints having been made to me by any one about the pit being unsafe. In my judgment the pit was quite safe. I form my judgment from experience, having been a miner from the cradle. I do not know that this air-gate was opened up to the time of the explosion. I should think this air-gate had fallen for a distance of twenty yards. The air-gate has not been entirely closed. I believe there had been a fall on the north side, but it had been removed some weeks before the explosion took place. None of the air-gates on the south side had fallen in.

Wm. Archer, of Worsbro' Dale, miner, said—I was working in the same hole in the Lundhill Colliery, on Wednesday night, the 18th ult., as Wm. Hubbishaw, namely, the 4th board-gate on the north side. We were taking a two-yard piece up for an air-gate to the benk. The old air-gate had fallen in.

James Flint, of West Melton, said—I have worked at the Lundhill Colliery for about 16 months. I left the pit on Thursday morning, the 19th ult., about 3 o'clock. I had been working in the main level on the north side. I cannot, in any manner, account for the accident. We have always had plenty of air where I worked.

Thos. Dallison, of Lundhill, said—I worked in the No. 2 board-gate, on the north side, up the leading benk. My two sons, aged 16 and 14, worked with me, and came out with me that morning. The wind-gate, which came up to the benk, fell in five weeks ago last Sunday morning. It has been impassable several weeks. The roof has broken down and weighed the packing down, and it had not been put up again. No person could creep up it. It had been in that way for about three weeks. I never saw any appearance of gas to do injury. I have seen as much gas as a candle would flash at. That has been since the air-gate was partly closed up. I have only seen gas there once which would flash a candle. I never told Mr. Coe or his deputies that there was gas in my benk which my candle would flash.

Thomas Price, of Hemingfield—Had, ever since the pit started, worked in the first board on the north side, on the left hand side of the leading benk. There was plenty of air in my benk.

George Ramsden, miner, of West Melton, who worked in the No. 1 board, straight

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up on the north side, said—I have noticed gas in our place several times. I saw some on the 10th of February. I worked with a candle. The gas has flashed at the candle when it has been stuck in the post side. The last time it did so was about the 10th of February. The brattices were not more than four yards from the face. I considered it unsafe, as the gas flashed at the lamps.

Abraham Levitt, of Hemingfield, said—The face of the fourth benk gets air from the place fallen in. It was the air-course to the fourth benk. The air got to the face by no other road. It had fallen about five weeks previous to explosion. Nothing was done towards opening it out that I know of, but a following-up benk which they were making alongside the fall. I consider Lundhill pit a fiery one. I have seen blowers of gas in the pit in the fourth benk on the north side, and the first board on the south. I have seen gas in the pit.

Joseph Coe, viewer of Lundhill Colliery, said—The benk-gate in the No. 4 board on the north side was partially fallen in. I went up the fallen benk gate as far as I thought it prudent to go. ... I then examined the goaf in that benk for about ten yards and found about two feet or two feet six inches of room on the top of the fallen stone. ... I went down the following-up benk-gate (No. 2 board), about eight or ten yards in into the benk that had fallen in, and examined the goaf, and found it free from gas. . . . About two feet had fallen in between the first and second following-up benks (No. 1 board). ... I did not find any blowers of gas, but in the face of all the board-gates we generally find a little gas making. One of the witnesses spoke about blowers of gas, but I think they would be lower down. The feeders of gas have neither been large nor numerous. When there is a little water the gas makes a hissing noise in forcing its way through it. In all my examinations of the Lundhill

Colliery (which have been three or four times a week), I have never found any blowers of gas of a magnitude which I considered dangerous. I did not find many small blowers. . . . But in the Lundhill pit which made such a small quantity of gas, I considered it perfectly safe. I have never found a place in the pit yet that would explode at a naked light. I never found one particle of gas, except in the places already referred to, where there were small feeders at the face of the coal. There are about twenty of these board-gate faces, and the gas is given off in small quantities.

Such appears to have been the state of the pit previously to, and at the time of the accident. The evidence shows that gas did exist in the colliery, in the face, generally, of the leading board-gates, and in the benks some of the men had seen gas. But there did not appear to be any defect in the general ventilation of the colliery. The workmen speak of the quantity of air, with one or two exceptions where falls had taken place, to have been quite as usual, and not to complain of. And the only conclusion which can be arrived at is, that shortly before the accident there were no signs of gas to indicate that the pit was in an explosive state where the men were working, or that the current of air was loaded with gas.

The accident took place at about half-past twelve o'clock on Thursday, the 19th of February, 1857. The explosion was indicated by a vast

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mass of dust, smoke, and flame issuing out of the upcast shaft. The report of the explosion does not appear to have been very loud, but the flame which issued from the upcast shaft is stated to have reached a height of from 50 to 60, and at one time to even 100 feet, and which, it is important to observe, continued to issue until means, which will hereafter be detailed, were taken to reduce its violence.

It appears, likewise, that the explosion threw the cage, or chain, which was near the top of the upcast shaft, up to the pully wheels and gearing, in which it became entangled. An attempt was made to extricate the cage, which was ineffectual, and the rope was cut, and put on the other side of the shaft. A bucket was put on this rope, and Mr. Coe, the underground manager of the mine, and two men thus descended the downcast pit. It was between three and four o'clock, viz., two hours after the explosion. When these persons descended, they found some of the boards blown off in the shaft, which caused some detention; and when they reached the bottom, there were fourteen or fifteen of the workmen at the bottom calling out to be drawn to bank; which was immediately done.

It is important, in a case of this nature, to attend very particularly to the state of the mine when first entered after the explosion. I shall, therefore, from the evidence of the persons who first entered, and from subsequent inquiries made by my colleagues and myself, give the particulars thereof.

Warhurst, the fireman, said—I went from the shaft and looked round as far as was prudent, and when I got to the cupola I found a great blaze, and a man lying on a heap of burning coal. I was unable to get more than a few yards beyond, in consequence of the fire-damp. It fired in my lamp. I returned to the level, and met another dead body forty yards from the other. I went on further along the south level, and met with another dead man. A little further I found another; and then I returned to the shaft, as I did not think it prudent to go further. I got as far as the fourth board with another person, and eighty yards further by myself. I went out of the pit, and reported what I had seen to

Mr. Coe, who, with Mr. Wm. Maddison, Mr. Utley, and Mr. Webster, I returned down the pit with. We proceeded as far as between the second and third boards. There we met with four or five dead bodies, about 250 yards southwards. The foul air then showed fire in the lamp, and we returned together to the shaft bottom, as we were all afraid to go further. I went to the top and brought down more men. Mr. Coe and Mr. Webster left me in the bottom, and told me to take the men to the dead bodies we had left, and then to return to them on the north side, I went with the men and Benjamin Hoyland, and I went as far as the fourth board on the south side, and forty yards up it. There the gas fired in the lamp. We did not find any more bodies beyond the place where we had found them before. I left the men to take the dead bodies to the bottom of the pit, and they were accordingly place

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there. I next proceeded along the north side, and found five or six dead bodies. We kept meeting with them on the north level, till I came to the end of it. Altogether I found sixteen or seventeen dead bodies, about one-half of whom were removed to the bottom of the pit. Frightened that the cupola shaft would fall in, we could not stay for the other bodies to be removed. We were alarmed, because we thought the furnace shaft would fall in and stop the draught. I went to the cupola, and the coal was on fire, the flames extending at least twenty-five yards on each side of the furnace bottom. I said to the gentlemen, if we stop here much longer we shall be numbered among the dead, for the shaft is falling in. I had seen the arches of the furnace pit fall. I also saw burning masses of coal falling from the sides of the furnace drift or road, and creating the flames. Mr. Coe and the other gentlemen agreed with me, and went out at once. The stables were all in flames. The stables were thirty yards in length, and were apparently all on fire, flaming and raging furiously. We could not get to both sides of the stables, as we found the board filled with inflammable gas, which fired in our lamp up the first board-gate on the north side. We went up every board as far as we could get. There was inflammable gas up every board, and there was after-damp so powerful as to bring the tears from our eyes. The greatest distance we got up any board was forty yards.

Mr. William Maddison, Barnsley, colliery viewer, said—After examining the plans of the colliery, immediately afterward we all proceeded to the pit together with William Utley, underground steward of Wombwell Main Colliery, and proceeded to the bottom of the downcast shaft. We had very great difficulty in keeping our lights, those in Davy lamps were altogether blown out. We were compelled to make use of a common glass lamp. On getting out of the tubs at the bottom, about eight or ten feet from the rails, we had to scramble over a large amount of debris and a large amount of broken slides, to the lamp cabin, where we lighted our Davy lamps. We immediately went along the south horse road, and the first opening we came to was a direct communication with the bottom of the upcast shaft, in which Mr. Coe informed us there had been two doors, not a vestige of either of which remained. The fire at the bottom of the upcast was raging furiously, the whole of the arching was one complete mass of ruin, and flames were shooting between the stones. We could also see fire coming down the centre board-gate to the furnace at the bottom of the upcast shaft. We then turned to the west in the hope of getting round to the fire; but in the first end, in the rise to the upcast shaft, we saw the flames shooting to the left, and stopping us from going in that direction. We continued to the rise, and at the first corner at the next end we found the coal on fire, but so slight that it was afterwards put out. We got about one pillar higher to the rise, at this point Mr. Coe left us, and went still further up. He returned and said he had lost the air and could proceed no further. We then came down the second board-gate, he continuing along the ending to the south. He joined us on the horse-road about 100 yards from the shaft. We continued along that horse-road turning up the different board-gates, and following the fresh air as far as we had it with us, and until the lamps fired. We so proceeded along the south horse-road about 350 yards and found three dead bodies. We went up every board we met with until we were stopped by the foul air, and the gas fired in the lamps, beyond which we considered it unsafe to go. We then returned to the downcast shaft, lost our lights, scrambled over the debris, lit our lamps, and then went on the north side. At the

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bottom, about ten or twelve yards along the horse-road, we saw a horse dead, which had just apparently come to the shaft bottom with a train of coals. In front of him had been four or five tubs, on the top of which he had been blown by the explosion. We then proceeded a few yards further and turned up the board into the stables. We found one horse lying dead at the entrance into the stables, and another one just previously. The stables we found on fire, the fire being principally on the high side of the stables, and more particularly at the head of the stables in the hay crib and at the edge of the coal round about. We then returned to the horse-road and went along it, turning up the first board-gate we met, in the endeavour to get to the other end of the fire, a large body of smoke was backing along towards the north, but we could not perceive any fire. We then turned along the north horse-road and proceeded along it, having a current of air along with us. We found several dead bodies, and could proceed no further on account of want of air and firing of the lamps. Again we proceeded to the north horse-road, and went along it, examining the stoppings as we went, some of which were not seriously injured. We went up the No. 3 board-gate, about as far as in the other cases (forty or fifty yards). We again had to return on account of want of air and firing of the lamps. We continued along the north horse road until we were within forty yards of the face at the foot of No. 4 board-gate. At this point we found a dead body, but so blackened that we could scarcely tell whether it was burned or not. I am under the impression it was burned, but would not speak positively. One of the party proceeded to the dip in the east, and into a water level which was then being driven, and found a dead body, which we brought into the horse-road. Just at this time Warhurst, the fireman, came to us from the shaft bottom, saying that if we did not at once return, there would be no means of escape. We did not leave the No. 4 board-gate until we had been in every direction in which it was possible for any one to live. Mr. Coe went up to the No. 4 board-gate, and we in no case returned until the lamps fired. We also examined minutely several places which were being driven to the dip, similar to those last spoken of, but did not find any one living or dead in any of them, those having evidently escaped who had been working in them. We then returned along the north horse road to the shaft, counting the bodies as we passed them, and found them in all to be eight. The last one we had passed in our journey northward, without having seen at all. It was only from the fact of my foot pushing against the body that we were enabled to find it. He was lying under a tub of coals. On arriving near the shaft we again went towards the south end of the stables. We then found the fire raging so furiously that it was utterly impossible for us to go near it. The whole length of the stables was evidently on fire—coal, timber, and all in a blaze. It was fearful to contemplate the difference in the state of the fire that existed, at the time of our first visit and our return. In the first instance, we might have gone up to the fire, and kicked it with our feet; but in the second we dared not approach it by many yards. Again, we went past the bottom of the downcast shaft to the upcast shaft, and found the fire there raging most furiously, the whole of the bottom being one white heat, and I can compare it to nothing better than the bottom of an iron furnace. Previously to proceeding along the north horse-road, we gave instructions that the bodies of the three men found in the south horse-road should be brought to the shaft bottom as quickly as possible, in order that they might be sent out. On arriving at the shaft bottom, out of the north

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horse-road, we gave similar instructions with respect to eight dead bodies found in the north horse-road. The men proceeded to perform that duty. We did not leave the pit until I, myself, felt convinced, beyond doubt, that there could not be anybody living in the pit, except those who had come down. We then came out of the pit. It would then be about half-past seven. We proceeded to the office to consult with the proprietors of the colliery as to the best and most efficient means to be adopted in the emergency. We had not left the pit many minutes before the whole of the men we had left down came out, declaring that it was utterly impossible for them to remain any longer. When we got into the office there were present Mr. R. C. Webster, of Hoyland; Mr. Jos. Coe, of Lundhill; William Utley, of Wombwell Main Colliery; Jno. Hoyland, of Rawmarch ; William Duckworth, Wombwell Main; Mr. James Cookson, Hoyland; W. Beevors, Lundhill; Jno. Warhurst, Lundhill; Messrs. James and Ellis Waincock, of Wombwell Main; all of whom are connected with collieries and had been in the pit. Mr. Taylor and Mr. Peacock were there also. There was a consultation amongst the whole of the above, and questions put to each of them as to whether anything further could be done for the recovery of the bodies, or whether it was their opinion that anyone was then alive in the pit? The answer was by each "I am decidedly of opinion, since examining the mine, that there is not now a living person in the pit, and at this hour, 7.40 p.m., it would be dangerous and unsafe for any man to descend the pit for any purpose whatever; now that the fire is raging so badly, the only way is to close the downcast shaft; and it should be done at once." At 7.40 the flames rose, in my judgment, to upwards of 100 feet above the cupola top, the sparks from which rose at least 300 feet into the air. In pursuance of our unanimous decision we then proceeded to close up the two downcast shaft pits, leaving the cupola open. I cannot give any opinion as to the cause of the explosion. Nobody objected to the closing of the shaft.

Mr. Morton—Was every exertion made to get into the pit as speedily as possible?

Witness—Yes. We had all requisite means at hand to meet the emergency. We had no water at hand to extinguish the fire when we first descended. We could not have extinguished that portion of the fire at the bottom of the upcast shaft when we first descended the pit. If we had had a 100 fire engines we could not have done it. The flames extended from fifty to sixty yards. The flames extended westward, and I should think not less than from seventy to eighty yards. I speak now of the period up to the time of the shaft being closed in, afterwards damp prevailed but not to any great extent. There were strong indications of gas all around the upcast shaft, but more particularly on the south side. Gas in a state of ignition prevailed from the two extremes of our journey along the horse-road, a distance of nearly half-a-mile.

Mr. Robert Charles Webster, colliery viewer, said—I accompanied Mr. Maddison and others into the Lundhill pit on the 19th ult. I have heard the evidence given by Mr. Maddison, it is perfectly correct, and I fully concur with him in every particular. I was present at the consultation, when Mr. Coe, Mr. Maddison, and I considered as to the necessity of closing the tops of the downcast shafts in the way described by Mr. Maddison.

From the above statements of Messrs. Warhurst, Maddison, and Webster it would appear that, after the explosion, gas existed in all the board-gates within thirty or forty yards of the levels, both on the north

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and south sides of the pit. That they were, however, able to proceed to the No. 4 hoard-gate on the north side, within forty yards of the face of the level, and about 350 yards from the shaft, or eighty yards beyond the No. 4 board-gate to the south.

Warhurst says—"The coal was on fire at the cupola or furnace, and the flames extending at least twenty-five yards on each side of the furnace pit bottom. The stables were all in flames. The stables were thirty yards in length and were apparently all on fire, flaming and raging furiously." And Maddison says—"The whole length of the stables were evidently on fire, coal, timber, all in a blaze. It was fearful to contemplate the difference in the state of the fire that existed at the time of our first visit and our return. In the first instance we might have gone up to the fire and kicked it with our feet, but in the second we dare not approach it by many yards." At the bottom of the upcast shaft the fire was raging most furiously, the whole of the bottom being one white heat, and I can compare it to nothing better than the bottom of an iron furnace. At 7.40 p.m. the flames rose, in my judgment, to upwards of 100 feet above the cupola top, the sparks from which rose 300 feet into the air.

It is requisite to note the near proximity of the gas to the flames of the burning matter. Warhurst says—"We could not get to both sides of the stables as we found the board filled with inflammable gas which fired in our lamps up the first board-gate on the north side. We went up every board as far as we could get for gas to the north and south. There was inflammable gas up every board, and there was after-damp so powerful as to bring the tears from our eyes. The greatest distance we got up any board was forty yards." Mr. Maddison says—-"There were strong indications of gas all around the upcast shaft, but more particularly on the south side."

We have, therefore, these facts:—That an extensive and rapidly increasing fire existed at the bottom of the upcast shaft and in the vicinity of the stables. That, except in the water levels, the whole of the other parts of the pit were filled with a mixture of inflammable gas and afterdamp. That all the parts of the pit which were not so filled had been traversed by the persons who had gone down the pit; and that as all the persons found in those parts of the pit which could be approached were dead, there was not the slightest doubt that the persons in those parts of the pit, then filled with inflammable air and after-damp, and which were not approachable, were also dead. Mr. Webster says,—

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"When we were in the pit we listened at every board-gate, very attentively, to hear if any living persons were there, all was as silent as death." It will be observed that, during all this time the flames were issuing out of the upcast-shaft, that the fire was rapidly extending in the mine, and that there were fears from the intensity of the flames, arising from the rush of air down the downcast shaft, that the upcast-shaft would be destroyed.

Under these circumstances the following proceedings took place as to closing up the pit, and so checking the velocity of the air upon the fire, with a view towards further proceedings and to extinguish the same. And it will be probably the best mode of conveying to the Institute all the important details, to give the resolutions successively come to by the parties employed.

"Lundhill Colliery, Thursday, Feb. 19, 1857, 7 o'clock, p.m.

Present—Mr. R. C. Webster, Hoyland Colliery; Mr. W. Maddison, Wombwell Main Colliery; Mr. Coe, Lundhill Colliery; W. Utley, Wombwell Main Colliery; John Hoyland, Rawmarsh Colliery; William Duckworth, Wombwell Main Colliery; James Cookson, Hoyland Colliery; William Beevers, Lundhill Colliery; John Warhurst, Lundhill Colliery; Benjamin Hoyland, Darley Main Colliery; John, James, and Ellis Wilcock, Wombwell Main Colliery.

Mr. Webster, Mr. Maddison, and Mr. Coe, accompanied by the other men above-named, descended the mine after the explosion, about 3.30 p.m. this day, and on their return at the hour of this meeting they all concur in the opinion that there is not an individual in the mine alive. That the only hope of preventing the shafts falling in altogether, by the increase of the fire, would be to close the downcast shafts at once, and stop the current of air. These gentlemen wished the other men present to express their opinion separately.

John Hoyland was asked certain questions, in answer to which he said, "I am decidedly of opinion, since examining the mine, that there is not a living person in the pit, and that at this hour (7.40 p.m.) it would be dangerous and unsafe for any man to descend the pit for any purpose whatever, that the only way, now the fire is raging so bad, is to close the downcast shafts, which should be done at once."

The several other men then separately expressed the same opinion,

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seriatim, and it was finally concluded to adopt the course suggested, and the downcast shafts were accordingly closed."

"At a Meeting of Gentlemen, held on Friday, the 20th Day of February, 1857, at the Office of the Colliery. Present—Mr. Day; Mr. C. Webster; Mr. William Maddison; Mr. Thomas Cooper; Mr. R. Maddison; Mr. B. Sellars; Mr. Child; Mr. Woodhouse; Mr. Holt; Mr. Camn; Mr. Hartop.

Upon discussion it was agreed that the first proceeding is to stop, as far as practicable, the top of the downcast pits. That the top of the upcast pit be closed to the extent of three-fourths. That the cupola at the top of the upcast pit be immediately pulled down, and a substantial cover of wrought-iron rails, covered with thick plank, or sheets, on the top, leaving an interstice of twenty-four inches between the rails, which can be reduced or enlarged as found desirable, and that the interstice be across the middle of the pit.

That Mr. William Maddison and Mr. Charles Webster be empowered to give the requisite directions for carrying out the above resolutions.

The importance of the explosion being a subject of the most grave consideration, it was resolved, "That the advice and assistance of Mr. Nicholas Wood be requested, and that Mr. Thomas Cooper do see Mr. Wood and request his attendance at Lundhill Colliery to-morrow at two o'clock, and that it be left with Mr. Wood to bring one or more professional viewer or viewers from the north if he think proper to do so.

"That it is the unanimous opinion of this meeting that, under all the circumstances, Mr. W. Maddison and Mr. Charles Webster had no alternative but to close the pits at the time they did so." (Signed,)

THOMAS COOPER, Park Gate Colliery;

R. R. MADDISON, Worsbro' Bridge;

BENJ. SELLARS, Mineral Surveyor;

JOHN HARTOP, Barmbro' Hall;

J. W. DAY, Hoyland and Elsecar Colliery;

CHARLES WEBSTER, Hoyland and Elsecar Colliery;

W. P. MADDISON, Wombwell Main Colliery;

HENRY HOLT, Wakefield;

JOHN THOMAS WOODHOUSE, Derby."

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"Lundhill Colliery, Feb. 21st, 1857.

In accordance with the resolutions passed at the meeting held yesterday, Messrs. Webster and Maddison beg to report that they immediately proceeded to act up to those instructions, and to remove the cupola from the top of the upcast shaft, and about 4 p.m. had completely removed the whole level with the surface. After which a trench was dug about two feet deep and one foot broad, round the outside of the foundations, (it being apparent that the latter were a good deal shaken), and the whole well puddled with clay. The top of the foundations was then covered with clay and a bed made, upon which the S.Y.R. 84 lbs. rails were laid flat, and with the edges close together, (an opening, one rail in width, being an area of four square feet being left across the centre of the shaft) upon which a layer of puddled clay was laid and all made tight, in which state it is at present.

Several observations with the thermometer and safety-lamp have been made during the afternoon of yesterday, through the night, and up to the present time. The results of which we beg to give, as follows:—

20th February,	4 0 p.m.	105° and put lamp out
	8 0 „	102°
	10 0 „	101½ °
	12 0 „	99°

21st „ 2 0 a.m....... 97°

4 0 „ .... 97°

6 0 „ .... 82½ °

8 30 „ .... 87°

10 10 „ .... 96°

1 30 p.m......... 95°

3 30 „ .... 85°

It will be observed that the opening left on the top of the upcast shaft is much less than the dimensions set forth in the resolution of the meeting, but Messrs. Webster and Maddison, acting upon the discretionary power left with them, considered, on mature deliberation, that such opening would have been too great considering the quantity of fresh air passing down the other shaft, which was, after every effort had been made on their part to close up all apertures, very considerable.

Simultaneously with the operations above detailed, two furnaces have been erected, one at each downcast shaft, connected with which at each furnace is an apparatus for applying the steam jet, the object being to produce a current of incombustible gases, and which are now ready to be applied with vigour at an hour's notice.

Messrs. Webster and Maddison, after consultations with other gentlemen, deemed it the most prudent to allow the result of the furnaces to be tried in the presence of the committee, the more particularly, that they would then have the benefit of day-light, and the opinions of other scientific gentlemen.

CHAS. WEBSTER, W. P. MADDISON."

In consequence of the above request, I made application to Mr. Thos. E. Forster, and Mr. George Elliot to accompany me to Lundhill, Mr.

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Forster was unwell and could not undertake the journey, and Mr. Elliot and myself proceeded to Lundhill on Saturday morning.

When we arrived the resolution of the previous clay had been carried into effect, and the tops of the two downcast shafts had been closed up entirely with deals, on which was laid a covering of clay. The top of the upcast shaft was also closed, with the exception of about eight inches across the middle of the pit. And it was found that a strong current of air and smoke highly impregnated with carbonic acid gas issued through the opening in the upcast shaft. The tops of the downcast shaft not being perfectly air-tight.

The following proceedings then took place.

"Lundhill Colliery, Saturday, 21st February, 1857. (Consultation.)

Present—Mr. Nicholas Wood; Mr. George Elliot; Mr. Charles Morton; Mr. C. Webster; Mr. Wm. P. Maddison; Mr. J. T. Woodhouse ; Mr. Joseph Coe.

Long discussion as to facts as far as they have been ascertained, and as to the best mode of speedily extinguishing the fire.

A strong opinion having been expressed that the introduction of fresh air, which would be required in any attempt to effect this object at once, by opening out the pit and endeavouring to extinguish the fire, would have the result of re-kindling the flame and causing another explosion.

A long discussion then ensued on the expediency of throwing in a jet of carbonic acid gas.

The above parties then agreed to examine the tops of the pits, when it was determined to reduce the opening left at the top of the upcast pit. Afterwards all returned to the office when the report of Messrs. Webster and Maddison, of the state of the mine when they ascended the pit, was read and considered, and the parties who formed the committee of yesterday morning having been also assembled, Mr. Wood explained to the meeting all the points discussed, and particularly that of throwing into the mine a supply of water to extinguish the fire.

After a long discussion and argument it was unanimously agreed that the plan of throwing carbonic acid into the pit, is not necessary in consequence of the vast quantity coming out, and that, therefore, no flame can exist at present in the pit.

That a steam jet be introduced in the downcast shaft, and that in the meantime the water be allowed to run into the workings of the Barnsley bed.

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As it appears from Messrs. Webster and Maddison's report that the temperature in the upcast shaft is gradually diminishing,

It is recommended that the operations above detailed be carried out by and under the superintendence of Messrs. Webster and Maddison until Wednesday next, and that they be requested to report daily."

The effect of closing up the shafts was to subdue, if not entirely to extinguish the flame. There would, however, be the vast mass of burning matter, which, though not emitting flame, cools very slowly when only in contact with almost stagnant air, and, though the shafts were closed as tightly as they could be at the surface, it was evident a considerable quantity of air escaped down the shaft, shown by the quantity of air issuing through the aperture in the upcast. It was suggested that carbonic acid gas should be sent down the pit, but as there seemed to be an objection on the part of the relatives of the sufferers, whose bodies were in the pit, that by possibility there might be some of them alive in the rise part of the workings, and as it was evident the flame had been extinguished, the cooling properties of carbonic acid gas on large masses of burning matter did not appear to be so great or effective, as in this case to violate those feelings, though, in the minds of everyone present, there was not the slightest probability of any one being alive in the pit.

To counteract the effects of so much atmospheric air passing through the leakages of the cover over the shaft, and so acting on the burning matter to keep up incipient combustion, a jet of steam was thrown in underneath the scaffold, which had the immediate effect of steam issuing through the leaks into the atmosphere, instead of so much of the atmospheric air passing downwards into the pit.

It was the decided opinion at the above consultation, that if the shafts were opened, and atmospheric air admitted into the mass of burning matter, it would kindle into flame, and probably produce another explosion; and that, having regard to the many instances where pits had been closed for several weeks, without cooling down masses of burning matter; the only certain, and, probably, the most expeditious, mode of completely cooling down the burning matter would be by pouring water down the pit, and allowing it to rise to such a height as that it would completely cover the burning matter. Orders were therefore given that this should be done, and that at the next meeting a final determination should be come to as to ulterior proceedings.

Orders were given that the temperature of the air issuing out of the top of the upcast shaft should be taken from time to time, and the

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following is the result up to the period of our meeting on the 25th. The steam jet applied at 3h. 50m. on the 22nd.

[see in original text Table]

Previously to our leaving the colliery we were presented with the following letter, which request we immediately complied with, and commenced to act thereon forthwith; and came to the resolution following the above-named letter.

"Low Elsecar and Lundhill Colliery, near Barnsley, 25th February, 1857.

To Messrs. Wood, Elliot, Woodhouse, and Holt.

Gentlemen,—We, the Proprietors of this Colliery, hereby request and authorize you to undertake the entire direction of the operations in re-opening our pits, and recovering the bodies of the persons now lying therein, and you are also hereby empowered to engage, at our expense, such assistants as you may think proper to employ. We are, Gentlemen,

Your obedient Servants,

WM. TAYLOR, Jun., THOS. S. GALLAND, E. T. SIMPSON, W. STEWART."

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"Low Elsecar and Lundhill Colliery, near Barnsley, February 25, 1857.

At a Meeting of the Gentlemen appointed by the Owners to undertake the operation of re-opening the pits and recovering the bodies therein.

Present—Mr. Wood; Mr. Elliot; Mr. Woodhouse; and Mr. Holt.

Resolved,—That it is our unanimous opinion that the only safe, efficient, and expeditious mode of re-opening the pit and recovering the bodies of the workmen is by filling the workings of the mine with water to such a level as will extinguish the burning matter.

That with a view of more speedily accomplishing that object, it is desirable that the water from the brook adjacent to the colliery be twisted and run into the downcast pit.

That until it is ascertained that the water has risen above the roof of the mine of the upcast pit, the tops of the pits remain closed as heretofore.

That Messrs. Maddison, Webster, Brown, and Potter be appointed to take charge of the before-mentioned operations until the next meeting'; and that they communicate daily with the Executive and the Government Inspector.

And that this meeting be adjourned till Saturday next at Ten o'clock.

NICHOLAS WOOD,

GEO. ELLIOT,

JOHN THOMAS WOODHOUSE,

HENRY HOLT."

In pursuance of the orders given by the Managing Committee, the following reports were given of the temperature, and of any other occurrence worthy of notice:—

[see in original text Table of temperatures on the 25th, 26th and 27th Feb]

On the 28th February, pursuant to adjournment, the Managing

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Committee met at the Colliery, together with Mr. Morton, the Government Inspector, when the following were the principal observations made and orders given:—

"That the water from the brook was turned into the downcast pit at 12.30 p.m., on the 26th, and together with the water from the Abdy seam, is still running down the pit, the feeders being about 300 gallons per minute; but that the water has not yet reached the roof of the mine at the bottom of the downcast shaft.

(It may here be observed that the roof of the mine at the bottom of the downcast shaft is about seven feet from the floor of the mine; but that in consequence of the height of the arching for the furnace drift, at the upcast, the roof is about fifteen feet from the floor of the mine: and that the floor of the mine at the latter is about six feet above the level of the floor at the bottom of the downcast shaft).

"Temperature of air at the bottom of the upcast shaft 100°. The temperature of the water flowing into the mine 45°, and of the water at the bottom of the upcast 83°.

"After a long discussion, and after hearing the statement of Messrs. Webster, Maddison, and Coe, as to the extent the fire had reached before they left the pit, and would probably reach before the shafts were closed, it was determined to allow the water to rise to the roof at a point ninety yards west of the downcast shaft, at least, subject to modification, if further information is obtained; and, on the assumption that the seam rises one in twelve, the water to rise thirty feet in the upcast previous to further consideration.

"That upon ascertaining that the water is above the roof of the mine in the downcast pit, the following operations were ordered to be carried out, viz.:—

1. Opening of the engine and downcast shafts by removing scaffolds.

2. Repairing the shafts to the Melton and Abdy seams.

3. Putting doors in the drift between the downcast and upcast shafts in the Melton seam, and also in the drift in the Abdy seam, and that nothing but safety-lamps be used in these operations."

On the 3rd March the following report was made by the viewers:— " Depth of water in downcast, 11 feet 1 inch; temperature of water, 85°, at 12.30 p.m. The scaffolds at the tops of the pumping and drawing or downcast shafts were removed early this morning, and at 1 p.m. we descended the pumping shaft to the Melton field coal, and made an examination of that seam.

"It appears a fire had extended from the upcast shaft to the full rise

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45 yards, and to the dip (being in direct communication with both the downcast shafts) not less than from 30 to 40 yards, and within a distance of 15 yards from the drawing shaft, and 30 yards from the pumping shaft. The stopping within four yards of the upcast had been blown down and others injured.

"The drawing shaft was then descended, and the Abdy seam entered. The drift was traversed from the drawing to the upcast shaft. It appears that this drift is arched with brick throughout. The fire had extended the whole length of this drift, and had nearly burnt one of the conductors in the drawing shaft through.

[see in original text Table]

On the 7th March the Managing Committee and Mr. Morton again met, and found that the instructions given at their previous meeting had been carried out. They gave orders that the water passing down the downcast should be taken down by boxes to the surface of the water, to enable the workmen to repair that shaft and make it ready for drawing water. Ordered three water tubs of sheet-iron to contain 500 gallons each, and directed that the cover should be removed from the top of the upcast.

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The following depths of water and temperatures were taken this day, and continued until the next meeting. [see in original text]

It will be observed that the total depth of water in the upcast shaft on the 24th March was sixty feet six inches. The Committee had previously determined, on the 28th February, that the water should be allowed to rise so as to cover the roof of the mine ninety yards west from the bottom of the upcast, and to a height of thirty feet in the downcast. They met on the 14th March, when the height in the downcast was thirty-five feet eight inches; when they considered that, making allowance for the compression of the air pent up in the mine after the shafts were closed, and after hearing further evidence as to the probable extension of the fire, they considered there might be some doubt that the water had risen to a sufficient height, and that it was advisable to allow the water to flow into the mine until the 18th, when they again proposed to meet.

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Accordingly on the 18th the Committee again, with Mr. Morton, met, when they came to the following conclusion. "After a long and full discussion it is unanimously agreed that the water be allowed to rise to the height of sixty feet in the upcast pit; and that upon its reaching that height, the drawing of water be immediately commenced, and continued without intermission night and day."

The water was then allowed to flow into the mine until the 24th March, when, having reached the height of sixty feet six inches in the upcast pit, it was stopped, and the drawing of the water with the tubs immediately commenced.

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The following table will show the progress made in drawing the water out of the mine until access was obtained into it. The observations thereon during the progress of drawing being given hereafter. [see in original text]

Nothing particular occurred during the progress of drawing water until the night of the 4th April, when a strong discharge of inflammable gas was given off, which continued, without intermission, until the afternoon

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of the 5th. On the morning of that day the water had fallen fifteen feet, and at 6 p.m. it was found that the water had fallen from forty feet in depth, in the downcast, to eight feet eight inches, making a total fall of thirty-one feet four inches, which, it would appear, was the column which the pent-up air in the mine sustained.

The water having thus fallen below the ingate of the upcast, causing a free communication for the hitherto pent-up air of the mine to escape, an opportunity was afforded of testing the temperature of such gas, which was found to be 63°. A meeting of the Managing Committee was held on the 8th April, when the following minute was made, and resolution come to thereon.

"It appears that on the 28th February, the temperature of the air of the mine in the upcast pit near the bottom was about 100°. That about the time when the ingate of the upcast pit was closed by the water rising, the temperature of the air of the mine was 75°. And when the water was lowered, and the ingate again opened, it was found to be 63°. Showing a gradual diminution in the temperature of the air in the mine.

The temperature of the water in the upcast

On the 28th February, was 83°,

On the 8th April ......61° at pit bottom,

And 59° at 3 feet 5 inches below the surface. Showing a diminution of 24°.

Judging from the above facts, the Committee are of opinion they are so far satisfactory as to justify them in the belief that the fire is extinguished, but the certainty of its being so cannot be definitely ascertained until the water is lowered below the ingate of the downcast shaft, and the atmospheric air again admitted into the mine."

At the meeting of the Committee this day (8th April), the arrangements requisite for re-opening the mine and for recovering the bodies were discussed, and the following gentlemen were appointed as viewers to carry out the instructions of the Managing Committee, and that two of them should be constantly in attendance at the colliery:—

Mr. W. P. Maddison,

„ C. R. Webster,

„ John Brown,

„ Richard Pease,

„ Edward Potter,

„ R. Maddison,

„ Thomas Cooper,

„ Joseph Coe.

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Mr. A. Palmer was subsequently appointed in lieu of Mr. Thomas Cooper, whose duties at Lord Fitzwilliam's collieries prevented his attendance.

The drawing of water was then continued until the 15th April, when the water fell below the ingate of the downcast shaft, and the air then passed down the downcast shaft into the mine, and up the upcast shaft; and, as a consequence thereof, as will be seen by the table of temperatures, the temperature of the air at the bottom of the downcast was reduced from 65° to 57°.

It must here be stated that during the time occupied in filling the mine with water, and in drawing it out again, two fans had been erected at the upcast shaft to ventilate the mine, when access was again obtained into it. And as these, together with a water-fall, formed, during the time the mine was being cleared of gas, were the ventilators of the mine, I shall give the dimensions and description thereof:—

One of the fans was what is called "Biram's Fan," five feet nine inches in diameter, with an inner circle four feet two inches diameter, on which the arms of the fan, 12 in number, placed at an angle from the line of the radii from the centre to the circumference of 15°. The space between the inner and outer circle of the fans being one foot three-and-a-half inches long, and two feet six inches in breadth. The cylinder was 12 inches diameter, stroke two feet. The fly-wheel, on which the driving strap passed round, was eleven feet eight inches diameter, and the sheave on the fan shaft, driven by the strap, was one foot six inches diameter.

The other was one of Naysmith's fans. Cylinder, twelve inches diameter; stroke, six inches; fan, five feet ten inches diameter, and one foot ten-and-a-half inches broad, having six radial arms, two feet two inches by one foot ten-and-a-half inches, truncated at the inner ends.

The pressure of steam at the boilers was 40 to 45 lbs. per square inch, but having to be conveyed some distance in pipes, the pressure at the fans would not be more than probably 35 lbs. per square inch. The number of revolutions of the fans varying from 180 to 220 per minute.

At first, when only a small portion of the mine was opened out, the water from the brook only was used as a waterfall down the downcast shaft, which was about one hundred gallons per minute; but as the openings were extended the water from the pumping engine of the Abdy seam was taken down, and then formed upwards of two hundred gallons per minute, regulated by the quantity which could be drawn by one tub, the cage on the other rope being used for general purposes.

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Things being in this state, the General Managing Committee met at the colliery on the 17th April, and, after examining into all the circumstances, developed the temperature of the air in the mine, and the viewers having made an examination of the bottom of the pit as far west as the stables (which were fallen in), and south to a fall near the upcast, and north to the water, and not discovering any appearance of fire, the committee came to the following resolution in which Mr. Morton concurred. "Judging from the additional facts" (developed since the 8th April), " and in the absence of smoke, smell of fire, or other indications, we are still of opinion that the fire is extinguished."

Arrangements were, therefore, made at that meeting for opening out the mine, and recovering the bodies as quickly as could be done consistently with safety to the persons employed in so hazardous an undertaking.

In the first place, it was arranged that the duration of each shift should be four hours, viz., six shifts in twenty-four hours, that Messrs. Maddison, Webster, R. Maddison, Potter, Brown, and Polam should respectively superintend the operations of each shift; and that they should have associated with each of them two deputy's practical and experienced mining superintendents; and that Messrs. Coe and Pease should undertake to render general assistance, which, from their previous experience in the working of the colliery, they were quite able to do. Out of a list of a great many volunteers seventy-two were selected, as the operatives, to assist the above staff of overlookers to recover the bodies and to restore the ventilation of the mine. And it was agreed that these workmen should work four hours' shifts, and that they should be paid six shillings per shift, with such a moderate quantity of stimulants as might from time to time be required.

It is scarcely necessary to observe that when the mine, which was closed on the 19th February, was re-entered again on the 17th April, the stench of the dead bodies, and horses, which were near the bottom of the pit, and which could not be brought to bank before the pit was closed, was most intolerable. The first object, therefore, was to remove such of them as lay exposed and could be obtained, and to send them to bank. It was found, however, that the roof of the mine was very much fallen, especially in the vicinity of the upcast shaft, and of the furnace, and where the fire had extended; and it was at once seen, that, independently of the time required to restore the ventilation, great labour and time would be required to clear away such of the falls of

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stone as were necessary to obtain the requisite air-ways and passages, along which the workmen employed in opening out the mine could travel, and bring out the bodies.

And, although there did not appear any doubt that the ventilating powers of the two fans, aided by the waterfall in the shaft, would be quite sufficient to produce such a quantity of air as would clear away the inflammable gas, or after-damp, and render the atmosphere of the current quite innocuous to the workmen; yet it appeared quite apparent that the vitiated and offensive atmosphere pervading all parts of the mine, not subjected to the force of the current, rendered it requisite that some artificial disinfecting compounds or substances should be used, to enable the men employed in the removal of the bodies to perform that office with impunity.

The attention of the Secretary of State for the Home Department had been called to this circumstance by Dr. Holland, Inspector of Burial Grounds, and the following observations of that gentleman of precautions to be observed in the recovery and burial of the remains of the unfortunate persons destroyed, was communicated to the Owners by Mr. Morton, the Government Inspector.

"1. It is believed there are in the pit the bodies of 189 men and boys, and of four horses. Some of them have probably been wholly or partially consumed by the fire, but many are likely to be in parts of the mine which were not consumed, being killed by suffocation.

2. It is now about a month since the explosion, and as much time must elapse before access to the mine will be possible, the bodies will be in an advanced state of decomposition. It is in their removal, therefore, that the chief difficulty will be experienced.

3. The water when drawn out of the mine may possibly be offensive, but its quantity is so great that this I think hardly likely, though some of it may become so towards the end of the operation.

4. It appears that there is no sufficient extent of land over which this water could be conveniently spread which would rapidly absorb any animal matter it may contain. The water of the brook into which it might be poured is used for domestic purposes, and to mix it with that would at least excite alarm, if not productive of worse consequences; and the only remaining alternative is that which is proposed, viz., that it shall be poured into an adjoining canal. I think this proposal free from real objection, if there be added to all the water a sufficient quantity of quick lime to rather more than

neutralize any carbonic acid it may contain. And if also to any of the water, which may be offensive, a small quantity of McDougall's disinfecting powder be added.

5. The cost of these precautions would be much less than that of filtering the water through charcoal, but either plan would be effectual.

6. When the water is removed, parts of the mine will no doubt be filled with offensive

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emanations from the putrifying bodies. The danger of approaching these will be greatly diminished by driving in fresh air before the men are employed, and it would be very useful to mix with this entering air either chlorine or sulphurous acid to decompose such putrid emanations. I think sulphurous acid (which may be disengaged by gradually mixing oil of vitriol to McDougall's powder) would be most convenient. Carbonic acid will also be thus disengaged, which will powerfully aid in the disinfection of the air and prevent the nuisance, which would otherwise be occasioned, by driving foul air out of the mine.

7. When the bodies can be approached, the men employed in their removal must be instructed to envelope the remains in cloth thickly sprinkled with the disinfecting powder, and as soon as possible place them in coffins lined with pitch, (to prevent any foul exudation running through), and to remove them with all convenient speed to the churchyard. Here a large number of brick graves are being prepared, in each of which two coffins will be placed. In every coffin a quantity of disinfecting powder will be sprinkled, each will be embedded in sandy soil, and entombed by flag stone mortared down; and the whole covered over with about 6 feet depth of soil, the surface of which should be covered with sods of grass, as growing vegetation will absorb any organic gas that may escape, for such escape (if any) will be extremely gradual.

8. The disinfecting powder mentioned, viz., Mr. McDougall's, of Manchester, is that, the efficacy of which Mr. Grainger and myself tested at the dissecting room of St. Thomas' Hospital, and has been very extensively and successfully used. I know of none so well adapted for such a case as this, but as its efficacy depends upon its being properly used, it would be very desirable that its employment should be superintended by Mr. McDougall himself, who has the strongest motive in ensuring its successful application.

9. I believe that if these precautions are carefully observed, the danger and annoyance necessarily attending the removal and burial of a large number of bodies, some partly consumed, others in an advanced state of putrification, would be reduced to the lowest possible amount; but I fear those are too sanguine who hope to avoid all annoyance whatever."

A second communication was received from Dr. Holland, induced it appeared by an incorrect statement in the Times newspaper, and which was contradicted by the owners of the colliery, of which the following is a copy.

"Burial Acts Office, 4, Old Palace Yard, Westminster, 20th April, 1857.

Gentlemen,

I am much obliged for your note informing me that the statement in the Times of a man having been made ill by removing a body from the shaft is incorrect.

I forgot to remind you of the utility of having sulphur burnt in the downcast shaft, so as to mix sulphurous acid in small proportionate quantities with the air. There need not be so much as to cause any inconvenience to the men employed. If the smell of it is distinctly perceptible it will be enough to destroy any dangerous emanations that may escape the disinfecting powder.

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I wish you would inform me how you find that powder to answer. If you have any difficulty I would suggest your getting Mr. McDougall's personal assistance.

I see by to-day's Times, that the men to be employed are taking various precautions against foul smell, such as wearing camphor bags. The only objection to this is lest it should lead them to neglect effectual means of protection such as free ventilation, the use of the disinfecting powder of sulphurous acid, and of the charcoal respirator, if the others are not completely effectual.

I presume that the men will enter the mine by the downcast shaft so that the air will carry the emanations of the dead bodies away from them, and that after applying the disinfecting powder, they will allow a little time for it to act before proceeding to remove the body.

I am, Gentlemen,

Your obedient Servant,

P. H. HOLLAND.

The Lundhill Coal Company.

P.S.—If any of the bodies are particularly offensive, it would be well to use a solution of the powder mixed with a little oil of vitriol."

The Surgeons of the colliery also presented a report of what they would recommend, but as their suggestions had been anticipated, and recommended to be carried out by the Managing Committee, it is not necessary to give them here.

The Managing Committee met on the 17th, and 21st April, and at those meetings took into consideration what appeared to them necessary, in a sanitary or disinfecting point of view, to be adopted.

With regard to the recommendations of Dr. Holland, they came to the following resolution.

"Dr. Holland's report was read, when, after discussion, it was agreed, that the recommendations therein be adopted, with the exception of the use of chlorine gas and sulphurous acid gas to mix with the air underground, inasmuch as the quantity of fresh air we expect to be able to introduce into the mine, and in which air the men are exposed, will carry off the putrid emanations floating in the air, and also with the exception of the use of flannel instead of cloth for enveloping the dead bodies."

And, "read also a communication from Dr. Holland of 20th ult., to the owners of Lundhill Colliery as to the mixture of sulphurous acid gas with the air passing into the mine. Resolved, that the owners of the colliery be desired to inform Dr. Holland that it is intended by the committee to cause a current of air to pass down the downcast shaft, and into the mine of 20,000 cubic feet per minute. That this quantity will, in recovering the dead bodies, be divided into two currents of 10,000 cubic feet per minute each; and, that it is not intended, neither is it

necessary, that the workmen in recovering the bodies should pass beyond the influence of such currents; which the committee think will be quite sufficient for all the purposes required, without the admixture of sulphurous gases."

The committee recommended that, a proper supply of stimulants should be provided; also a supply of chloride of lime; also at least five tons of McDougall's disinfecting powder, and that the presence of Mr. McDougall at the colliery should be requested to superintend the application of the disinfectants as recommended in Dr. Holland's report; that a quantity of coal tar be provided; also that suitable gloves be provided for the use of the workmen in handling the dead bodies; and that a medical adviser be on the spot night and day during the removal of the bodies; and, it may also be stated that a full supply of the patent respirators had been provided by the owners.

All these recommendations being concurred in by the owners, and steps immediately taken to have them carried out; and the state of the mine near the bottom of the pit, as reported by the viewers, having been corroborated by Messrs. Woodhouse and Elliot, who descended the pit for that purpose, and they having reported "that they found a strong current of air passing between the pits, and through that part of the mine adjacent thereto; and that they were of opinion that no fire existed in the pit, but recommended that the orders previously given (17th April) of making the requisite explorations to ascertain the fact, be first of all proceeded with," the following instructions were given by the Managing Committee to the viewers, as to the mode of proceeding in opening out the pit and recovering the dead bodies.

"That the attention of the viewers be first of all directed to find their way around where fire could have, by possibility, existed previously to shutting up the pit, so as to ascertain beyond any doubt that no fire at present existed therein. That they likewise, at the same time, be clearing away the falls of stone so as to obtain a free air-way to the upcast shaft. That as soon as the explorations have been made to ascertain that the fire is completely extinguished, and a free air-course obtained to the upcast pit, the operation of restoring the ventilation of the mine, ridding the falls, and recovering the dead bodies, be proceeded with as expeditiously as practicable, consistently with the safety of the workmen employed therein."

Accordingly all the bodies in the vicinity of the shaft were removed, and also those of the horses, and the workmen employed in clearing the

passages around the stables, and where the fire was known to exist, and also to make air-way to the upcast pit. These were operations of great difficulty, the roof of the mine having fallen and almost completely closed all the openings. Inflammable gas existed in all parts of the pit, except where the current of air was directed, and, although the air felt warm, and smelt strongly of burnt matter, no fire was discovered. The temperature in the vicinity of where the fire had been, varied from 63° to 67°. The temperature at the bottom of the upcast being about 56°.

When sufficient air-ways were made to the upcast shaft, and while so many of the workmen as could be employed for that purpose were clearing the passages around where the fire had existed; it was determined to restore the ventilation, at the same time, in the other parts of the pit, in order to recover the bodies with as little delay as possible. The Managing Committee, then, after consultation, determined that, as a general principle, the ventilation should be restored to the same state as it was previous to the explosion, viz , a division of the current into two splits, one current traversing the south levels to the western extremity, and working round the board-gates and banks northwards to the furnace board, and so to the upcast; and the other current traversing the north levels to the eastern extremity, and passing round the board-gates and banks southwards to the furnace board, and so to the upcast. But as the southern division appeared to be the most open, and it being desirable, in the first instance, that the air should not be more divided than into one current southwards, and into what was required for the workmen clearing away the falls around the region of the fire; it was determined to proceed at first to restore the ventilation on the south side, and then to commence on the north side when the operations near the pits was finished, and when the air required for those operations could be directed to the northern division of the pit.

It was soon found that the shale roof over the coal had fallen quite close in all the banks, and that the only open passages in the mine were the levels, board-gates, and slits. It was, therefore, determined to convey the air, and confine the restoration of the ventilation to those open places, and so recover all the bodies which might be found in them, and in such parts of the banks as were approachable, in the first instance; leaving the clearing away of the falls, and the restoration of the ventilation in the banks to a future opportunity, when the general ventilation was restored in all the levels, and board-gates, and in such of the banks as the air could be forced through.

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It is unnecessary to give all the details of these operations, which were unusually difficult and hazardous, and which added to the extremely painful and unpleasant operation of recovering and handling such a number of dead bodies, which had been in the pit for nearly three months, and were in every stage of decomposition. The operation required the utmost care, attention, and no slight degree of nerve; and I only here repeat the often expressed satisfaction of myself and colleagues of the judgment, assiduity, perseverance, care, and attention pursued by those in charge of such an operation, and of the workmen employed in so hazardous a duty. And it is a source of satisfaction (if any thing can be called satisfactory on so melancholy an occasion), and redounds greatly to the credit of all employed, and to the care and caution displayed by them in the execution of their hazardous task, that not a single accident of any kind happened to any one employed during the entire operation. And it is likewise satisfactory to add, that the sanitary means taken were quite effectual in preventing any injurious effects from the effluvia and stench arising from so vast a mass of putrid matter, except occasional sickness, and the natural temporary unpleasant effects from immediate contact with the dead bodies.

The operations of opening out the pit commenced, as previously stated, on the 17th April. The principal effort at first being directed to ascertain if any fire existed in the pit, and of ridding some heavy falls on the north side. While this was being performed, on the 25th April the operation of conveying the air along the south levels commenced, and on the 30th April the face of the south levels was reached, temporary stoppings, immediately followed by permanent brick stoppings, having been put in the holings or holt-holes, and double doors in the board-gates on the west side of the levels. The air was then successfully put around the Nos. 5, 4, 3, 2, and 1, board-gates, passing down the upcast board-gate to that shaft. The other split of air was likewise carried to the face of the north levels, which was accomplished on the 8th May, the falls having been very heavy. And on the 9th May the Managing Committee visited the colliery and reported—

"That the air had been put round the south side, that it was going freely into the faces of the board-gates, and finding its way between the board-gates through the goaves, the bank faces being nearly closed and quite impassible, the board-gates being quite open. That the air had been carried to the extremity of the north levels, and up No. 4 board-gate, and that the workmen were proceeding to open No. 3 and No. 2"

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"Resolved,—That the viewers proceed with all expedition to get the air through Nos. 3, 2, and 1, board-gates on the north side, and to recover the bodies therein."

The air having been got round all the board-gates on the south side, and access being had through the slits to the sides of the banks, and the operation of clearing away the falls of the banks being likely to take a considerable time; the Committee determined to make an examination of the south side of the pit on the 16th May, and gave orders for the requisite preparations for such examination; and as this examination was for the purpose, as well to ascertain the precise state of the mine left by the explosion, as to ascertain the cause or causes which led to such explosion, I shall give the result of such examination in detail, with such explanations as may enable the members of the Institute to have a correct notion of the facts and circumstances of the explosion.

Plan No. 2, will show the state of the stoppings and doors as affected by the explosion, and the parts of the mine where the bodies of the sufferers were found. It was, of course, very important to ascertain in what direction the stoppings and doors of the mine were blown, to show the probable direction of the blast; darts are therefore placed where every door or stopping existed, and where the direction in which they were blown were clearly ascertained. Where this could not be done with accuracy no darts are placed, and where no stoppings or doors are shown, it must be concluded they were blown away, and that the direction could not be clearly ascertained. In some few instances the stoppings were either not blown away, or were partially damaged, but left standing, and these are marked with the letter G. The dotted parts show where the coal was on fire, and the figures denote where each body was found.

With these observations I give, first of all, the result of the examination of the south side of the pit, which was conducted by the Managing Committee, and the viewers, accompanied by Mr. Morton, the Government Inspector.

After descending the pit the party made an examination around the bottom of the downcast shaft, and entrance to furnace drift which was much fallen. Two bodies were found here, with all appearance of great violence having existed. Proceeded southwards to the first bolt-hole beyond

No. 1 board-gate, stopping blown west. Then proceeded south along the level, and found the stoppings in all the bolt-holes and the doors in the board-gates on the west side blown towards the west; came to a place in the low level, between the 6th and 7th bolt-hole, where a

[A Plan of the Lundhill Colliery Workings shewing the effect of the explosion]

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shovel had been driven with great violence into a back or fissure of the coal; all showing that the blast had proceeded from the shaft, or from No. 1 board-gate, along the two low levels towards the south. The violence appeared greatest between the Nos. 4 and 5 board-gates, the tramway plates being torn up and bent and the sleepers blown about. It is worthy of observation, that where the greatest violence existed at this place, it appeared as proceeding from south to north, which we supposed to have been the re-action of the blast when stopped by the force of the solid coal. The stoppings in the bolt-holes between the horse-level and the water-level were blown some east and some west, apparently depending upon the comparative precedence of the blast in one or other of these drifts, in its progress southwards. The conclusion, up to this point, was that the blast had proceeded along the levels towards the south, and up to this point there was no appearance of fire, no charred coal, or charred dust on the wall sides of the coal.

The party then proceeded up the fifth board-gate east, to the bottom of the No. 5 bank, across the slit to the back-board, up that board to the face, and then down the No. 5 board-gate to the level. The stoppings between the back-board, and main No. 5 board-gate were all driven south, the effect, no doubt, of the blast having passed up the main board-gate, and expanded itself into the back-board and bank. It was difficult to determine in what direction the door in the slit between the No. 5 board-gate and the No. 4 bank was blown, though it was thought towards the No. 4 bank. There was no appearance of fire in this route. The bodies of the workmen were found where they had been working, destroyed by the effect of the blast and the impure air, but not burnt.

The No. 4 board-gate and bank was then explored, the party passing up the board-gate to the first slit, into the back-board, and up that board to the top slit, and into the fore-board, and so down the fore-board to the level. The stoppings between the fore and back-board were found to be all blown south, but there was no evidence to show in what direction the blast had taken through the slits between No. 4 and No. 3 board-gates. It appeared to have passed from the levels up to the No. 4 board-gate, and to have been strongest at the upper extremity, or near the face. Parts of a body were found in the back-board, opposite the uppermost slit, or bolt-hole, blown to pieces, the remains showing that the blast had proceeded from the north to the south through the slit. No appearance of fire could be satisfactorily ascertained, though the dust on the different parts of the mine was minutely examined, and though

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the viewers reported that one of the bodies was burnt. The blast had, it appeared, impinged with great force against the face of the coal in the fore board-gate, as a pick with which a man had been working was driven into his body, and others of the bodies were mutilated, and the rails were also blown about and bent.

No. 3 board-gate was next traversed, the party proceeding up the board-gate to the bank level, and through the slit to the back-board, up the back-board to the top slit, around the face of the board-gate, and down the main board-gate to the first slit into No. 2 bank; examined the leading bank, and then came down the main board-gate to the level. The stoppings were found to be blown as shown on Plan No. 2. The bodies found in this board-gate and slits were considerably mutilated, the blast having been apparently very powerful. The viewers report that some of the bodies were burnt, but this did not, on a subsequent enquiry, appear very clear, and certainly there was no appearance of fire in any of the parts of the mine examined by the party. The direction of the blast appeared clearly to have proceeded from north to south.

The examination of No. 2 board-gate was then proceeded with, the party travelling up the main board-gate to the bank level, through the slit to the back-board, up the back-board to the face, and into the fore-board, and down that board to the level. The stoppings and doors were found to be blown, as indicated by the Plan No. 2. The force of the explosion was greatest at the face of the board-gates, greater in the fore-board than the back-board, and clearly appeared to have proceeded from north to south. The bodies were much mangled, and some said to be burnt, though the coal and dust were not charred. The Nos. 4 and 5 slits on the north side of this board-gate showed evident signs of the blast having passed out of the No. 1 bank south into the No. 2 board-gate. In the other slits the indications were doubtful. This closed the examination on the south side of the pit on this day.

The ridding of the falls of stone on the north side had, on the 20th May, been so far completed that the ventilation was restored in all the board-gates, slits, and levels, so as to enable the Committee to make an examination of this portion of the mine, and also that portion of the south side not examined on the 16th May.

Accordingly, on the morning of the 20th May, the Committee, accompanied by the viewers and Mr. Morton, descended the pit, and commenced the examination of the north side of the pit.

They proceeded along the main level towards the north. The first bolthole

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on south side of shaft is used as a cabin, and the remaining part of the bolt-hole being stowed close, the stopping was not blown down. The next bolt-hole is the road to the stables, in which was placed two doors, but there was no indication in what direction they were blown, the roof having fallen to a considerable height; neither could any trace be found of the door which was in the No. 1 board-gate. The stoppings of the next three bolt-holes were blown east. The door in the No. 2 board-gate could not be found. The first stopping north of No. 2 board-gate was blown east. At the next bolt-hole some bricks were found in the level, but more on the west side, showing, in the opinion of the party, that a partial explosion had at first blown some of the bricks towards the level, but that a more powerful blast, or re-action, had blown the remainder west. The stopping in the third bolt-hole appeared to be blown west, though, on the wall side opposite this bolthole, there were evident signs of bricks having been blown through the bolthole against the coal opposite. Came to No. 3 board-gate, the door of which was blown down and lying, in the level, but the brick-work and door-frame were left standing, showing little violence of blast. The same with the three next stoppings, which were blown west, the first partially east. Proceeded to the face of the north level, where candles were found hanging up, without any appearance of fire having been near them, and the brattices, though blown down, were not much injured. It will be seen that some bodies were found in this level, some of whom were burnt, and some not burnt, and it will be seen by the evidence of Mr. Maddison, what state this level was in previous to the closing of the pit.

The party then proceeded up the No. 4 board-gate. The dart in the middle level shows an explosion to have passed from north to south, and a tarpaulin, or sheet, was blown against the south-west angle of the pillar of coal between the middle and bank levels, near the dart, showed also that the direction of an explosion had passed into the middle level, and up the board-gate. After examining the face of the board-gate the party came back to the level, as they could not travel across the No. 4 bank. A body found in the face was much burnt.

The examination of No. 3 board-gate was then taken, the party proceeding up the board-gate to the middle level, went north, and then up the first bolt-hole to the No. 4 bank, to examine one of the places said to have been obstructed, such obstruction being between the following-up and leading banks, as shown on the Plan, found no appearance of fire in the bank, then came back to the board-gate. The stoppings were found

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blown, as shown on the Plan. Bricks blown on both sides, of the stoppings. Went north, into the face of the leading-bank of No. 4, found candles hanging up not melted. No signs of fire. Two bodies were got out the day before, not burnt. Returned, and went into face of board-gate, through the slit, and down the back-board, to the level. Found indications of fire at places marked on the Plan. Went into the edges of bank No. 3, but found it fallen within the entrance of the slits.

Came south to No. 2 board-gate. Went up that board-gate to the face, examining it very carefully for appearances of fire; found indications at some places, as marked on the Plan. Went along the second slit above the bank level, to examine where lamps were found unscrewed, found two lamps with tops off, not the effect of the explosion. Two men were found here, but they were not much burnt. This slit is nearly opposite to where there was an obstruction of the airway, by a fall of stone in the side of the bank; found indications of charred dust in this slit. Came back to the board-gate, and went west. Found tokens not burnt through; there were evident traces of charred dust on the rise side of them, and on the dip side strong indications of fire existed, as if the fire had come with great force and heat down the board, and charred the coal and dust. Went up to face of board-gate, found strong indications of fire on the brattices, and also in the slit leading to No. 2 bank. At the top of the back-board, candles were found with the tallow melted off. Went down the back-board to the level; found all the doors and stoppings between the fore and back-boards blown south, with the exception of four marked G on the Plan, which were not blown down ; found traces of fire in some parts of the back-board and slits.

Next examined No. 1 board-gate. Found the coal on the sides of the middle level next the stables coked three or four feet into the solid coal, and fallen quite close, produced by the standing fire. Went west and into the back-board; found indications of fire in the slits between the backboard and No. 1 bank; went up to face and then down the fore-board to the level. The direction in which only one of the stoppings was blown between the fore and back-boards, was ascertained, and that was south. There were strong indications of fire on the sides of the solid coal, but it was difficult to distinguish clearly whether these, or how much of them, were attributable to the blast, and how much to the standing fire. The bodies found in this vicinity were burnt, more or less.

Went next to No. 1 board-gate south. Found one stopping standing on the north side of the fore-board-gate, (which here is on the south

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board, the north board being the return board); the next stopping was blown north, and here there were indications of fire from the explosion, and there were also similar indications in the other slits between this board and the No. 1 bank. The three next stoppings appeared to have been blown south, and the direction of the remainder could not be ascertained. Went to the face of the board, through the slit into the furnace-board, and down that board to the furnace. Great violence appeared to have existed near the face of these two boards, the bodies were much burnt, and strong appearance of fire upon the wall sides and other parts near the face; and in all the slits between the furnace-board and No. 1 bank, appearances of fire existed. But it is requisite to state, that in the second slit from the bank level on the south side, gunpowder was found in a cask, not exploded. Examining the furnace-board we found the arch of the furnace fallen in; the main arch, however, not fallen; but, owing to the rubbish and fallen roof not being cleared away, we could not examine the bottom of the upcast shaft.

On examining into the state of the bottom of the downcast shaft, as left by the explosion, we found that the cage and tub, which were standing at the bottom of the pit, when the explosion took place, had been blown out of their places towards the north and into the level, the bunting, or cross timber, being broken on the north side of the shaft, while that on the south side was undisturbed.

The foregoing were all the circumstances elicited in our examination of the state of the mine, at least such as appeared to bear on the subject, as it was left after the explosion. There is only one circumstance requiring notice, but which is of great importance in the case, viz., the mode of lighting the mine. It appeared that candles were generally used by the workmen in getting the coal, and by the boys in hurrying the coal to the shaft. That safety-lamps were only used when parts of the pit were discovered to be unsafe to use candles, and then safety-lamps were ordered to be used in such places of danger; candles being used alike in the board-gates or leading places, the slits, and in both the leading and following-up banks. In the operation of building the packs, or pillars, which were in close proximity to the goaf, lamps were only used when gas was found to exist in the goaves, and it appeared to be discretionary with the packers to use lamps or not, or to use them with the tops on or off, at their discretion. And it must likewise be noticed, under this head of enquiry, that, in the examination of the pit previously detailed, and in the search for the dead bodies of the workmen, all the

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safety-lamps found had their tops off, and the tops appeared to have been off at the time of the explosion. It is, therefore, to be presumed that, at the time of the accident, the pit was entirely lighted by candles, or with lamps with the tops off.

Although not bearing on the question of how, or in what manner, this deplorable accident happened, it may be of utility, in a practical point of view, to state, that the means used to produce ventilation during the progress of clearing the mine of inflammable gas and after-damp were quite effectual, and produced a current of air in the mine quite equal to, or beyond what was considered sufficient by the Managing Committee as requisite for that purpose, when the operation was commenced. In the communication with Dr. Holland, it was stated that the Committee expected they would produce a current of 20,000 cubic feet per minute; and, although the quantity of air produced varied from time to time, as the length of current increased or the obstruction arising from the contracted and extended air-ways operated to add to the resistance, the quantity of air measured on the 3rd of May was ascertained to be 23,540 cubic feet per minute.

Having thus, I trust, given in such detail all the circumstances arising out of this lamentable and distressing accident; and having given, likewise, in detail, all the means taken to recover the bodies, and restore the ventilation of the mine; and having, also, given all the data which presented themselves on the re-opening of the pit, which could in any way throw any light upon the cause or causes which led to the fatal accident; or which could in any way elicit practical data or experience which may be the means of preventing the recurrence of such a calamity ; I must, therefore, leave to the discussion of this paper by the members of the Institute, the development and practical bearing of such facts, towards the elucidation and discovery of the causes which led to such accident. I was, of course, obliged at the inquest to give my opinion of the causes which produced the explosion, and subsequent reflection has not altered such opinion; still it rests with the members of the Institute, if they think proper to do so, to investigate, by the discussion of this paper, what, in their opinion, were the causes which led to such a lamentable accident; and, which is of equal if not more importance, if any matter or thing elicited in the operations or circumstances connected therewith, can be of any utility in the prevention of such accidents in future.