PAPER READ

BY

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OF THE

DUDLEY AND MIDLAND GEOLOGICAL AND SCIENTIFIC SOCIETY AND FIELD CLUB,

AT

A CONFERENCE

OF

MINE OWNERS, MINE AGENTS, AND MEMBERS OF THE SOCIETY.

Subject.—"THE YIELD OF THE TEN YARD COAL AND THE BEST MODE OF INCREASING IT, HAVING REGARD TO THE SAFETY AND ECONOMY OF THE WORKING."

DUDLEY:

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1864.

It will be remembered that I was called upon as one of your Vice-Presidents to take the Chair at our Wolverhampton Meeting. As one of our objects in meeting there was to give that important town a means of becoming better acquainted with the Society, I took the opportunity of commending it on account of the practical utility of the sciences to which its attention was particularly directed. Although there are at present some topics under discussion of more than usual interest to Geologists, I thought the proper subject for "The Dudley and Midland Geological Society and Field Club" to introduce to a Wolverhampton audience should relate to the great geological facts, in which all were interested, and with which some of them had to deal in the business of every day life. I therefore opened the business of the evening with an address on the working of their Coal Mines, a subject intimately connected with Geology as one of the sciences which ought to direct the operations of the miner. I referred more particularly to that most valuable of all England's gifts of mineral wealth, the great "Ten Yard Coal," and I stated, amongst other things, that the yield per acre was, in the present mode of working very insufficient, and that it might be greatly increased by adopting the modern "long wall" system of working instead of continuing the old method of working by "ribs and pillars," or as it is now the fashion to call it "square work." I also stated that the safety of the miners in long work compared with their peril in square work ought of itself, and apart from any economical considerations, to be sufficient to induce mine owners to adopt the long wall working.

Gentlemen, there was nothing new in what I stated at Wolverhampton. The facts are all well known and the same opinions have been expressed by eminent authorities upon the subject—By Messrs. Warrington Smythe, and Lionel Brough, by Mr. William Mathews, our Chairman this evening, and even as long ago as 1836 by the late Thomas Smith, in his "Miners' Guide," and last not least by Mr. George Jones, who has left amongst the workmen of South Staffordshire traditions of his great prac-

tical skill as a miner, and who is said to have first introduced the long wall system to the district. Although the subject of the relative advantages of "rib and pillar" and "long wall" working was not new, it does not seem, hitherto, to have had the attention to which its great importance entitles it. Since the publication of the reports of my address, however, either from the greater interest of such enquiries generally in the present day, or from my having placed this question in a more popular light by shewing its pecuniary aspect, a lively interest has arisen upon the matter, so much so, that it has been thought right by our Committee to place it in a position for thorough consideration. Under these circumstances, I have acceded to the request of the Committee to attend this meeting and open the discussion by a Paper on "The Yield of the Ten Yard Coal, and the best mode of increasing it, having regard to the safety and economy of the working." I was asked to read my Wolverhampton Paper; but I there spoke from notes only, indeed, as the Wolverhampton Meeting was one of our ordinary pleasant gatherings for mutual interest and instruction, I did not go as fully or specifically into this branch of the subject, in a general address, as I feel bound to do before this assembly of the Mine Owners, Mining Engineers, and Mine Agents of South Staffordshire and East Worcestershire. I think it more respectful to gentlemen, called together by special invitation as experts, to give their assistance at this Conference, that I should, rather than repeat statements of results, go carefully, and, if time permits fully, into this very important question.

The first fact then, to be ascertained is the weight of a given bulk of the ten-yard coal. I will take a cubic foot as the measure of bulk, because that is taken for the standard in ordinary use in England—a cubic foot of distilled water at 60 Fahrenheit is taken at 1000, or reduced into lbs. 62.50, I first look to the published authorities upon the weight of coal. In Willich's tables I find the average specific gravity of the examples of coal there given is 1.323. At that gravity the average weight of a cubic foot, is 82 lbs. and $\frac{7}{10}$. If we consult the gravity table compiled for the Society for Diffusion of Useful Knowledge, and published in the Penny Encyclopædia, which is the best gravity table I know—we find it differs very slightly from Willich. The gravity there given is 1.318—which will give $82\frac{4}{10}$lbs to the cubic foot. Hunt gives 25 examples of English Coal, the average of which would be somewhat less than the foregoing, it would be 1.289, or a small fraction less than 81¼ lbs. per cubic foot. The result of all these published

authorities upon the subject is, I think, that taking the average of English coals, the weight of a cubic foot is about 82½lbs. Upon that weight it would give a ton per cubic yard, less 13 lbs. It happens, however, that with one exception, none of the examples given are Staffordshire coal. They are Welsh, Newcastle, Cannel, Derbyshire and Lancashire, but not one of them the ten-yard measure of this coal basin. I have not in the country access to the means by which the various strata comprising the thick coal beds could be weighed with scientific accuracy. Indeed the component parts of the ten-yard coal differ so much, not only in different districts, but even in the same beds, that it is impossible to arrive by experiment at a result which would be indisputably and absolutely certain. I will take 82½ lbs. per cubic yard as the result of an average spread over all the examples I can fairly find to guide me to a true result. That weight per square foot would give a ton per square yard, less 13 lbs. If I cannot quote the published authorities of men eminent in science for the weight of our ten-yard coal, I can rely upon the local knowledge of practical men of business, who upon that knowledge, the result of years of observation, treat for business calculations, a square yard of coal as weighing a ton.—That is a ton legal weight. I say "Legal weight" because at Wolverhampton I did not explain why the trade estimate of weights varied. This, however, is a subject which I shall treat afterwards. The weight of 82½lbs. to the square foot is then not only the weight shown by the tables, but it is that which the experience of years has resulted in establishing as the standard for business calculations in the neighbourhood. 82½ lbs. would give us 2227 lbs. to the cubic yard; or as I said, 13 lbs. less than a ton. It will be easy to make the deduction from the gross quantity, if upon experiment the weight is found to be less than I have taken. Upon the figures upon this datum quantity the deduction will appear small, but upon the acre of mine, although the relative quantities must of course be the same, the figures appear large. It will be quite near enough for all practical purposes if 544 tons per acre is deducted from the estimate I shall give of the quantity of thick coal in the solid for every pound which it may hereafter be found to be less in weight than 82½ lbs. to the cubic foot. I have made my present calculations upon the basis of 82½ lbs. to the cubic foot.

Next, as to the number of cubic yards of coal per acre. This will depend upon whether the coal bed is really ten yards of vertical depth.

Now towards the North-Western boundary—and also at the South, so far as it has been proved, and in some places nearer the centre of the great Coal Field the ten-yard coal strata are divided—not only do the partings vary in thickness, but the two upper strata rise so far above the main body of the measure that they were for some time believed to be a distinct stratum, and received the local name of the flying reed or red. What I mean then when I speak of the thick or ten-yard coal, is all the strata of that group together; and when they are so placed they measure, allowing for partings, on an average throughout the district, thirty feet in vertical thickness. This fact does not rest upon my own statement alone. There is again the common knowledge, the ordinary language and nomenclature of the whole district. It is "The ten-yard Coal." We have also the result of the most complete and accurate survey of the district ever made,—that made for Her Majesty's Government by my friend Mr. Beete Jukes, and published by the School of Mines at p. 173, part 2, vol. 1. Mr. Jukes gives from actual measurement many sections of the ten-yard coal, and (at p. 173 et seq) he says :—

"As good typical sections of the "Thick Coal" I will give two taken from the central part of the district, one given me by Mr. R. Smith, from Lord Ward's Office, of the Claycroft Colliery, at the Foxyards, about two miles North of Dudley; another an old sinking in 1797, at Tividale, one mile East of Dudley, communicated by Mr. Becket, of Wolverhampton."

(Mr. Jukes then gives the two well-known sections—one shewing 36 ft. 6 in. of coal, with 2 ft. 11 in. of parting, and the other 28 ft. 7 in. of coal, with 1 ft. 9 in. of parting) and then proceeds :—

"A few years ago the unusually thick coal at Foxyards was worked openwork as it there cropped out to the surface, and was got out from a large quarry exposing a cliff of coal 40 feet high, and about 100 yards in length. Proceeding from this central portion of the district in every direction we find several minor changes taking place in the construction of the thick coal. The individual beds, even where they are all present, vary frequently in thickness, and often in quality in such a way, however, as to maintain the mean aggregate thickness of 30 feet over by far the greater portion of the district."

Mr. Brough, in speaking of the Thick Coal says—"This coal with the exception of a few localities, is really ten yards thick, sometimes eleven, or even more."

The third fact cannot be subject to any variation by discussion.—There are 4840 square yards in each acre.

It results from these three facts—the weight, the depth vertically, and the superficial area, that there are 48,400 tons of the ten-yard coal as it lies in the earth solid and untouched by man.

The next branch of the subject is how much of this 48,400 tons of coal per acre is actually "won" and brought to the surface by our local rib and pillar mining operations. Before I state calculations upon this branch of my subject, I should say that in speaking now of weight, I mean not as before legal weight or the weight of science, but what I will for the purpose of the present call "Lease weight."—As I shall afterwards have to go into the subject of weights, it is unnecessary that I should now say more—indeed it is the most intelligible mode of treating, the subject to say that for the purpose of using authorities upon the matter of tons of yield, a ton must be taken to be 2,880 lbs. avoirdupois weight.

The first statement of the quantites wrought by square work I give is from Mr. Thomas Smith's "Miners' Guide," a book which fairly represented the state of the workings in this district five-and-twenty years ago. He put the quantity per acre by the square or usual mode of rib and pillar working at 15,400 tons an acre. Mr. Warrington Smythe, of the Government School of Mines, in his "Report of the mode of working the Coal and Ironstone of South Staffordshire," says—"By the common plan it is considered that 16,000 tons of coal obtained from an acre of ground represents a very fair produce, and no doubt a very much lower number is often obtained."

I believe I may quote our Chairman as an authority for 16,000 tons as the thick coal yield by rib and pillar work. Relying upon my own experience I may say that I know of many bargains made between buyer and seller of the mines in the solid, based upon much smaller quantities than these I have quoted. The best means, however, of judging of quantities in this case as of other facts within the knowledge of many persons, is from the evidence they give upon oath opposed to each other in the particular case, and subject to a cross-examination always upon the information, and often at the dictation of experts as competent as themselves. I have heard very much evidence upon the produce of the ten-yard coal,—in compensation cases where the coal had to be purchased for the support of Railways, Canals, Bridges, &c.—in disputes upon the "Ingleby Clause,"—in leases where the question was whether the lessee could work to a profit. But perhaps better still for my guidance upon this

question in actions for trespass encroachments where the value is taken strictly against the wrong-doer, and the measure of damages is the value of the coal removed at the place where it was broken from the freehold and became a chattel. This value is arrived at by deducting from the sale price the cost of carrying the coal from the place in the pit where it is gotten, to the point of delivery to the customer—generally about one shilling a ton. So that the damages are nearly the retail value of the coal, and worth fighting for down to a single ton. The result of my experience is that 18,000 tons may be taken as the generally admitted average quantity per acre of the Thick Coal yield throughout the best worked part of the district. This is not for a first working only, but for the whole yield of the ten-yard seam of coal. I say generally admitted, because I have in some few cases—very few—heard evidence given of a larger quantity being gotten in particular pits. When I have for my private information enquired into the details of such cases, I have always found some special circumstance producing the excess—such as an extra thickness of the seams,—the unusual quantity sold land sale at short weight,—or, as Mr. Brough informed me in one case, "It was not him, it was his father who managed the pit, and it is the best square work in the district."

Taking then 18,000 tons to be the average quantity, I now come to a very important matter, I mean the question of weights. I told you that in speaking of tons in relation to yield, I took a very long weight. This it was necessary to do, because it is the custom of the country so to deal with the subject, so that to avail myself of current information, I must take it in the state in which it is presented to me. Before I begin to compare the yield with the cubic quantities taken in legal weight, I must first reduce the 18,000 of the longest or "Lease weight" into statute weight. Taking lease weight then at 2,880 lbs, the difference between that and 2240 lbs. the legal weight upon the produce per acre of 18,000 tons I must add 5143 lbs., or increase the apparent to the real yield by mere arithmetic from 18,000 to 23,143 tons per acre. I cannot stop even here, for mining engineers, mine agents and others, in speaking of tons' yield, mean really tons to the "*Ticket Book.*" But I must therefore account for some quantities which although actually brought from the mine and used, never go into the ticket book. These must of course be added to the credit side of the account with the miner before I strike a balance between the quantity in the earth and the sale produce.

I will estimate these quantities which do not go into the Ticket Book upon a pair of ordinary Thick Coal Pits, drawing 800 tons a week from two sides of work, with a forty horse power engine winding during the day, and drawing water night and morning, or it may be all night, and employing in the pit and on the bank or about the field sixty pair of hands. As I calculated my total in the solid, I must take the produce in any shape. I begin then with the engine slack. Of course that would vary according to the construction of the boilers, furnace, &c.; but I take fully enough when I put 30 tons a week to work the 40 horse engine. It would take rather less than 23 weeks to work over half an acre square work drawing 800 tons a week, but if I take 25 weeks, that gives per acre, 750 tons for the engine.

The next item is "Allowance Coal." There would be, under the circumstances I have stated, about 40 persons receiving full pikeman's wages; but I think 50 would contrive to receive, or as they would call it, "draw" Allowance Coal,—the married men a ton for every 24 full turns; the unmarried men, under the new rules, a ton for every 48 full turns. To make a full week is the exception for a Collier, taking "Pit at Play," "Saint Monday," the "Wakes," the national and local holidays, and it will not be found that, for these 50 workmen, more than 40 tons a month will be given as Allowance Coal for the workmen's use, that is 10 tons a week. This, for 25 weeks, gives 250 tons per acre. This Allowance Coal is not always, and indeed if I spoke of the whole district, I might say not usually given from the Thick Coal, the theory is that the Collier should have a load of "lumps" from the measure he is working; but if any inferior measure is being worked in the same field his coal is taken from that, and not from the Ten Yard Coal. However this may or may not be, and I will therefore add this item. I have said given for the workman's use. It was intended as a substitute for "picking" and "carrying" by the Colliers' wives for their own fires; but if I had not known before, I should have soon learnt at the Dudley County Court that this Allowance Coal is often drawn to the Huckster, the Tally-man, or the Tavern-keeper. It is in fact an irregular supplement to wages. Then something must be allowed for "Rodney Fires," and, I am sorry to say, notwithstanding the Allowance Coal, for "picking" and "carrying," also, something for the domestic consumption of lessor and lessee, and, under whatever care the produce is disposed of, a moderate amount of surface waste. For these, which I will call "miscellaneous items," I will take 350 tons an acre.

I have now the whole of the data for trying the yield of an acre of Ten Yard Coal, worked in the ordinary way of the district. I have taken facts where they were established, and estimated candidly, and to the best of my judgment where the figures were not positive. Let us now see how the account stands:

Tons per acre in the Ticket Book		18,000
Add to make difference between the legal weight and boat weight		5,143
Engine Slack, per acre		750
Allowance Coal, ditto		250
Miscellaneous Items, ditto		350
Tons per acre, legal weight		24,493
In Solid	48,400	
Gotten	24,493	

Leaving a net deficiency of 23,907 to be accounted for in the ordinary Ten Yard Coal Seam, taking the ordinary weight, and the ordinary mode of working by what is called "square work."

This important general result cannot be taken without estimating the influence of circumstances, which in some cases, will, alter this net deficiency.

First although as I have before stated, the general thickness of the Ten yard Coal would average thirty feet, and justifies me in founding my calculation upon that basis, there are some localities in which, either from the vertical depth of the seam not measuring so much, or from the partings being thicker than usual, the depth of the coal itself is less than the thickness upon which my calculations are based. The 48,400 tons will be less by 1613 tons for every foot of deficiency in thickness. If, however, the coal is less, the ordinary yield of 18,000 tons would also be proportionately less in rib and pillar work, so that the whole of this 1613 tons to the vertical foot short should not be deducted from the final figures; but only such proportionate part as the facts justify. When I come to speak of other modes of working, it will be found that the yields, although so much larger, are upon the workings of seams considerably less than thirty feet, so that in comparing square work with long work as to yield, although we should give square work credit, so to speak, for deficiency, we should not debit long work with a thickness beyond that of the particular measures from which our examples are taken.

Secondly, I refer again to the possible deficiency in weight; my calculations are upon 82½lbs. to the cubic foot; of course, if it is found the weight is less, the rule I have before suggested of deducting 544 tons per acre for every lb. less than that quantity will enable any one at once to correct my figures. They contain the nearest approximation to certainty to which I can come; as however they are more or less founded upon estimates and aggregates, I have given the data upon which my calculations are based.

I will now say a few words upon second and third workings, for I know that an opinion prevails that something more should be taken into my account for second and third and even fourth workings. Square working has very greatly improved within the last few years. If you look upon any working drawing of a coal mine, made to illustrate the rib and pillar system of working, such as Mr. Cope's plan upon the wall before me, it looks like the ground plan of a building supported by columns. You would fancy, from the plan and written description, that when the side of work was finished, you could pass on through the bolt hole and find yourself in the crypt of a black cathedral, with rows of columns standing square and in parallel lines, with architectural regularity. My recollection of a thick coal pit is very different from this; there is, or rather was at the time I was in the habit of descending coal pits, very little squareness about thick coal square work; in fact there were very few parallel lines anywhere in the work. The pillars were irregularly shaped masses of coal, left uncertain sizes, and even at uncertain distances. The stalls were, of course, as irregular as the pillars, of different widths and heights, and the floor was a series of irregular heaps of "gob slack," "parting batt," "shale," and other waste dislodged in the working but not drawn up to day-light. In fact it is a misnomer to call our rib and pillar work the "square work" system, as that term is used in the North of England. In disputes about damage to the surface by working over the ribs and pillars, we frequently have the old workings brought as clearly before us, as though they had been uncovered like buried Pompeii. It is very much the same narrative in every case,—"no working plans; we cleansed the shaft and drove out a job road here to point A in the hollows, and at this place we came to a pillar, and we thinned it, and we came to another, and we left it because the roof was so tender there, and then we thurled the rib, and we stripped the rib so far, and we drove a trial head in it: and we did not thurl it in so many yards, and so we thinned that rib; or we worked so

many stalls in it." This is the account we get of the state in which old workings were left. I have no doubt, that after the slovenly first workings of former years, the second workings have been productive, but nearly all that is found by the second must be deducted from the first working. As to third workings, I have known instances of going three times over the same ground, and I have heard of even four. What a comment the fact of these several after workings conveys upon the insufficiency of the first!

I have, however, another word of explanation about these successive workings. I said the description of opening the pit anew, was, "we drove out to point A, say east of bottom." The pit, from some cause, is stopped again. After a time another person opens the work; that is a third time the pit is worked. He drives out, not to point A east of bottom; but perhaps to point B, west of bottom. Although therefore, it is the third working of the same pit, it is only the second working of the same ground. Again, we must be careful not to base our figures upon the first and second working at different places by the same person. A butty may be perfectly accurate when he says, "I got 15,000 tons an acre the first working of a maiden mine when I worked in Smith's field, and I know what can be drawn from ribs and pillars, for we drew 8000 tons an acre when I worked the ribs and pillars in Jones's field." The only true tests are where reasonably accurate accounts are kept over workings in the same ground, and to any such accounts, properly authenticated, I shall always give due importance in working out the ultimate quantities. Gentlemen, I am told that since the time I have personally examined thick Coal workings, the rib and pillar system is much improved. I believe this is so, the necessity of complying with the Mines' Inspection Act, by keeping plans, must force workers to obtain better information of the state of their pits; still, as between square work and long work, improvement only alters the proportions without materially affecting the main issue.

The third subject to which I will refer is the vexed one of Weights. Of course to the extent that the weights I have taken are less than those in actual use, and from which entries are made in business books, the deficiency will be rather apparent than real.

We have in our colliery district three different weights, each called, and commonly recognized as a ton. First, the statutable ton, that is the avoirdupois weight of 2240lbs. Next, we have the "long hundred,"

or long weight as we commonly understand it, that is 120lb. to the hundred weight, instead of 112lb., giving 2400lbs. to the ton. And, then thirdly, (I was going to say *lastly*, but I have still another,) we have the boat load of 24 "long hundreds," or 2880lbs. to the ton. But now comes the lastly. There is a measure acted upon, I am sorry to say, for business purposes called "A boat load." I should very much like some one to tell me any rule by which I can ascertain the exact weight, according to the law standard, of the whole or an aliquot part of a "boat load of coals." I know a boat load of coals is twenty tons, and the furthest to which I can carry the weight is twenty tons, lease weight, that is 57,600lbs, or 25 tons, 13 cwt., 2 qrs., and 16lbs. legal weight; and yet I am told that sometimes a boat load of coals, will what is called "weigh out" 30 hundred weight to the ton.

This is not a pleasant subject to talk about, and, I think, the sooner we know the extent of each other's knowledge about it the better; but as my purpose is to fix, with as near an approximation to certainty as I can, the true weight of yield; I will explain how I have dealt with this question of over-weight. Some portion of the coal is sold land sale over the machine, statute weight. A greater portion is sold, going by Railway at the ordinary long weight, that which, for this purpose, I may designate middle weight, 2400lbs. to the ton; and I trust a still greater portion is sold by the fair lease weight of 2880lbs. I have taken the whole at the heaviest weight, that can be fairly, I might almost say honestly used, leaving any of the irregularities of overweight to be balanced by the instances where less than the highest or rather the heaviest weight is loaded.

Taking an average of years, that is setting off the times when the demand for coal is brisk, and boats have to wait their turn in the basin for loading, when the big boats are off the home station and used for drawing bricks, or sand, or ashes, or are hired "up the country," against those other times when the coal master must ask three times for an order, although he knows that the big boats are all again in regular commission, and that he can sigh but must not complain when he sees the fleet of leviathans mooring in his basin awaiting for loading at any quantity for a ton which can be exacted from his commercial necessities. Allowing then for any deficiency in the measure itself—or for what may be shown to be produced above the quantity per acre I have taken—or for the uncertainty of the weight recorded, still there is a very great and in a pecuniary point

of view, a very serious difficulty in the yield of the ten-yard coal. The important question is—how can this deficiency be reduced to the minimum, having regard to economical and safe working.

I do not hesitate to say that the first step in the right direction is to substitute the "Long wall," for the old pillar and stall system of working. The complaints of the waste of the square system are as old as Lord Dudley, who wrote in 1665, two centuries ago come next year. Smith, in the Miners' Guide, goes carefully over the whole question, both in its engineering, financial, and moral bearings.—Mr. Warrington Smythe reports upon the subject.—Mr. Lionel Brough, who combining perhaps the greatest amount of practical and theoretical knowledge of any living authority upon coal mining, has written, spoken, and lectured upon the subject.—Mr. William Mathews, in an able and convincing paper, has brought the question under the notice of the Society of Mechanical Engineers, and all these great authorities agree in stating that long work is the most economical. Smith describes and gives plans and sections of a mode of working long work in successive steps. As I am not familiar with his system, and therefore I cannot judge of it from experience, I will not ask you to rely upon it, but he says the cost of getting the coal would be $3\frac{1}{4}$d. a ton less, which would be about eleven per cent. of what he gives as the cost at that time, whilst the yield he states to be 31,495 tons an acre as against 15,400 which he gives as the produce of square work. Mr. Warrington Smythe says the increased yield would be ten to 15,000 tons an acre,—that is from 16,000 to 26,000, or even 31,000 tons. Here let me say, because it bears upon the subject of the different thickness of the seam to which I have before referred, that Mr. Smith was speaking from Mr. Foster's workings at Shut End, where they have a deficient thickness, and he therefore takes 16,000 as the yield at square work. Mr. Brough gives his high authority for saying that the yield may be increased 10,000 tons an acre, and lastly I will quote Mr. William Mathews, who gives the lowest, but on that account not perhaps the least trustworthy estimate when he says the produce may be increased from 6,000 to 7,000 tons an acre. I should say that Mr. Mathews' illustrations are taken from a district in which the ten-yard coal measure is defective, indeed the average of the four sections he gave shows an average deficiency as great as $3\frac{1}{2}$ feet. The district of which we speak has also been very much dislocated and disturbed by igneous action.

Although I have quoted these high authorities, I might have relied

upon a general description of square work contrasted with that of long work. For this purpose a very general description of the two systems is sufficient.—In what is called square work in this district, the colliers work in chambers called sides of work, and take at one working, beginning at the bottom and working upwards, the whole perpendicular height of thirty feet. As the roof is so high, no artificial props can be used to support it, so they leave about one-third of the measure in the solid to prop the work and divide the one chamber or side of work from another. As the work reaches to such a great height, and as scaffolding is troublesome and slack cheap, a large portion of the measure gotten is thrown into heaps in the pit for miners to stand upon in the middle part of their work. This, under the name of gob slack, becomes mixed with parting batt and roof dirt, and is allowed to accumulate in each side of the work, and is ultimately left piled in heaps against the pillars, when the colliers leave the chamber and close the door behind them,—that is dam up the bolt hole. In the long wall work on the other hand the ten-yard measure is taken in two courses,—the upper part of the measure first, and the lower half afterwards. For each course gate roads are driven out to the end of the boundary intended to be reached by the pair of pits. A heading is drawn from one gate road to the other, and so a "face of work" or long wall is formed the width of the "Navie," from which the colliers begin "holeing off," breasting back towards the pit bottom, carrying out all the mine before them and keeping the roof behind them by building up artificial props with pieces of parting batt, shale, and such matters for "cogs and builders" as the work may provide, and using timber where such material is not found in sufficient quantities, and of course drawing the timber where that is practicable as the work advances. The working of the lower division is taken in the same way, with this difference only, that where the division cannot be taken so as to leave a hard parting batt for the roof of the second working, care is required in removing as much coal as can be safely gotten, after it has fulfilled its office of giving mechanical support to the superincumbent "shut" of the first working. Upon the question of yield then, it is obvious that the horizontal system by which all the measure is broken down and carried up to daylight, must give a greater quantity than the perpendicular, by which part is necessarily left for props and divisions, and a further part is allowed to become mixed with rubbish, and then abandoned.

As to the comparative cost of labour in the two systems, I do not propose now to enter. I have never heard it suggested as an objection to the long wall system that it is more expensive, and I will therefore have that branch of the subject to rest upon the experience of practical miners. There is, however, one subject connected with the pecuniary cost of working to which I must refer,—the expense occasioned by surface damage. Surface damage in this district arises principally from the thick coal working,—the most destructive part being the attempt to get out a portion of the ribs and pillars. Where the mine is near to the surface taking out a pillar often causes a displacement of earth immediately above the spot from which the pillar is taken. The surface falls into the shape of an inverted cone, and forms one of those pits we call "pot-holes," or "crownings-in." Where the mines are deeper, and two or three pillars, or a length of rib is disturbed, the surface falls not perhaps suddenly, but rapidly into a hollow more or less regular, and forms what we call a "swag." The most destructive disturbance by our thick coal workings is when the mines lie deep, and the old ribs and pillars are disturbed. The surface displacement is gradual, there is a lateral and downward sliding of the superincumbent strata, by which the pillars in a whole side of work are "uncapped" and crusted. The displacement of surface in this case is not immediately over the cavity filled, for the strata are drawn for a greater or less distance according to the depth of the mine, and partly to the strength of the strata to bear the strain. This produces that fruitful source of loss and litigation a "draw" of the surface, and of course a wreck of all the buildings upon it. That you would be liable to a sinking of the surface to supply some of the displacement by mining in whatever way you worked the mines is certain; but you would have neither a "crownings-in," nor a "swag," nor a "draw" by long work. What subsidence took place would be gradual, and even so that although the surface would be lowered it would not generally be broken. In fact the surface damage by the long wall work would be only such as we see in districts where the mines are thin, and not of that extensive, and therefore expensive character which we see nearer at home. I have therefore a right to claim the decrease of loss from injuries to surface property as one of the items in favour of long work.

Gentlemen, I must now refer to some of the difficulties which are said to prevent the adoption of the long wall work. The first and most for-

midable is fire. It is said, by the rib and pillar system, if your side of work fires you can by damming up the bolt hole prevent the fire spreading at the loss of only that side of work,—you may leave a rib, and drive your leading head for the back stall of the next side of work in succession on the same day. This no doubt is so.

But you do not by stopping the bolt hole extinguish the fire, you only prevent the raging of the flame by excluding the oxygen of the atmosphere. The fire goes on burning, and sometimes increases the temperature of the next side of work so that the heat is scarcely endurable, and where the mine is near the surface the fire will gradually extend to the overlying bituminous shale and ignite that. When the shale is calcined it becomes so friable that it will not stand even for the short length between the pillars, and it falls into small burning pits called "fiery holes." This is the condition of things over a large tract of land near Moxley.

My answer, however, to the fire objection is, that by your mode of working you cause the fire that you require to control. The fire comes in the great heaps of gob slack which you leave on the floor of the working. In long work you leave no such heaps. The immediate cause of fire in our ten-yard coal pits has never yet been satisfactorily explained. "spontaneous combustion" is a very general expression,—"spontaneous ignition" is perhaps more accurate, but not much more definite. I am not myself able to conduct—even if this was the place to enter upon, a recondite discussion on this point; but I may say mechanical friction as an agent in producing fire in pits seems to require much more attention than it has yet received. When I look at a chemical analysis of coal, and think that in a thick coal pit those inflammable substances are reduced together to a fine powder, and then subjected to such an amount of friction as is occasioned when the base of a thick coal pillar is forced downwards under a pressure of hundreds of tons into the hard pouncil batt, and the hard batt is forced upwards against the outer circumference of the pillar, forming what is called the "creep" of the working, I cannot but think that at the point of contact and grinding there, friction must have a tendency in the centre of a great heap of slack, already hot, to raise the heat up to the point of ignition. However, gentlemen, by whatever cause fire is produced in our coal workings, there are two cardinal means of guarding against it,—not to leave your slack in heaps, and to have a ventilation sufficient to neutralize your inflammable gases in every crevice, —and both these objects can be attained by long work.

I will now address myself to some other objections. It is said that in some instances from tenure, the land being cut up amongst small proprietors, or more frequently from being divided by faults and dislocations, you cannot depend upon a sufficient area to lay out your work upon the long wall plan. It is a disadvantage upon either mode of working to have a small area; because the cost of plant and some other dead charges must be spread over, or rather imposed upon a smaller amount of gross returns; but I know of no reason why the one method should be preferred to the other over a limited area. No one thinks of working nowadays by beginning at the pit's bottom and carrying forward with gob roads, and if you are to drive out to your boundary in the dip, you may as well bring back with a long face as in separate chambers of pillars and stalls divided from each other by ribs. I cannot suggest any circumstances which would give a preference to square work over long work. The latter can be worked at a great angle of dip—or with a "side basset,"—or in fact anywhere that the back stalls of squarework can be cut out; but if a state of things should in any case exist in which ribs and pillars are preferred, you have still square work to fall back upon without pecuniary loss, for if you had not the information upon which you act before, you would obtain it upon driving out, and your roads would be as useful for the one plan of working as the other. It is said that leases form an impediment to adopting long work,—that the covenants are to work by ribs and pillars. Gentlemen, I think when the subject is better understood, that the impediment which the lessors' covenants interpose will be more likely to stop square work than long work.

One more, and I have done anticipating objections that may be urged against me. It has been, and perhaps may again be said, that by long work more slack is made than by the pillar and stall system. Gentlemen, I deny the truth of this statement. It has been found by experience, that other circumstances being equal, there is even less slack by long wall work than by the other mode. It is true you get fewer very large lumps of coal, and, perhaps at a time when the size of coal was taken as some test of quality, it might have been a greater advantage than it is now to have very great blocks. The enormous quantities of coal of excellent quality in small sizes brought from other districts by railway, has familiarized consumers with the fact that quality does not depend upon size, and they no longer insist upon pieces too large to be used whole. No doubt there would at present be great waste by slack in whatever way the mine was worked. Indeed the loss

by slack at present unsaleable unless under exceptionally favourable circumstances, will account for a considerable part of the deficiency of yield at the ticket book I have before pointed out. I may be permitted here to say a few words about slack—not that it is part of, but because it arises fairly out of my subject. First then, I would say it ought all to be screened so that as little shall be set aside as "fine" slack as possible. Secondly, the attention of every intelligent man in the district would be well bestowed upon the best means of utilizing this fine slack.—It will burn for ordinary heating purposes if the grate is properly constructed.—It will make good strong furnace coke, when mixed with mineral pitch. This was fully proved by Mr. Blackwell, at Corbyn's Hall; but unfortunately the demand for coking purposes raised the price of mineral pitch so high as to make the operation for the time unremunerative. It will, coke with a mixture of the fine slack of the more bituminous or "caking" coal, and lastly, from it can be extracted a fluid which will give a better light in an ordinary lamp than either camphine, paraffine, or petroline. Surely some means will be found of giving a commercial value to this enormous bulk of material,—what I cannot say; but certainly he will be a great benefactor to this district who makes the discovery.

Having so far spoken of the economical part of my subject, I feel that I cannot conclude without making some observations upon that which I ought perhaps to have placed first in my argument, I mean the moral aspect of the question. Gentlemen, the life of the miner is safer in a pit worked long-wall, than in a pit worked by ribs and pillars. Two things are imperatively necessary for the safety of the collier at work—absolute command of the roof, and perfect ventilation. In long work you have both. I will not go so far as to say that in a rib and pillar pit you have neither; but this I will say, that you never have command of the whole roof, and that perfect ventilation is the exception not the rule. Contrast the two plans as to roof. In the one, instead of being exposed to what may happen to the roof over a whole side of work, the miners have only the narrow roof space between the face of work and the building behind, and if the face is, as it ought always to be, kept close cropped, risk from roof-falls is reduced to the minimum. Further, as in the one case the roof—narrow as it is, is also low, and can be reached, the collier can examine it. He can "sound" it and take his precautions accordingly. If he has not sufficient builders, he may, where it is necessary, leave

"cogs" in the solid, to be worked out when the face of work is advanced sufficiently far to let the shut come down, or set trees to be drawn under the same circumstances. That is, he may prop, by leaving cogs or setting timber until he has passed the dangerous part of a tender roof. In the other case he is working perhaps in the band with a roof so high above his head that it cannot be even seen distinctly with an ordinary pit candle from the floor, and as to propping it artificially, it is impossible. He could not cog it up with builders, and if you will consider the weight of a balk of timber strong enough to bear that enormous weight to be supported, and thirty feet long, it will be evident how impossible it is even to move such a weight in a coal pit, much less to fix it as a prop. In practice the roof of a rib and pillar pit is, and must be left to chance. The consequence is, as might be expected, that although at and for a short time after the fall of coal men keep out of danger, when they are engaged in removing and taking out the displaced coal, accidents from the fall of roof occur, with lamentable frequency; whilst in the long work pits of the thick coal, they are of very rare occurrence. If there is danger from the roof at the first working of the maiden mine, how fearfully must it be increased when the colliers come into the same chamber or side of work, after a lapse of time for a second working, that is reducing the props. You all know the danger, and therefore, I will not dwell upon it, further than to say that this second course over, is part of the ordinary system of square work. Next, as to ventilation. In a rib and pillar, a draft is created by "air beds or "spouts," either into the gate road leading to the "upcast" shaft, or into a wind-way driven up to that shaft. If these "spouts" are in the lower part of the measure as the combustible gases rise, they are apt to hang upon the roof of the working, to the great danger of explosion. If the air aperture is high the colliers are short of air before they reach it. In any case the air seldom circulates freely in all parts of the side of work; it is in fact, like a very large building above ground would be with one door, and one or perhaps two windows open. There will always be parts of the excavated chamber in which the air is unwholesome, and sometimes dangerous. With long work on the other hand, the men are working in a place which I may describe as a narrow passage open at both ends; one commencing with the downcast and the other with the upcast shaft with a thorough draft through. This draft can be increased to any required extent by having a furnace

in the upcast shaft to rarify the air and so by increasing the displacement, give force to the supplying current. So far from being dangerous from want of ventilation, there really is no practical difficulty in making a long work pit positively wholesome. Happily the loss of life by explosions in the square work pits of this district is not large; but I fear the loss of health and stamina from breathing impure air would be found to be much more than many of you are at present aware of. Gentlemen, it is a strong argument in favour of a comparatively safe system of work, that it gives confidence to the men. They feel they are cared for—that duties towards them are fulfilled, protection fosters allegiance. Men with a safe roof over their heads, a good building behind them, and fresh air for their hard toil, will work not only with greater confidence, but with contentment, and even cheerfulness.

It is, however, by falls from the roof, and particularly in the second or third workings that such a fearful mortality is occasioned in our ten-yard coal workings. Attention has been called again and again to this painful subject. Every Inspector who has had the supervision of the district since the Mines' Inspection Act came into operation has reported upon the subject. Mr. Wynne, Mr. Brough, Mr. Langridge, and now Mr. Baker; surely they cannot all be wrong. I might read you extracts from every, I believe without exception every report in confirmation of my statement. I will not, however, repeat what you have all an opportunity of being familiar with; but take one and only one of many extracts from the annual reports of the District Inspector. Mr. Brough, in his report of February 24, 1858, says, "Of the 54 casualties in the 'thick-coal,' full half of them were in 'rib and pillar pits' that is to say, in those which had been wrought before." * * *

"The original excavation of the whole height of the maiden seam by pillar and stall is dangerous enough, but the second and third explorations surpass anything in the annals of British mining for insecurity to human life. The plan adopted by W. O. Foster, and B. Gibbons, Esqrs., does away altogether with these rib and pillar pits, and I now beg to repeat the statement I made last year, that if such a system had been in practice throughout South Staffordshire there would have been an astonishing mitigation of the casualties contained in my "List," "not *one life*" (the italics are the

author's) "having been lost in the extensive thick-coal collieries of these two gentlemen during the whole period of my residence in the district." There can be no better evidence than this; and I can add to it by stating, that in a large thick-coal work of the New British Iron Company, which is laid out for getting at twice, only one fatal accident occurred in the past year, and even that was from a cause entirely irrespective of the system. I may further mention that, of the total 81 deaths, only 5 took place in mines where the long wall mode was in use, all the others were in those where the coal is obtained by pillar and stall. But in whatever manner the "thick-coal" is excavated, it should always be driven out in two mines and then worked back either by "long wall" or by "cogs." It is far too lofty a seam to be taken away from floor to roof at one working. Timber will not reach the top measures, and setting up "trees" in them, and their removal is an operation too dangerous to be thought of."

I can also quote Mr. Baker, as I am glad to find he is present. In one of my conversations with him upon this subject, he said,—In the long wall pits at Shut End, I have not the complaint of any underground injuries, not so much as a "pinched finger."

Gentlemen, the sad summary is this, that for every two millions of coal and slack gotten in Great Britain ten men are killed by falls from roof and coals, whilst in this district twenty-seven lives are lost for the same quantity of materials.

I now commend this subject to your serious deliberation. If I have established, first, that the yield from the working of the ten-yard coal is greatly deficient; second, that the yield may be increased by adopting the long wall system of working; and third, that the number of fatal accidents may be reduced; then I have justified myself in arousing your attention and bringing public opinion to bear upon your own special vocation. The interests involved reach far beyond the coal worker or the coal owner. The interest is brought actually home to every Englishman's fire side. The prosperity of our manufacturers, and employment of our artizans depend upon it. Point out to me on the map where the coal is worked, and you indicate the districts from which our national wealth is derived. I then know the centres around which an industrial population is gravitating, and where the productive arts are in their highest state of development. Fuel is power,—the

continued prosperity of our enormous manufacturing system depends upon an abundant supply of coal. It is not for these reasons alone I ask you to deliberate upon the facts I have presented to you. The vital statistics throw upon us a grave,—I may say a sacred responsibility. The distruction of life must be prevented.

Gentlemen, my observations will I trust receive your favourable attention. You know my object has been to improve the condition of things around me,—to increase the wealth of the proprietor, and the profit of the worker, whilst the life of the working collier is protected, and that attention paid to his health and comfort, without which his moral character cannot be elevated.

FINIS.

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