

STOCKS: "COAL BALLS" AND "BAUM POTS." 395

by such water percolating through the rock, and be carried by it into the coal, where the carbonate of lime would deposit round some stem or other part of a plant, thus forming a coal ball; the phosphate of lime being left with the decomposing shells, which would themselves become gradually covered by carbonate of lime from the surrounding shells, and in time form a "baum pot" which would contain most of the phosphoric acid of the shells, thus accounting for the presence of it in greater quantity in the "baum pots" than in the "coal balls."

The amounts of silica and alumina are also larger in the "baum pot" than in the "coal balls," this would seem to show that the carbonate of lime in forming the "baum pot" had enclosed some of the shale, which did not occur in the formation of the "coal balls."

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ON THE FIRE-DAMP DETECTOR, WITH RECENT IMPROVEMENTS  
IN THE MINERS' SAFETY LAMP; AND SOME REMARKS ON  
THE DIFFICULTIES CONNECTED WITH DEEP MINING. BY  
W. E. GARFORTH, C.E.

THE early history of the safety lamp is, that in the year 1815, Sir Humphrey Davy and George Stephenson, the celebrated railway engineer, unknown to each other, invented the lamps known by their respective names.

It is generally admitted that Dr. Reid Clanny, of Sunderland, first conceived the idea in 1813, but as his lamp was dependent upon a supplementary appliance, and not on the surrounding atmosphere, the credit is given to Davy and Stephenson, both of whom received public recognition for the invention.

The safety of the Davy lamp is based on the principle that a flame in passing through a metal gauze of a certain mesh (the standard at present is about 784 apertures to the square inch), loses so much of its heat as to be incapable of igniting the explosive atmosphere surrounding it.

Safety lamps when first introduced were received with some distrust, but after a time the Davy, with apertures of  $\frac{1}{40}$  to  $\frac{1}{60}$  of an inch in diameter, became to be implicitly relied upon, especially in a current moving at a slow velocity. The Davy lamp now exhibited, is supposed to be a fac-simile of Sir Humphrey Davy's original lamp, the first ever used in a coal mine, and was sent by him, in the early part of 1816, to the Rev. John Hodgson, Vicar of Heworth, Newcastle-on-Tyne, and afterwards presented by his relatives to the School of Mines, in London. This lamp is almost identical with the Davy of to-day, the slight difference being in the strength of some of the parts, an improvement which any ordinary workman could suggest.

About the year 1835 the Davy lamp was proved unsafe in an explosive current of 6ft. per second, and since that time some of our most eminent scientific men have endeavoured to find a safer light. The result has been, that more than 100 different patents have been taken out. For many years past the writer has been endeavouring to discover a Light without a Flame sufficient for practical use in the mine. Experiments have been conducted on Phosphorus, the Electric Light, and different kinds of safety lamps. Without troubling you with the details of such experiments, it may perhaps be well to state the danger of applying the Electric light in mines. There is an impression that the incandescent lamps (now in general use on the surface) might be used with advantage, if sufficient electricity could be stored in a portable form, but the objection is that if electric wires are allowed to cross each other and then separate, an action similar to the effect produced by a fall of the roof, electric sparks are emitted by which the gas has been ignited. What is required in a mine is not only a light, but an indication to the miner that the atmosphere surrounding him is sufficiently pure to breathe.

The principal requirements of a safety lamp are:—to be so sensitive as to indicate at once the presence of gas, by allowing the atmosphere to reach the flame without obstruction, and yet so shielded as to resist an explosive current moving at a high velocity; that an ample supply of air may be obtained to support combustion, and yet have some internal arrangement by which the products of an explosion inside the lamp will cause it to be self extinguishing;

to be so small as not to be an encumbrance in getting through the small roadways or places to be examined, (also to prevent the force of an explosion inside the lamp bursting the gauze,) and yet so arranged that it will burn for 8 or 10 hours without getting too hot; to be so light that it may be carried for hours without difficulty, and yet so strong as to resist a certain amount of rough usage; to give a good light, not only to enable the miner to get the coal, but to enable him to see the breaks in the roof (it has been stated there are more accidents from falls of roof, on account of the poor light given off by the Davy or Stephenson, than with the candle.)

The comparative lighting power of some of the principal lamps now in use is as follows:—

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| English Standard sperm candle burning 120 grains per hour | 100 |
| Improved Mueseler   | 70  |
| Davy  | 37  |
| Stephenson  | 20  |

The writer succeeded about three years ago in constructing a lamp unlike any existing one, which fulfilled many of the before mentioned requirements, but as it was dependant on the movement of a small fan to obtain and regulate the supply of air, it could not be recommended for daily use, as some of the parts were liable to derangement owing to the dust in the mine. As an instance of the difficulty of obtaining a perfectly safe light, it may be stated that recently a prize of £500 was offered by Mr. Ellis Lever, and 108 different lamps competed, but no lamp fulfilled the conditions ordinarily required in a mine, and the prize was not awarded.

During the last few years, and based on a great number of experiments and trials, several improvements have been made in the lamp, the most important being the Mueseler Chimney and the Tin Shield. The object of the chimney is to throw back the carbonic acid gas (the result of the explosion inside the lamp) on to the flame and so extinguish the light. With a properly constructed chimney where all the space can be filled with carbonic acid gas, the flame of the lamp, in an explosive current of 19 feet per second, is extinguished before firing the gas outside. Above that velocity, and with the current directed to the upper part of the internal chimney, the flame can be drawn (somewhat on the principle of the Injector) to the top

of the chimney, when it simply acts like the Davy, as there is then only the gauze between the flame and external atmosphere. If, however, the lamp is fitted with a tin shield securely fastened to the middle flange of the lamp, the chimney and gauze are so protected that lamps of this description have been made to resist a velocity of 51 feet per second. This velocity is more than is required under ordinary circumstances, but it is difficult to say what is required to resist the extraordinary conditions met with in mining, such as the concussion of air produced by a blown out shot, or after a heavy fall of the superincumbent strata, either of which might force a large volume of explosive mixture at a high velocity on to the lamp. Considering the cubical capacity of a large goaf as compared with the narrow roadways leading thereto, it may be imagined that a velocity of more than 50 feet per second results when a heavy fall takes place. Judging from the latest trials, it is thought that at 60 feet per second no existing lamp is safe. The advantages of resisting a high velocity are undoubtedly very great, and will become of still greater value year by year in those deep and extensive mines where large volumes of air are required for ventilation and for reducing the temperature of the strata at great depths. In my opinion, however, the advantages of the tin shield and double or triple gauze have been gained by shielding or placing a species of obstruction between the flame and external atmosphere. Such being the case, the old argument that the mine can be kept safer by using the Davy, which detects small quantities of gas, still holds good in a sluggish ventilation. The Davy is known to be most unsafe, for the reasons mentioned of not being able to resist velocity, and was some years condemned in Belgium; and in many English mines. The last serious explosion in this country, happened at Altham, in Lancashire, by which 39 lives were lost, and a great number injured; the accident was traced beyond doubt to the use of the Davy, and since the explosion the Tin shield lamp has been substituted.

From the foregoing remarks it would seem that in any existing safety lamp where one qualification is increased, another is proportionately reduced; so it is doubtful whether all the necessary

qualifications can ever be combined in one lamp. The writer believes they cannot, and with a view of making the Tin shield or any other description of protected lamp as equally sensitive as the Davy, he has invented the Detector as the most suitable adjunct or second vessel to the lamp.

The Detector, as will be noticed from the one exhibited, simply consists of an India rubber ball, so small that all the air within it is expelled by the compression of one hand, and a pure sample of the suspected atmosphere obtained. If the ball were larger, and a portion of the air remained, the sample would then be diluted. It has been found by a great number of trials that it obtains quite sufficient gas for testing purposes. That only one hand should be engaged in testing is an indispensable condition, on account of holding the lamp, &c. It will be apparent that by the ordinary action of compressing the ball and then allowing it to expand, a vacuum is formed within it, and a sample of the suspected atmosphere drawn from the breaks and cavities of the roof or any part of the mine.

When the sample is forced through the tube near the flame, gas, if present, at once reveals itself by the elongation of the flame in the ordinary way; at the same time burning with a blue flame at the top of the test tube. If gas is not present, the distinction is easily seen by the flame keeping the same size, but burning with greater brightness owing to the increased quantity of oxygen forced upon it.

The advantages claimed for this method of detecting fire-damp are:—

1.—The Detector, on account of its size, can be placed in a break in the roof, where an ordinary lamp—even a small Davy—could not be put; and a purer sample of the suspected atmosphere is obtained than would be the case even a few inches below the level of the roof.

2.—The method of obtaining and testing a sample as above described, takes away the possibility of an explosion, which might be the result if a lamp with a defective gauze were placed in an explosive atmosphere.

(Although lamps fitted with a tin shield will be subjected to the same strict examination as hitherto, still they do not admit of

the same frequent inspection as those without shields, for in the latter case each workman can examine his own lamp as an extra precaution, whereas the examination of the Tin shield lamps will rest entirely with the lampman).

3.—The lamp can be kept in a pure atmosphere, whilst the sample is obtained by the Detector, and at a greater height than the flame in a safety lamp could be properly distinguished. The test can afterwards be made in a safe place at some distance from the explosive atmosphere; and owing to the vacuum formed, the ball (without closing the mouthpiece) has been carried a mile or more without the gas escaping.

4.—The Detector supplies a better knowledge of the condition of the working places, especially in breaks and cavities in the roof, which latter, with the help of a nozzle and staff may be reached to a height of ten feet or more, by the Detector being pressed against the roof or sides, or by the use of a special form of Detector.

5.—Being able at will to force the contents of the Detector on to the flame, the effects of an explosion inside the lamp need not be feared.

6.—The use of the Detector will permit the further protection of the present Tin shield lamp, by an extra thickness of gauze, if such addition is found advantageous in resisting an increased velocity.

7.—In testing for gas with a safety lamp, there is a fear of the light being extinguished, when the lamp is suddenly placed in a quantity of gas, or in endeavouring to get a very small light; this is especially the case with some kinds of lamps. With the Detector this is avoided, as a large flame can be used, which is considered by some a preferable means of testing for small quantities, and the test can be made without risk. Where gas is present in large quantities, the blue flame at the end of the test tube will be found a further proof. This latter result is produced by the slightest compression of the ball.

(I need not point out the inconvenience and loss of time in having to travel a mile or more to re-light.

Although the question of safe lighting is one of the most important connected with coal mining (for without a light no work could

be done), still there are other serious difficulties to contend with, in consequence of the increased depth at which coal will in the future have to be won. Fortunately, large quantities of water (which in some shallow pits has been the chief drawback to the mine being worked profitably) are seldom met with at great depths; and fire-damp, which might naturally be expected to be given off in greater proportions, owing to the increased weight of the the superincumbent strata, is found to be little, if any more, than in mines lying nearer the surface. The cost of actually raising the coal is not seriously felt, on account of the various improvements which have been made in ropes, compensating winding drums, regulating valves, and the more economical use of fuel in both engines and boilers. The improved manufacture and reduced price of steel has contributed very materially to these and other advantageous results.

The principal difficulties of deep mining are, increase of temperature, and the effects of the weight of the superincumbent strata. With reference to the former, it was thought, about the time the Royal Commission was appointed to enquire into the probable duration of the English coal-fields, that the temperature of the strata increased about one degree for every fifty feet, (after sixty feet from the surface); but recent sinkings have proved the increase is not so great, being only one degree for every seventy-six to seventy-nine feet. At Ashton Moss Colliery, near Manchester, the deepest shaft in England, and at Dukinfield Collieries, Cheshire (with both of which the writer is well acquainted), the temperature at 2,880ft. deep is eighty-four to eighty-five degrees.

The natural temperature of the strata has been much reduced in some mines, by passing large volumes of air at a low temperature along the roadways; but as deep mines will have to work extensive areas to save the cost of sinking additional pits, it follows that in an increased length of air-way, the air will become warmer, and less able to absorb the heat given off by the surrounding strata. To obtain sufficient air for cooling purposes, in addition to the ordinary requirements connected with the men, horses, lights, and diluting the noxious gases, a great increase of motive power will be required.

The greatest help to obtain this increased quantity is by a larger

sectional area. This raises the second difficulty of dealing with the effects of the superincumbent weight.

Considering the difficulty and heavy cost of increasing the velocity, it becomes a question whether it will not in the future be more advantageous to reduce the temperature by artificial means.

As regards the effects of the superincumbent strata at great depths, it seems to be a difficulty quite as serious as increase of temperature. Pillars of coal, which formerly resisted the effects of the overlying strata, are now much crushed even if a larger proportion of pillar be left. Of course no system of working can diminish the pressure, but on the contrary, must increase it. The faults of a wrong system of working, which were not apparent at shallow depths, are now seen by an increased proportion of small coal, which in most instances makes the difference between profit and loss. There is also the difficulty (a most serious one) of the liability of sudden outbursts, which has been the cause of several dreadful colliery explosions.

From the foregoing it would seem that coal has been placed within our reach, but apparently too deep for work; and when the hands are stretched forth to obtain it, a sacrifice of life takes place. But when we remember, and from statistics published by the Royal Commission, that only 60 per cent. of the produce of the seam was formerly obtained in some districts, it would appear as if coal had been Divinely stored at a great depth to prevent it being wasted, both in the method of getting and in the consumption. At the present time, as much as 95 per cent. (in some cases more) of the seam is obtained, and  $2\frac{1}{2}$  lbs. of coal per hour per horse power, is now doing the same amount of work that some years ago required 4 to 5 lbs.

The writer believes it is possible to overcome many of the difficulties that have been referred to, by a better and more systematic method of working. When we take into account that most mines rest upon an under clay, it will be understood that the same pressure which is crushing the coal is also affecting the dirt. If that effect is only properly studied, it is possible it may not only be the means of saving the coal, but by being crushed into suitable pieces for packing, it will enable the goaf to be filled, and thus



reduce the cause of sudden outbursts to a minimum ; at the same time prevent accumulations of gas, and form good roadways without leakage for the ventilation.

An eminent writer asks, " May it not be said that the experiments of science are the answers made by nature, to the questions put to her by man." This remark may for many reasons be considered specially applicable to mining. If the laws of nature are scientifically and properly studied, it will be found that the difficulties of deep mining are far less than at present apprehended ; and though we may for a time be perplexed, yet in the long run it will be proved in mining, as in other things, that the fault does not rest with nature, whose wonderful laws appear grander and more marvellous the better they are understood.

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ON A NEW SPECIES OF HETEROLEPIDOTUS FROM THE LIAS.  
BY JAMES W. DAVIS, F.G.S., &c. (PLATE XXII).

Genus HETEROLEPIDOTUS, Egerton.

HEAD large ; snout obtusely conical ; maxillary and mandibular bones straight ; teeth of various sizes, the larger ones strong and bluntly pointed ; the smaller ones sharp and numerous ; gape wide ; pectoral and ventral fins large ; dorsal fin remote ; scales large, thick, and lustrous, more or less serrated on the posterior margins ; abdominal scales small and elongated ; tail broad, the upper lobe ridged with strong fulcral scales. (*Egerton.*)

HETEROLEPIDOTUS MINOR, Davis.

The specimen which forms the subject of the following description has been in my cabinet for some years awaiting the discovery of others which would exhibit more perfectly the characters lacking in this one. The body of the fish represented by the accompanying plate is slightly distorted so that the abdominal region is brought prominently forward, and both the right and left pectoral and ventral fins are exhibited in a more or less perfect condition. The scales are displaced ; the head is imperfect ; the whole of the