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EXPLOSIONS IN MINES

AFTER the occurrence of great colliery explosions such as those which took place recently in Pemberton and Blantyre collieries, one very general and pertinent question presents itself to most minds, namely, What has been done or attempted with the view of preventing these disasters? It would be impossible to condense into an article like the present all that could be said in reply to this question, but I shall endeavour to give a brief outline of the subject, and point out, as well as I can, what appear to be its most prominent features.

Before the invention of the safety-lamp, the only means of guarding against the ignition of firedamp consisted in the employment of an apparatus called the "steel mill." The light obtained by its aid was feeble and uncertain, and Mr. Buddle informs us that explosions were known to have been caused by the sparks emitted by it. When Davy made his brilliant invention in 1815–16, the steel mill was laid aside for ever, and it was then imagined that colliery explosions had also become phenomena belonging to a past order of things. So confident, indeed, was Davy in the efficacy of his lamp, that he believed it could be safely employed for carrying on work in an explosive atmosphere; and he even went so far as to propose to make use of the firedamp itself as the light-giving combustible. These fond expectations were soon roughly dispelled, as one explosion followed another in an apparently unaccountable manner; and at length they were succeeded by a feeling of positive distrust, which found expression in the report of a select committee appointed, in 1835, to inquire into the nature of accidents in mines.

In 1850 Mr. Nicholas Wood made a series of experiments, which proved that when a Davy lamp is subjected to an explosive current travelling at the rate of eight or nine feet per second, the flame soon passes through the wire gauze. This was corroborated about 1867 by experiments conducted by a committee of the North of England Institute of Mining Engineers.

Lastly, in 1872–73, the writer demonstrated, also by experiment, that when a lamp burning in explosive gas is traversed by a violent sound-wave, such as that produced by a blasting shot, the same result follows, that is, ignition is communicated to the outside atmosphere. These are weak points inseparable from the construction of the ordinary Davy and Clanny lamps; but as it is now a thoroughly-recognised maxim that work must never, under any circumstances, be continued in an explosive atmosphere, they are seldom put to the test.

The atmosphere of part of a mine may, however, become explosive before the men can escape, either by the sudden influx of a quantity of firedamp from some natural cavity in which it had existed in a state of tension, or by a partial or total cessation of the ventilating current; and I propose in the next place to consider how such an event could produce an explosion supposing all the men to be provided with safety lamps.

This will happen, firstly, if the inflammable gas passes over a furnace at the bottom of the upcast; secondly, if it is carried against a Davy or Clanny lamp at a greater velocity than seven feet per second, or if the lamp is traversed by a sound-wave; thirdly, if a blasting shot is fired directly into it; and lastly, if it reaches a safety lamp that has been opened by one of the men.

The means that have been provided for guarding against these contingencies are as follow:—1. Furnaces have to a large extent been replaced by ventilating fans in fiery collieries. 2. Davy and Clanny lamps are still almost universally employed, and little importance seems to be attached to their known imperfections by those who are supposed to be capable of deciding the question. 3. Shot-firing having been found to originate many explosions, although probably in a manner not yet understood by most people, is now carried on under certain restrictions which it could easily be shown are still insufficient. 4. Much nonsense has been talked and written about miners opening their lamps. That they sometimes do so is beyond a doubt; but why should this state of matters be allowed to continue when it can be easily put an end to? The present flimsy pretence for a lock is not a necessity but a cheap convenience; and who is responsible if say a hundred men are killed through its being opened by one? Is there no responsibility attaching to the owners or the legislature for placing the lives of ninety-nine innocent men in danger? I think surely there is.

The influence of changes of weather on the internal condition of mines has been remarked since the remotest times, and for the last fifty or sixty years at least many have asserted that firedamp is more prevalent when the barometer is low than in the opposite case. The explanation of these phenomena is easily found by anyone who has an elementary knowledge of the physical properties of gases. On the other hand, when vigorous artificial means of ventilation are employed, and ordinary skill practised in distributing the air, the effects of changes of weather become much less perceptible.

Hence if a large proportion of explosions can be shown to occur simultaneously with, and therefore, presumably, in consequence of, those atmospheric changes that would tend to augment the amount of firedamp in the workings, there is a strong argument in favour of the supposition that they are preventible, and cannot therefore be considered as accidents in the true sense of the term. With this object in view diagrams have been made from time to time by Mr. R. H. Scott and myself, and also by one or two others, showing the connection that exists between the two classes of phenomena, and an examination of these is sufficient to convince unbiased persons that there is a striking coincidence between the explosions and the favourable atmospherical conditions. As might, perhaps, be expected, some persons engaged in mining either fail to see the connection, or possibly they do not understand it. Nevertheless a general rule was inserted in the Coal Mines' Regulation Act (1872) making it compulsory for mine-owners to place a barometer and thermometer at the entrance to every mine in the coal-measures.

It has always been difficult, and sometimes impossible, for mining men to give an adequate reason for the extent of great explosions, and more especially when it is known that, immediately beforehand, little or no inflam-

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mable gas has been present in the workings. The reports of the Inspectors of Mines bear ample testimony to the correctness of this statement. It has therefore been customary in the absence of any other tenable hypothesis to assume that a large volume of firedamp had been suddenly poured into the workings. But these so-called "outbursts of gas" are entirely unknown in some localities in which great explosions have occurred; and therefore it is much to be marvelled at that some other explanation was not at least sought for.

In September, 1844, before the appointment of inspectors of mines, Lyell and Faraday were sent to Haswell Colliery by the Home Secretary to report on an explosion that had just taken place there. I am unable to quote from their official report, but I am firmly convinced that the following sentences taken from their article on the subject in the *Phil. Mag.* 1845, is the true key to a solution of the problem as regards both the mode of occurrence and means to be used for the purpose of avoiding great explosions in future; and, moreover, I believe that it has been highly unfortunate, both for the cause of the miner and his employer, that these two philosophers were not induced to prosecute their investigations further than they did.

The sentences referred to are these:—"In considering the extent of the fire for the moment of explosion, it is not to be supposed that firedamp is its only fuel; the coal-dust swept by the rush of wind and flame from the floor, roof, and walls of the works, would instantly take fire and burn, if there were oxygen enough in the air to support its combustion; and we found the dust adhering to the face of the pillars, props, and walls in the direction of, and on the side towards, the explosion, increasing gradually to a certain distance as we neared the place of ignition. This deposit was in some parts half an inch, and in others almost an inch thick;[1] it adhered together in a friable coked state; when examined with the glass it presented the fused round form of burnt coal-dust, and when examined chemically, and compared with the coal itself reduced to powder, was found deprived of the greater portion of the bitumen, and in some cases entirely destitute of it."

About three years ago M. Vital, Ingénieur des Mines in France, showed that a flame resembling that produced by a blasting shot which blows out the tamping is greatly lengthened in an atmosphere containing a cloud of coal-dust; and soon afterwards the writer ascertained that air containing a small proportion of fire-damp (less than one per cent. by volume) becomes highly inflammable when coal-dust is mixed with it.

These discoveries complete what Lyell and Faraday began, and show how explosions of any conceivable magnitude may occur in mines containing dry coal-dust. A blasting shot or a small local explosion of firedamp, or a naked light exposed when a cloud of coal-dust is raised up by a fall of roof in air already containing a little firedamp is sufficient to initiate them, and, when once they are begun, they become self-sustaining.

These remarkable facts are either not yet sufficiently well known or their true significance is not yet fully appreciated. In conclusion I may state that out of many hundred collieries known to me there is not, to my knowledge, a single damp one in which a great explosion has happened; while, on the other hand, there is a considerable number of very dry ones in which explosions causing the deaths of from 12 to 178 men at a time have occurred.

W. GALLOWAY

[1] In the reports of the Inspectors of Mines, human bodies, timber, and coal, are described as being *charred* or *burnt* where they are covered with this deposit.—W. G.

THE SUN'S PHOTOSPHERE

DR. JANSSEN has just made a communication to the French Academy of Sciences, which will be received with interest, not only by students of solar physics, but by all who follow the various triumphs achieved by modern scientific methods. It seems a paradox that discoveries can be made depending on the appearance of the sun's surface by observations in which the eye applied to the telescope is powerless; but this is the statement made by Dr. Janssen himself, and there is little doubt that he has proved his point.

Before we come to the discovery itself let us say a little concerning Dr. Janssen's recent endeavours. Among the six large telescopes which now form a part of the equipment of the new physical observatory recently established by the French government at Meudon, in the grounds of the princely Château, there is one to which Dr. Janssen has recently almost exclusively confined his attention. It is a photoheliograph giving images of the sun on an enormous scale—compared with which the pictures obtained by the Kew photoheliograph are, so to speak, pigmies, while the perfection of the image and the photographic processes employed are so exquisite, that the finest mottling on the sun's surface cannot be overlooked by those even who are profoundly ignorant of the interest which attaches to it.

This perfection and size of image have been obtained by Dr. Janssen by combining all that is best in the principles utilised in one direction by Mr. De la Rue, and in the other by Mr. Rutherfurd. In the Kew photoheliograph, which has done such noble work in its day that it will be regarded with the utmost veneration in the future, we have first a small object-glass corrected after the manner of photographic lenses, so as to make the so-called actinic and the visual rays coincide, and then the image formed by this lens is enlarged by a secondary magnifier constructed, though perhaps not too accurately, so as to make the actinic and visual rays unite in a second image on a prepared plate. Mr. Rutherfurd's beautiful photographs of the sun were obtained in a somewhat different manner. In his object-glass he discarded the visual rays altogether and brought only the blue rays to a focus, but when enlargements were made an ordinary photographic lens—that is, one in which the blue and yellow rays are made to coincide—was used.

Dr. Janssen uses a secondary magnifier, but with the assistance of M. Pragmowski he has taken care that both it and the object-glass are effective only for those rays which are most strongly photographic. Nor is this all; he has not feared largely to increase the apertures and focal length, so that the total length of the Kew instrument is less than one-third of that in operation in Paris.

The largely-increased aperture which Dr. Janssen has given to his instrument is a point of great importance. In the early days of solar photography the aperture used was small, in order to prevent over-exposure. It was

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