FIRES AND IGNITION IN MINES.

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The heading of this paper covers a wide field, embracing as it does cases of spontaneous heating without actual fire, blazing fire, which may be due to spontaneous heating or to some mechanical or electrical cause, ignition of gas with subsequent flame but practically no explosion and ignition of gas or coal dust with a more or less severe explosion.

Spontaneous heating.—This is quite a common occurrence in coal mining operations although it is one of the things which the Mining Engineer takes the greatest precautions to prevent.

Cause of heating.—Coal in its natural state always absorbs oxygen and in doing so a certain amount of heat is generated; unfortunately coal is a very bad conductor of heat and the heat thus formed is not easily dissipated, with the result that the temperature rises and this is immediately followed by an increase of the rate of oxidation thus producing more heat until finally ignition temperature is reached.

Liability to heating of different seams.—Different seams of coal vary greatly in their liability to spontaneous heating and this is chiefly due to two causes: (*a*) the thickness of the seam and (*b*) the physical constituents of the coal. (*a*) It is a well-known fact that in thin seams 4′-0″ thick or less, spontaneous heating is very rare indeed, this is of course to be expected as the heat generated by the oxidation of the coal is dissipated through the roof and floor of the seam and also there is not the same quantity of coal lost in mining operations as there is in a thicker seam. (*b*) Coal consists of 4 physical constituents—Clarain, Durain, Vitrain, and Fusain—and of these four constituents it is the last, Fusain, which is primarily responsible for the spontaneous heating as it absorbs oxygen far more readily than any of the other three constituents. In addition to its affinity for oxygen the Fusain in a coal seam also tends to create spontaneous heating because it is the softest part of the coal and coal with much Fusain in it is softer and therefore more liable to disintegrate than coal which has little of this constituent, *e.g.*, Anthracite which contains no Fusain is not liable to spontaneous combustion at all; this disintegration of the coal exposes more coal surface to the air and therefore the rate of oxidation of the coal increases.

One other factor which has a definite bearing on the liability of a coal seam to spontaneous heating is the nature of the floor and roof: if the floor and roof are composed of sandstone or some similar rock which is a good conductor of heat there is definitely less likelihood of spontaneous heating

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than there is if they are composed of shaly material which is a bad conductor of heat.

Rate of progress of spontaneous heating.—The rate of progress of a spontaneous heating until it becomes a blazing fire varies considerably depending on several factors: (*a*) the degree of spontaneous combustibility of the particular seam, (*b*) the amount of the coal concerned in the heating, (*c*) the state of disintegration of the coal, (*d*) the amount of oxygen that is available for the coal to absorb, *e.g.*, there is more likelihood of heating developing in a seam which requires a high watergauge to ventilate it than in one with a low watergauge, other things being equal.

As spontaneous heating starts and developes in a mine it produces effects which enable an experienced mining man to detect it in most cases before it becomes a blazing fire, although in cases where oxidation is very rapid this is not always so.

The definite stages of a heating can be classified under the following headings:

1st stage ..	.. Sweating, or deposition of moisture on the roof, sides, etc.
2nd ,, ..	.. 'Gob stink' smell produced
3rd ,, ..	.. Paraffin or petrol smell produced.
4th ,, ..	.. Burnt tar smell produced.
5th ,, ..	.. Smoke appears.
6th ,, ..	.. Flame visible.

'Gob stink' so called because heating usually occur in the goaf or 'Gob' has a very distinctive odour and an experienced man can detect the very faintest trace of it by his sense of smell and if even the faintest trace is detected it is absolutely infallible proof that a heating is starting. It is safe to say that over ninety per cent of fires in mines that are caused by spontaneous heating are discovered by some one detecting a smell of gob-stink in the mine; the remaining small percentage are exceptional cases where the air getting to the heating is under pressure of some kind and development of the heating is so rapid that when it is discovered it has already reached one of the more advanced stages outlined above.

Other fires in mines.—Fires other than those caused by spontaneous combustion may be initiated in a variety of ways which it is convenient to classify as 'Mechanical' and 'Electrical'.

Mechanical initiation of fires.—In the majority of cases this class of fires is caused by some kind of mechanical friction which continues over a period of time until sufficient heat is generated to set alight any combustible material which may be near at hand. The most common instances are the rubbing of a continuously running endless haulage rope on a defective pully which has ceased to revolve or on some obstruction such as a sleeper which has got out of position; the rubbing of a steel jigger face conveyor on timber due to the

conveyor being improperly built up or having been pushed out of alignment by shot-firing or some other cause; to the rubbing of an endless belt conveyor on part of the steel framework which has got out of alignment or been damaged, or on some projecting piece of wood which is fouling the conveyor; again if a belt conveyor is badly overloaded the belt may be continually slipping on the driving drums and eventually generate so much heat that if there happens to be any very inflammable substance close to it this is set alight.

Other causes of initiation of fire which come under this heading are defective or damaged safety lamps or of course in open-light mines the naked lights used by the miners. Actually a defective safety lamp is not likely to cause a fire in a mine unless it is in a place where there is some gas, in which case it may ignite the gas and cause a fire or an explosion; but there have been cases when miners' clothes have been hung over a safety lamp with the result that the latter has become red-hot and set the clothes alight, though this is an extremely rare occurrence.

Electrical initiation of fires.—The initiation of fires by electricity without the presence of either gas or coal dust is uncommon because if there is a defect in the electrical apparatus and a flash occurs this is of such a short duration that it must be in contact with something that is very inflammable for a fire to be started; the usual medium of propagation of the flame is either oil or oily waste or rags which have been left lying about near to the electrical apparatus by some negligent attendant and it is most essential that where there is electrical apparatus in a mine the place in which this apparatus is housed shall be kept as clean as possible.

An occasional source of serious trouble in this way is a transformer and in this case there is always oil in the transformer itself, this is set alight and causes an alarming fire; when transformers are in use underground they should be kept in a completely non-inflammable house and no inflammable material must be kept in the same house.

Another occasional source of an electrical fire is a defective cable which bursts, this is always due either to serious overloading of the cable or to some mechanical damage which causes the insulation to break down, the flash that occurs will sometimes set fire to the paper insulation in the cable and thus initiate a fire especially if, as is quite a common practice in this country, the cable is supported on wooden pegs let into the coal sides of the roadway; these pegs often get very dry and readily propagate the flame once it has started and if they become properly alight and no one discovers the fact there is every likelihood of a serious fire occurring.

Open-light mines.—In mines where safety lamps are not used the ordinary lamps carried by the workmen are in themselves an obvious danger as they are liable to set alight any dry inflammable material with which they come in contact and it is really rather surprising that cases of initiation of fires are not more numerous than they actually are in these mines; the saving factor really is that in the majority of mines where no CH_4 is found, and therefore

open lights can be used, there is more or less percolation of water throughout the mine and the damp atmosphere renders anything in the mine far less susceptible to ignition than it otherwise would be.

It is an old saying in the mining world that you do not usually get major trouble from 'gas' and 'water' in the same colliery but that you are very lucky if you have not trouble from either one or the other; it is this water in the non-gassy mines which is the great safeguard against fires being caused by the open lights.

Ignition of Gas and Coal Dust.

Ignition of gas.—Ignition of gas (CH_4) can occur in a mine either with or without a more or less violent explosion. It is a well-known property of CH_4 that it is only explosive between the limits of a 4·5% and 13·5% mixture with air, and it is not uncommon for an accumulation of gas to be ignited in a mine without causing an explosion at all; this is I think usually the case when an ignition of gas occurs in an open-light mine as in these instances there is almost always just an isolated pocket of gas in a certain part of the working but nothing at all in the general body of the air, with the result that if some source of ignition such as an open light comes in contact with the gas the latter just bursts into flame and burns itself out without causing an explosion; the classical example of this kind of ignition was the custom that was prevalent in the old days when a miner before starting work deliberately used to light up the gas in his working place by holding his open light above his head while he himself crouched down and allowed the flame to pass over him; this removed any accumulation of gas and he could then carry on with his work without fear of further ignition as the movement of himself and his mates was sufficient to cause any gas which was given off to become mixed with the air and carried away.

Now-a-days when the majority of mines are rather deep and liable to gas it is essential to have a system of mechanical ventilation by means of some kind of fan, in order to keep the working places clear, and it is unusual to find large isolated pockets of gas as it is diluted by the air as it is given off from the strata, but what usually occurs to cause an ignition is that through some cause the ventilating system fails for a certain part of the workings either through breakdown of the ventilator or more usually through the air being allowed to short circuit owing to some separation doors having been left open or broken, and in this case the whole body of air in a district, or at least a large part of it, becomes charged with the gas to such an extent that it is an explosive mixture, in these circumstances should any source of ignition be present a serious explosion of gas occurs.

The most common causes of ignition of gas in a safety lamp mine are: (1) fires or spontaneous heating, (2) shot-firing, (3) electricity, (4) defective safety lamps.

Ignition by fires or spontaneous heating.—This is the most common and is liable to occur at any time when a heating or fire is being sealed off, there is always production of gas when coal is distilled by heat and as the area is sealed off the ventilation into the area is gradually reduced with the result that an explosive mixture may be formed and of course if this comes in contact with the heating or fire an explosion occurs.

Ignition by shot-firing.—Where shot-firing is done in a mine in which gas is found there is always a risk of an explosion because although the law insists on all possible safeguards being taken, such as only permitting the use of specially tested explosives, making the use of stone dust compulsory, prohibiting the firing of shots if any gas at all can be detected, encouraging the use of sheathed explosives and in various other ways, yet there is always the personal element present and a little slackness or fool-hardiness on the part of the shot-firer is liable to cause an explosion, for instance an improperly placed shot-hole or too large a charge in a hole will result in a blown-out shot producing flame and if the shot-firer has omitted to test for gas the result is an explosion; or again in firing in stone rippings in roadways behind a Longwall face if a break in the stone crosses the shot-hole and connects with the goaf the flame from the shot may ignite gas in the crack and cause an explosion of gas in the goaf.

Ignition by electricity.—As with shot-firing, so with electricity, it is always a potential source of danger in a gassy mine, because although the Electrical Engineers tell us that with really up-to-date protective devices and modern plant there should be no danger of an explosion, yet the fact remains that those protective devices again depend for their efficacy on the human element in setting them and keeping them in perfect adjustment and the human element is always liable to be at fault, especially in the dark conditions prevailing in a coal mine.

Practically speaking any piece of electrical machinery, even when of the so-called 'flame-proof' type, may cause an explosion either because of negligence on the part of some electrician who has been examining or repairing it and who in putting it together again has not done so properly so that although it works quite satisfactorily it is no longer 'flame-proof', or because it has been damaged in some way by a fall of stone or coal or by a derailed set of tubs. Instances are on record when even cables which have been damaged or overloaded have burst and started a fire. It is of course needless to say that if there is any gas present when a spark or flame occurs from the electrical machinery it ignites at once and either explodes or burns according to the percentage present in the atmosphere.

An extremely good example of the circumstances in which ignition by electricity may take place occurred a few years ago when an in-bye auxiliary fan was shut down for a short time for repairs, after the repairs had been effected the switch was put in to re-start the fan, this sparked and an explosion occurred killing the men who were there. The stopping of the auxiliary fan had caused

the ventilation in that particular part of the pit to be reduced with the result that the normal emission of CH_4 from the district was not sufficiently diluted by air and an explosive mixture was formed.

Ignition of coal dust.—It is of course a well-known fact now-a-days that dry coal dust, if in a sufficiently fine state of sub-division, is extremely explosive and in all countries where the coal mines are dry and dusty extensive precautions are taken to minimise the danger of explosions from this source by spraying water or spreading inert stone dust around the galleries of the mine where the coal dust collects; an explosion of coal dust is almost always far more violent and destructive than an explosion of gas alone and in fact practically all the really major explosions in coal mines have been coal dust explosions.

In order to have a coal dust explosion it is necessary for the coal dust first to be raised up in a cloud and well mixed with the air and then, while in this state, for some source of ignition to be applied to it. The most usual cause of an ignition of coal dust is by a previous ignition and explosion of gas as this provides the necessary violence to raise the dust in suspension in the air, and also the flame to ignite it; it is a fact that the great majority of coal dust explosions are caused by a previous small gas explosion.

It is possible however for coal dust to be ignited without a gas explosion, *e.g.*, a blown-out shot may do it or some unusual occurrence such as happened not so very long ago when a set of loaded tubs broke away and after gathering speed piled up at a bend in the roadway where there was an electric cable, the coal in the tubs was tipped out by the crash and of course the fine dust rose in a cloud, at the same time the cable was broken and it emitted a flash which started an explosion. This is an extremely unusual combination of events but things like this do happen and are of course extremely difficult to guard against.