

and ammonia-alum are similar. Mixtures of 20 per cent. dynamite and 80 per cent. of nitrate of ammonia detonate perfectly in a tin tube of 0·98in. and 1·57in. Mixtures of cotton (=0·68) and nitrate of ammonia are similar to dynamite and nitrate of ammonia.

Effect produced by Explosive stemmed in a Shot-hole and ignited with Fuse.—The explosive detonate by the action of the detonators; they may continue to burn—at least, generally—when they are ignited by flame. When this second method of decomposition happens it may be the cause of special danger in fiery mines. If it occurs unconfined the firedamp would be ignited; but it is rather difficult to understand how a similar accident could be produced in practice. When an explosive is placed at the bottom of a shot-hole it may be ignited by the action of the Bickford fuse, if that fuse comes in contact with the explosive before it fires the detonator. These conditions have been reproduced with a dynamite cartridge well stemmed in a tin tube of 0·98in. and 1·57in.; into this cartridge and right to the bottom is inserted the Bickford fuse, carrying at its end a detonator of 23gr. of fulminate. The firedamp is ignited. This effect does not occur if the detonator is not used. Doubtless the detonator has the effect of projecting outside the already-swollen tube the flame, which fills it entirely.

Summary.—General Rule for use of Explosives in a Fiery Mine.—This part of the studies of the Commission may be summarised by saying that explosives which do work are less dangerous than those which do no work, and they are so much the less dangerous as they work better. All the conditions which tend to diminish the useful effect of the explosive, such as the absence of stemming, or imperfect stemming, the space left between the stemming and stemming of the explosive, and contact between the Beckford fuse and the explosive, ought to be avoided with the utmost care.

Method of firing Shots in Mines.

Detonators plugged and unplugged.—Difference of their Effects on the Ignition of Firedamp.—The detonation of explosives necessitates the use of a detonator, which is usually formed of a small cylindrical tube of copper or brass, generally containing fulminate of mercury, more or less mixed with other substances. It was found, as already mentioned, that so-called plugged detonators, with 23gr. and even 31gr. of fulminate, do not ignite firedamp. Plugged detonators, with 23gr. of fulminate, do not even ignite mixtures of air and coal gas, but they do ignite mixtures of air and hydrogen. Plugged detonators containing 77gr. of fulminate ignite firedamp. With unplugged, the charge of 23gr. of fulminate will produce ignition of mixtures of air and firedamp.

The principal difference between the unplugged and plugged detonators is that in the latter the fulminate placed at the bottom of the cylinder is almost covered with a small metallic bonnet with an orifice at the top which exposes the fulminate and allows firing to be effected. Moreover, the thickness of the metal is greater, and the fulminate, being more compressed, has a greater density. According to the principles whose correctness has been demonstrated above, the plugged detonators have a greater metallic mass and a greater density of charging; the gases resulting from the detonation of the fulminate expend more energy in the shape of mechanical work before coming in contact with the external gases; they ought, therefore, as has been observed, with equal charges, to ignite gaseous mixtures with greater difficulty. Moreover, if the unplugged detonator, with 23gr. of fulminate, be lapped externally with contiguous spirals of fine copper wire, the mechanical work that the gases of the detonation must produce is increased, and it has been proved that under these conditions the detonation of the unplugged detonator no longer ignites the firedamp mixture. The experiment is a new demonstration of the principles above stated.

Various Detonators.—It has been found that the detonators from Paulilles, those fired by electricity, as well as those fired by Bickford fuse, do not ignite firedamp. The same may be said of the Abegg detonators, fired by electricity. The Ruggieri and Scola detonator does ignite the firedamp mixtures.

Dangers which characterize the Bickford Fuse.—The detonation of the detonator can be caused by the Beckford fuse, and it has been ascertained that the combustion of this fuse can occur in the midst of firedamp without igniting it, provided, be it well understood, that the end which is lighted be outside the inflammable mixture. The danger attendant on the use of this fuse are, however, very evident. It is safe only when of good quality, and its safety depends on the perfection of its make, which it is impossible to control. Another very serious cause of danger arises from the possibility of a mistake by the workman pushing the fuse too deeply into the cartridge, and thus putting it in direct contact with the explosive. Under these conditions the explosive, burning before detonation, may project gases produced by the combustion outside the hole and produce an ignition of firedamp. The source of danger is so much the more grave as the safety of the mine depends upon an operation performed by a workman, and impossible to control, without speaking of the inconvenience which results from lighting the end of the fuse, which can only be done at a point in the drift where the absence of firedamp is well ascertained. It therefore seems desirable that the use of the Bickford fuse should be suppressed in fiery mines.

Use of Electricity.—Electricity, either tensional or its currents, may then be employed. Without entering into a profound discussion of the various means of electric ignition, the inconvenience of tensional electricity which may give off on its circuit sparks capable of igniting firedamp and which can only be carried to a short distance when the wires are not perfectly insulated, should be considered.

Detonating-strings.—It was proposed to replace the electric wire by a detonating-string of nitro-cellulose, which would be made to explode by means of a plugged detonator placed outside the hole, and ignited either by electricity or a friction-match, or even by a Bickford fuse, which would be much less dangerous, because then it could never come in contact with the explosive. At the same time the inconvenience of stemming upon a detonator which explodes by percussion would be avoided, and that of having after a miss-fire a cartridge with its detonator at the bottom of the hole. Unfortunately, it is certain that these strings, when of small diameter, do not cause with certainty