

"The new facts which are herein explained confirm the conclusions of the first report, and allow their definition and completion. The normal temperature of ignition of firedamp mixtures is known within 90° Fahr., but it is necessary that the effect of that temperature should be prolonged for some time, in order that ignition may be produced. The new experiments, in harmony with the present ones, show that, owing to the retardation of ignition characteristic of firedamp mixtures, owing also to the almost instantaneous mixture of the gases resulting from detonation with the surrounding air, and to the quick cooling consequent thereupon, explosives whose temperature of detonation is less than 3,992° Fahr. are incapable of igniting firedamp mixtures when detonated under the normal conditions of their use—that is, in holes properly stemmed. The stemming made with care should always be vigorously enforced as one of the most essential conditions of safe blasting.

"The guarantees of safety diminish, all things being constant, in proportion as the stemming becomes more imperfect. At the limit, and where the cartridge detonates unconfined without envelope, the conditions of safety cannot be formulated with any exactitude. Safety would doubtless be still insured completely if the explosive consisted of one substance only, whose detonation would develop a temperature sufficiently low and only yield incombustible products. Unfortunately, nitrate of ammonia is as yet the only substance known which realises these conditions, and its facility of detonation appears insufficient. Resort must therefore be made to mixtures at least dual, and which are never absolutely intimate, whatever may be the precautions taken. Now, if one of the mixed substances are combustible, or, when detonated alone, is susceptible of developing a temperature higher than 3,992° Fahr., or of giving off combustible gaseous products, it may always be feared that a particle of that substance placed on the surface of the cartridge may happen at the time of detonation to ignite the exterior gas. Such is doubtless the cause of the irregularities which occur in the ignition of firedamp by the unconfined detonation of the same mixtures. These ignitions, in a way accidental, are the more to be dreaded as the substance which may produce them is used in higher proportions as the mixture is less intimate, and as the surface or—which is nearly the same thing—as the weight of the cartridge increases."

The only means by which this happily secondary cause of danger may be avoided is to insure the utmost perfection in mixing, and to diminish as far as possible, without too greatly reducing the facility of detonation and the power of the explosive, the proportion of the substance capable of igniting the gas. Besides, it is important to remark that safety in the use of explosives in the midst of a firedamp atmosphere depends, as has been previously mentioned, upon the almost instantaneous mixture of the gases of the detonation with a sufficient volume of surrounding air. It would be dangerous, therefore, to fire shots in a too limited space, and with a weight of explosive too great for the volume of the surrounding air as compared with that of the gases of detonation. These various considerations justify the recommendation given by the Commission in the first report. In the present state of knowledge the dual mixtures which may be used as explosives suitable for insuring the safety of fiery mines necessarily contain nitrate of ammonia as one of their elements, and can be divided into two categories.

I. Nitrate of ammonia may be mixed with any substance detonating at a high temperature but yielding incombustible products, nitro-glycerine for example. Safety appears to be sufficiently assured when, the nitro-glycerine being used in the state of dynamite, the proportion does not exceed 30 per cent. Two cartridges of 3,086·5gr., containing 30 per cent. of dynamite with 70 per cent. of nitrate, were detonated unconfined in a firedamp mixture without igniting it. Cartridges of 771·6gr. and 3,086·5gr. of a mixture containing 20 parts of dynamite and 80 parts of nitrate did not produce ignition of the firedamp. A cartridge of 771·6gr of the same explosive can even be detonated unconfined in a mixture of air and coal-gas without igniting it.

II. Nitrate of ammonia can be mixed with a substance combustible in itself, or yielding combustible products on detonation. Mixtures of this nature should satisfy the following conditions :—

Develop a temperature of detonation as low as possible, and in all cases less than 3,992° Fahr. Not yield combustible gases after complete detonation. Possess sufficient explosive-force so as to avoid the use of great weights of explosives. Possess a great facility of detonation—at least, in a stemmed hole—so that the proportion of missed shots may be unimportant. Capable of preservation for a long time against all changes. Lastly, be capable of sale to users at not too high a price.

Among the numerous mixtures based on nitrate of ammonia fulfilling more or less all these conditions, and which the Commission has tested, those which ought apparently to be mentioned in preference are as follows :—

- (1.) Mixtures containing at the most 75 parts of nitrate of cuproammonia. This maximum proportion, detonating unconfined, has neither ignited firedamp with cartridges of 3,086·5gr.—three exceptions—nor coal-gas with cartridges of 1,543·2gr.—two exceptions.
- (2.) The mixture containing 6 parts of naphthalene, which detonated unconfined, did not ignite firedamp with cartridges of 3,086·5gr.—two exceptions—or coal-gas with cartridges of 771·6gr.—two exceptions—and only ignited coal-gas with cartridges of 3,086·5gr.
- (3.) The mixture containing 15 parts of octonitric cotton, which, detonating unconfined, did not ignite firedamp with cartridges of 3,086·5gr.—two exceptions.
- (4.) The mixture containing 10 parts of mononitric naphthalene, which, detonating unconfined, in five experiments made with cartridges of 925·9gr., 1543·2gr., and 3,086·5gr., only one ignited the firedamp with a cartridge of 925·9gr.
- (5.) The mixture containing 10 parts of dinitro-benzol, which, detonating unconfined, did not ignite firedamp with cartridges of 1,543·2gr.—four exceptions—and with cartridges of 3086·5gr. only ignited once in three experiments.

Practical trials made in the mine, and which are now being made, can alone enable mine-owners to choose between the various explosives.