

Gun-cotton and Nitrate of Ammonia.—Mixtures of cotton and nitrate of ammonia were next tried. Messrs. Sarran and Vieille made an exhaustive study of a mixture containing 60 per cent. of endecanitic cotton and 40 per cent. of nitrate of ammonia, in which the oxygen of the nitrate suffices, with a very small excess, to complete the combustion of the cotton. Cartridges manufactured with this combustion some years ago at Moulin-Blanc do not explode or explode imperfectly. New cartridges were made at Serran by employing either military gun-cotton, equal to 0.81 cubic inch NO_2 per grain, or a much less nitrated cotton, equal to 0.68 cubic inch NO_2 per grain.

Cartridges containing 30 parts of military cotton and 70 parts of nitrate have ignited firedamp twice out of thrice. Cartridges containing 20 per cent. of military cotton and 80 per cent. of nitrate have ignited firedamp once out of two experiments. A cartridge containing 20 per cent. of cotton of 0.68 cubic inch, and 65 per cent. of nitrate ignited the fire-damp. Cartridges containing 20 per cent. of cotton of 0.68 cubic inch and 80 per cent. of nitrate did not ignite the gas. In seven experiments the detonation was effected easily enough in all of them with two caps of 23gr. of fulminate.

It appears, therefore, that cartridges containing 20 per cent. of lowly-nitrated cotton are practically secure. It is possible that security will be still better insured, without compromising the completeness of the detonation at least when confined, by still further diminishing the proportion of cotton. Lastly, it is evident from the experiments that it is possible, by mixing an explosive with substances which are non-explosive in themselves, or which produce a smaller explosive effect than the explosive itself, to diminish their power, and thus to manufacture dual explosives which, while producing sufficient mechanical effects, do not cause, at least in the majority of cases, fired without envelope, the ignition of the gaseous mixtures which surround them. Attention may be directed to an important point: with simple explosives such as dynamite, the ignition of firedamp, if the explosive is liable to effect it, is always and certainly produced. For certain dual mixtures the phenomena appear to be constant; but for many others the ignition occurs capriciously, being produced on one day and not on another.

Theoretical Inquiries.

Ignition of Gaseous Mixtures.—Two members of the Sub-Commission in previous researches estimated the temperature of the ignition of firedamp at about $1,202^\circ \text{Fahr.}$ These observers, however, laid great stress on the considerable retardation of ignition which may occur in mixtures of firedamp with air, or even with oxygen. This retardation is naturally greatest when the temperature to which the mixture is heated is about $1,202^\circ \text{Fahr.}$ At this temperature even the retardation may amount to ten seconds. This allows the perception of the possibility of this fact, in appearance paradoxical: that with a gaseous mixture inflammable at $1,202^\circ \text{Fahr.}$, gases may be produced without causing the explosion of the mixture whose temperature is, as shown hereafter, above $3,632^\circ \text{Fahr.}$ But as these gases have been formed by the detonation of an explosive, they are suddenly given off, and under very high pressure; they expand and cool with extreme rapidity—in some thousandths of a second—before having had time to ignite the mixture of air and firedamp with which they come in contact. Would the experiments have given a different result had they been made in a mixture of any other gas than firedamp?—a cartridge made of equal parts of dynamite and Blanzky coal-dust, which does not ignite mixtures of firedamp, and does ignite mixtures of air and coal-gas. These mixtures, however, still show a certain retardation of ignition. With mixtures of air and hydrogen this phenomenon, if it exists, is less marked; and it has been found that a plugged cap of 23gr. fulminate, which ignites neither firedamp or coal-gas, ignites hydrogen.

Temperature of Detonation of Explosives.—Formula for Calculation.—It is customary to look on explosives as regards their force—that is to say, the intensity of the mechanical effects which they may produce. They are now to be considered from a different point of view. The chief consideration now is not on the force developed, but the temperature produced. This leads us to endeavour to calculate the temperature of detonation of a mixture whose composition, the laws of its decomposition, and thermo-chemical phenomena by which it is characterized are known.

The process of these calculations is well known. As it is important to obtain figures as near as possible to the real temperature of detonation the increase of the specific heat of the gases, as established by experiments of MM. Berthelot and Vieille, and by those of MM. Mallard and Le Chatelier, is introduced. The formula given by the latter for carbonic acid, aqueous vapour, and the so-called perfect gases—elementary gases, carbon, monoxide, hydrochloric acid, &c. have also been used. These calculations have been applied to numerous explosive substances, and more particularly to mixtures of dynamite and nitrate of ammonia endecanitic cellulose, with nitrate of ammonia and octonitric cellulose with nitrate of ammonia. The results are graphically shown by the curves in fig. 5, 6 and 7. For each of the three above-named mixtures two curves are shown; having for abscissas the weight of the nitrate contained in ten parts by weight of the mixture. One of the curves has for ordinates the temperatures of detonation, t , the other the quantity, f , which somewhat defines the power of the explosive, and which is expressed by the equation $f = \frac{vo \cdot T \times 1.033}{w \times 273}$ in which vo = the volume of the gases produced by the explosion, reduced to $0^\circ \text{centigrade}$, and 760mm (29.92in.) mercury; w = the weight of these gases; T = the absolute point of explosion. With mixtures of dynamite and nitrate of ammonia the decomposition occurs with excess of oxygen, and the gases are completely burnt with mixtures of nitric-cellulose and nitrate of ammonia. The mode of decomposition described in the note by Messrs. Mallard and Le Chatelier, added to the report is adopted. When the amount of oxygen is not sufficient to completely burn the combustible gases to carbonic-acid gas and water it is supposed that the oxygen after converting the whole of the carbon into carbon-monoxide, is divided between this gas and hydrogen.

Pressure developed by Explosives.—Formula for Calculation.—The exactness of the results given by calculations have been compared with the pressure-readings of Messrs. Sarran and Vieille. The pressure, P , developed in the volume, v with a charging-density, d , may be obtained by using the