The trials made with mixtures of dynamite, or of cotton, with nitrate of ammonia should be continued, and it is permissible to hope that there may be formed with these substances mixtures in various proportions, possessing, along with great certainty of safety, all the degrees of explosive-power which may be regarded as necessary in practice.

Explosives fired in a Closed Vessel.

Much time has been devoted to the phenomena which explosives exhibit when detonated unconfined, although this method of detonation, for which they are not intended, ought to be prohibited in mines. But it is evidently under these conditions that explosives present the maximum danger, and under which it is easier to classify them as regards safety. Moreover, it may often accidentally happen, in consequence of the imprudence or inattention of the workmen, or from any other cause, that the explosive used in the working may be detonated before being stemmed in the shot-hole. The danger peculiar to unconfined detonation is not, therefore, purely imaginary. It is none the less true that in normal use explosives should be fired in a closed vessel, and the dangers which can arise under these conditions will now be examined.

Process of Experiment.—When an explosive detonates at the bottom of a shot-hole, if the shot is not blown out, fissures more or less great are produced in the broken mass, through which the resulting gases escape. The variety of means by which this effect can occur is infinite, but in almost all, if not in all, cases the gases of the explosion only come in contact with the external air after having exerted a certain mechanical work on the rock.

To realise something analagous in the boiler, but under conditions certainly more dangerous than those which can be met with in practice, the explosive enclosed in a metallic tube of lead, or of tin, closed at the bottom and open at the top, was suspended in the midst of firedamp. The explosive in the tube rested on a 2in. to 2¼in. of clay or sand. It was covered with a stemming of clay or sand, or, even in certain cases, with coal-dust, generally 4in. to 4¾in. thick. The detonation, when it occurred, projected a piece of metallic dust, the part of the tube with which it was in contact. The lower and upper parts of the tube usually remained nearly intact at the bottom of the boiler. The nature of the metal—lead or tin—and especially its thickness, could be varied. These observations, however, have not been made, and would be of interest only with unconfined explosives igniting firedamp.

Experimental Results.—Under normal conditions of detonation, the explosive being well rammed against the sides of the tube, and between the two tampings, the facts summarised in the following table were observed.

Nature of Explosive.	Internal and External Diameter of Tube in Inches.	Material of which Tube was made.	Action of on the Gaseous Mixtures.
Dynamite No. 1	1·06, 1·57	Lead ...	N
"	1·18, 1·57	" ...	I
"	1·18, 1·38	" ...	I
"	0·98, 1·57	Tin ...	N
Mining gun-cotton	1·26, 1·65	Lead ...	N
"	1·18, 1·38	" ...	N
Blasting-gelatine	0·98, 1·57	Tin ...	I
Gelatine-dynamite	1·06, 1·57	Lead ...	N
Ammonia-dynamite	0·98, 1·57	Tin ...	N

N, Non-ignition of firedamp. I, Ignition of firedamp.

Doubtless all explosives cease to ignite gas when the thickness of the sides of the tube is sufficiently great, but the thickness adequate to produce this effect varies with the explosive. With gun-cotton a lead tube of 1·18in. and 1·38in. and only 0·10in. thick is sufficient to hinder ignition. With dynamite No. 1 or gelatine-dynamite a lead tube 1·06in and 1·57in., or a tin tube 0·98in. and and 1·57in., is required. With blasting-gelatine the tin tube of 0·98in. and 1·57in. is not sufficient to prevent the ignition of firedamp. This is in accordance with the considerable amount of heat developed by this explosive, which, amongst all those derived from dynamite, should be considered as the most dangerous.

Explanation of the Effect produced as regards the Ignition of Firedamp by the Tube which envelopes the Explosive.—Work developed by the bursting of the Sides of the Tube.—It may be asked what is the cause of the effect produced by the tube, which, on the whole, does not prevent the gases of the explosive from coming very rapidly, and at a very high temperature, in contact with the firedamp mixture. It appears that this cause should be solely attributed to the cooling which the gases undergo in consequence of the mechanical work which has to be expended to impart a certain kinetic energy to the sides of the shattered tube. The mechanical work is considerable, and may be estimated in a very simple manner by exploding the cartridge stemmed in its tube, in the midst of the closed boiler filled with air, and registering the pressure caused by the explosion as has been previously remarked. The observed initial pressure $P' - P$ gives, when multiplied by the coefficient 58·4, the amount of heat, Q', imparted to the air in the boiler after the explosion. But this amount of heat is equal to that, Q, set free on explosion, diminished by the amount of heat, AU, equivalent to the kinetic energy, U, communicated to the walls of the tube.

If, first of all, by the unconfined detonation of the same, explosive Q has been measured, AU can be formed by subtraction. Under these conditions a cartridge of 772gr. of No. 1 dynamite has