carefully weighed charge of explosive was formed into a small cartridge, fitted with a fulminate detonator, and pressed into the bore of the block with a bronze stemming-rod, the compression being regulated so as to insure equal density throughout all experiments with a given explosive. The stemming being then introduced and pressed down in the usual manner, the charge was fired by a Bickford fuse.

After firing, the volume of the resulting crater was gauged with water, the block being then sawn in two, axially, to reveal any bubbles which, in badly cast blocks, might falsify the result of the test. The materials used for stemming were: Finely powdered dry quartz sand, dry clay, water, ordinary moist sand, clay rubbed down in water, and forming a plastic mass of about the consistence of glaziers' putty. The following explosives were employed: Grisoutine dynamite, with 12 per cent. of nitro-glycerine; Favier's grisounite-couche, with 4·5 per cent. of trinitro-naphthalene; Favier's grisounite-roche, with 8·5 per cent. of di-nitro-naphthalene; and Cugny's dynamite-gomme, with 92 per cent. of nitro-glycerine. The results obtained are considered to show that plastic clay forms the best stemming under all the conditions of stemming employed—sand, dry clay, and water all proving inferior.

Another set of experiments was afterwards conducted under different conditions, the sides of the bore being made as rough as possible so as to contrast with the smooth walls in the first set of tests. With this object an Abel block was completely imbedded in brickwork, the latter being pierced by a channel forming a continuation of the bore in the lead block. Iron ties were fitted to bind the block and brickwork more firmly together, thus forming a block of high resisting-power, measuring 65 cm. across and 90 cm. in height. The bricks forming the walls of the central channel were roughly dressed, and thus presented considerable irregularity of surface.

A preliminary test having shown that a 50-gramme cartridge of grisounite-roche could be exploded in the centre of a similar block without shattering the lead, this weight of explosive was taken throughout, the more so because it corresponds fairly well with the charges used in practice. The stemming, about 60 cm. (24 in.) in height, only penetrated into the lead for a distance of 6 cm. (2·4 in.), nearly the whole remaining within the brickwork. The charge was exploded in the centre of the leaden block, and the resulting crater could therefore be measured with great precision. Under these new conditions, which more closely approximated with those of practice, sand stemming proved superior to plastic clay.

It therefore follows that the conditions of use have a decisive influence on the superiority of the materials employed for stemming, and it is consequently difficult to ascribe marked superiority to any of those examined. In any event, however, it would seem that, in practice, ordinary sand is preferable to clay, contrary to the conclusions that one would be inclined to draw from the experiments with the Abel blocks.

Risk of Blown-out Shots.

In the course of the previous experiments the stemming was invariably blown out of the tube, even in the case of small charges (10 grammes) and with long stemming (up to 80 cm.). Consequently the Abel blocks, which do not allow any of the gas to escape, are badly adapted for the comparison of the different kinds of stemming in this respect. To remedy this defect a trial was made with blocks pierced with a narrow bore for the purpose of allowing the gas to escape; but this method proved unsuitable, the vent being in some cases obstructed as a result of the deformation produced in the metal by the explosion, and the results being far from comparable.

Parallelopiped blocks of cement concrete were then employed, the dimensions finally selected being: Width, 30 cm.; height, 60 cm.; central bore, 30 mm. in diameter and 45 cm. high. With these blocks it was possible to use 50-gramme charges without risk of dangerous projections of material. All the blocks were made of the same mark of cement, with stones of the same size, and the comparative tests were made with blocks prepared at the same time, so as to have identical conditions of experiment. The blocks were imbedded in clayey ground, and well rammed all round, the top of the blocks being flush with the surface. A large wooden screen was suspended at a height of 30 cm. above the blocks, in order to stop any scattered fragments. In the case of blown-out shots the stemming was projected with violence against the screen, on which it produced a well-defined impression.

Ordinary sand and plastic-clay stemmings were tested, the sand being tamped in the hole with a stemming-rod, whilst the clay was first rolled into short plugs, which were rammed gently after insertion in the hole. The results show that a minimum length of 30 cm. of stemming is necessary to prevent expulsion in the case of clay, but that about 25 cm. of sand is sufficient, the latter being therefore the best.

Risk of Ignition by Friction.

The chief danger incurred in shot-firing is that of ignition, by friction, of fragments of the explosive, or traces of nitro-glycerine left adhering to the sides of the shot-hole after the charge has been driven home. This risk is mainly confined to explosives of the dynamite and black-powder types, the Favier explosives, on the other hand, affording almost perfect safety in this respect. Consequently the tests were limited to ordinary dynamite (75 per cent. of nitro-glycerine) and fine-grain black mining-powder. In order to approximate as closely as possible to the conditions obtaining in practice, use was made of a reciprocating-piston, working in a pump-barrel, the latter representing the shot-hole, the former the stemming-rod. The pump-barrel was composed of cement and flint concrete, and was open at both ends, the interior being recessed in the shape of a spiral intended to retain small quantities of the explosive during the stroke of the piston. The latter measured 40 mm. in diameter, and had a stroke of 12 cm.; whilst the crank from which it was driven was arranged to run at a speed of 125 or 375 revolutions per minute, the linear velocity of the piston in the former case being 50 cm. per second, and in the latter 1·5 m. per second.