

sives, and to be always well assured of the ignition or non-ignition of the gaseous mixture. To fulfil these conditions, a steam-boiler of about 350 cubic feet capacity was chosen. Fig. 1 shows the ground-plan of the apparatus used for the experiments; fig. 2, elevation and section of the apparatus used for generating marsh-gas; fig. 3, plan and section of the boiler; and fig. 4, details of the attachment of the cartridge to the lid of the small hole of the boiler. In fig. 1—*a*, apparatus for generating the gas; *b*, a gasometer for the collection of the manufactured gas; *c*, a small Belleville steam-boiler, used to raise steam to work an ejector; *d*, an iron boiler, tested to $8\frac{1}{2}$ atmospheres, provided with an ejector; *e*, a shelter for the experiments.

Apparatus for generating Marsh-gas.—The apparatus for the generation of marsh-gas consists of ten iron tubes or retorts, 7ft. 8 $\frac{1}{2}$ in. long—see fig. 2.—filled with cast-iron plugs at one extremity, and at the other with a screwed extension of less diameter than the body of the cylindrical tube. These retorts, placed in two horizontal ranges above a fire-grate, are held in position by means of three plates pierced with holes fixed in the side walls of the furnace. At the end of the furnace is a receiver, to the bottom of which curved tubes penetrate, connected with the retorts by screwed joints; lastly, a pipe, 2.36in. diameter, traverses the receiver, ending at the dome, and connects it with the little gasometer.

The charging of this apparatus is effected by introducing into the retorts semi-cylindrical troughs, in which the mixture of acetate of soda and caustic soda and lime has been previously placed, each charge consisting of about 4 $\frac{1}{2}$ lb. of the powdered mixture. The retorts being charged, a wood fire is kindled, which is slowly fed, the fuel being distributed uniformly over the surface of the grate. The gases having passed through the water contained in the receiver, are conveyed to the small gasometer *b*.

Experimental Boiler.—The boiler employed for the experiments, fig. 3, measures externally 18ft. 5 $\frac{1}{2}$ in. in length, and 4ft. 11in. in diameter. The thickness of the plates is 0.63in. on the cylindrical part, and 0.55in. on the egg ends; its internal capacity, exclusive of the reservoir for the transmission of pressure to the pressure-gauge, is 359.2 cubic feet. The boiler is provided on its upper part with an elliptical man-hole, T, 1ft. 1 $\frac{3}{4}$ in. by 1ft. 5 $\frac{1}{4}$ in., with a rectangular hole, *t*, placed in the middle of the length, measuring 3.94in. by 1.97in., for the insertion of charges, and with a hole, E, 3.94in. diameter, on which the steam-ejector is fixed. On the lower part, at one end is a circular hole, A, 1.97in. in diameter, for filling the boiler with air, and at the other end is a flanged plate, *b*, for the purpose of attaching the lead pipe which connects it with the pressure-gauge. This gauge was found to be useless, and abandoned after the first experiment. On the horizontal section passing through the axis are four cocks 0.39in. in diameter, and two brass plugs. The cocks, R R, one at each end of the boiler, are connected with the gasometer. A third lateral one, *r*, is connected with a tube dipping into the water, which permits the measuring of the vacuum obtained by the action of the ejector. Lastly, a fourth Lateral cock, *r*, is connected with the water-gauge formed by a U tube. One of the brass plugs is provided with two insulated copper wires, which allow either a spark to pass into the gaseous mixture or raise a fine iron wire to red heat.

The cartridges of the various explosives to be tested are introduced through the rectangular hole in the upper part of the boiler. They can also be introduced through the man-hole if their diameter is too great. It is seldom necessary to use this means, which prolongs the operation. Electricity is generally used to fire the explosives for this purpose. The lid of the small hole is provided with two screwed plugs of lignum-vitæ, B and B, fig. 4, which passes through it. Through the axis of each of these a copper rod passes, which is also screwed, projecting outside, and terminated by a hook at the inner end. Lastly, in the centre of the lid are fixed two small copper angle-plates, *e d*, the open arms of which are clamped by a pressure-screw, *v*, which holds the wooden rod *b*, 2ft. 5.53in. long. The deal rods, 1.18in. by 0.2in., in section are fitted with copper wires, *f f*, connecting the detonator with the hooks of the lid, thus forming a closed circuit.

Gasometer.—The gasometer measures 9ft. 2 $\frac{1}{2}$ in. in diameter and 3ft. 3 $\frac{1}{4}$ in. in height, giving a capacity of 217 cubic feet.

Boiler and Ejector.—The steam-boiler used is twelve-horse power. A cock placed on the steam-pipe drives the ejector by a current of steam of from 10 to 12 atmospheric pressure. This last apparatus will produce a vacuum of 6in. of water-gauge in one or two minutes.

Mode of Carrying out an Experiment.

The boiler was well aired before carrying out an experiment. The plate which closes the hole A in the bottom was raised; steam was turned on to the ejector, and allowed to work seven or eight minutes. All the other openings in the boiler being closed, a current of air traversed the boiler from one end to the other, and upwards from the bottom. This operation being completed, all the apertures were closed, and the explosive to be tested was introduced.

The cartridge, fixed on the wooden rod, was fitted with a detonator, which could be fired by an electric current. The copper wires of the rod were connected with those of the detonator, and with the hooks of the copper rods which pass through the wooden plugs in the lid. To fire the explosive it was therefore necessary to fix the wires of the battery to the ends of the copper rods which project above the lid, and to close the circuit. This method allows the explosive to be tested to be fixed beforehand on the rods. It is then only necessary to fix the rods between the two angle-plates by means of the pressure-screw, and to fasten the wires on to the hooks. This operation can be quickly performed. The lid being in position, the cartridge will be in the axis of the boiler, and in the centre-line. The joints being closed, the ejector is worked, and the water rises in the glass-tube connected by indiarubber tubing.

When the vacuum is seen to be sufficient the cover of the ejector is closed, being previously coated with white-lead, so as to obtain a hermetical joint, and to be assured, by the steadiness of the water-gauge, that the boiler shows no leak. This observation made, the boiler is placed in communication with the small gasometer, and the two cocks placed at the ends of the boiler are simultaneously opened to allow the entrance of the firedamp. The gradual descent of the water in the gauge is observed till the desired proportions of air and firedamp are indicated. The gas