This form of insulator is still largely used and is a very serviceable pattern, though possessing the defect that the porcelain cup is not removable from the iron bolt on which it is mounted. The Cordeaux insulator (fig. 2) is made in one piece. A coarse screw-thread is formed in the upper part of the inner cup, and this screws on to the end of the iron bolt by which it is supported. Between a shoulder, *a,* in the iron bolt and a shoulder in the porcelain cup, *c,* is placed an indiarubber ring, which forms a yielding washer and enables the cup to be screwed firmly to the bolt, while preventing

the abrasion of the porcelain against the iron. The advantage of the arrangement is that the cup can at any time be readily removed from the bolt. At the termination of a line a large insulator (fig. 3). mounted on a strong steel bolt having a broad base flange, is employed. Connexion is made into the office (or to the under­ground system, as is often the case) from the aerial wire by means of a copper conductor, insulated with gutta-percha, which passes through a “ leading in ” cup, whereby leakage is prevented between the wire and the pole. The insulators are planted on creosoted oak arms, 2½ in. sq. and varying in length from 24 to 48 ins., the 24 and 33 in. arms taking two, and the 48 in. four, insulators. The

unequal lengths of the 24 and 33 in. arms are adopted for the pur­pose of allowing one wire to fall clear of that beneath it, in the case of an insulator breaking or the securing binder giving way. The poles are of red fir, creosoted, this method of preservation being the only one now used for this purpose in the United Kingdom. The number of poles varies from about 15 to 22 per m. of line; they are planted to a depth of from 2 to 4 ft. in the ground. For protection from lightning each pole has an “ earth wire ’’ running from the top, down to the base.

Gutta-percha-covered copper wires were formerly largely used for the purpose of underground lines, the copper conductor weighing 40 lb per statute mile, and the gutta-percha covering 50 lb (90 lb total). The introduction of *paper* cables, *i.e.* copper wires insulated with carefully dried paper of a special quality, has practically entirely super­seded the use of wires insulated with gutta-percha. The paper cables consist of a number of wires, each enveloped in a loose covering of well-dried paper, and loosely laid up together with

a slight spiral “ lay ” in a bundle, the whole being enclosed in a stout lead pipe. It is essential that the paper covering be loose, so as to ensure that each wire is enclosed in a coating not of paper only, but also of air; the wires in fact are really insulated from each other by the dry air, the loose paper acting merely as a separator to prevent them from coming into con­tact. The great advantage of this air insulation is that the electrostatic capacity of the wires is low (about one-third of that which would be obtained with gutta-percha insulation), which is of the utmost importance for high-speed working or for long­distance telephonic communication. As many as 1200 wires are sometimes enclosed in one lead pipe.

Between London and Birmingham a paper cable 116 m long and consisting of 72 copper conductors, each weighing 150 lb per statute mile, was laid in 1900. The conductors arc enclosed in a lead pipe, 2¼ in. in outside diameter and ¼ in. thick, which itself is enclosed in cast iron spigot-ended pipes, 3 in. in internal diameter, and buried 2 ft. below the surface of the roadway. At intervals of 2 m. “ test pillars ” are placed for the purpose of enabling possible faults to be accurately located. Each conductor has a resistance (at 60o F.) of 5∙74 ohms per statute mile, and an average electro­static capacity per mile between adjacent wires of 0∙06 microfarad, or between wire and earth of 0·1 microfarad; the insulation resist­ance of each wire is about 5000 megohms per mile. The under­ground system of paper cables has been very largely extended. Cables between London, Glasgow, Edinburgh, Liverpool Leeds, Bristol, Exeter and other important towns have been laid. and eventually telegraphic communication between every important town in the United Kingdom will be rendered safe from interruptions caused by gales or snowstorms.

The one disadvantage of paper cables is the fact that any injury to the lead covering which allows moisture to penetrate causes telegraphic interruption to the whole of the enclosed wires, whereas if the wires are each individually coated with gutta-percha, the presence of moisture can only affect those wires whose covering is defective There is no reason for doubting, however, that, provided the lead covering remains intact, the paper insulation is imperishable; this is not the case with gutta-percha-covered wires.

In order to maintain a system of telegraph lines in good working condition, daily tests are essential. In the British Postal Telegraph Department all the most important wires are tested every morning between 7.30 and 7.45 a.μ., in sections of about 2∞ miles. The method adopted consists in looping the wires in pairs between two testing offices, A and B (fig. 4); a current is sent from a battery, E, through one coil of a galvanometer, *g,* through a high resistance, ***r,*** through one of the wires, 1, and thence back from office B (at which the wires are looped), through wire 2, through another high resistance, r', through a second coil on the galvanometer, *g,* and thence to earth. If the looped lines are both in good condition and free from leakage, the current sent out on line 1 will be exactly equal to the current received back on line 2; and as these currents will have equal but opposite effects on the galvanometer needle, no deflection of the latter will be pro­duced. If, however, there is leakage, the current received on the galvanometer will be less than the current sent out, and the result will be a deflection of the needle proportional to the amount of leakage.

The galvanometer being so adjusted that a current of definite strength through one of the coils gives a definite deflection of the needle, the amount of leakage expressed in terms of the insulation resistance of the wires is given by the formula

Total insulation resistance of looped lines = ½R(D∕d-½) ;

in which R is the total resistance of the looped wires, including the resistance of the two coils of the galvanometer, of the battery, and of the two resistance coils *r* and r' (inserted for the purpose of causing the leakage on the lines to have a maximum effect on the galvanometer deflections). In practice the resistances r, r' are