plates. It will be observed that the circuit is not in this case actually *open;* the meaning of the expression “ open circuit" is “ no battery to line.” In normal circumstances the instruments at both ends arc ready to receive, both ends of the line being to earth through the receiving instruments. A signal is sent by de­pressing the key K, and so changing the contact from *a* to *b,* and thus putting the battery to line. On circuits where the traffic is small it is usual to make one wire serve several sta­tions. At an intermediate or wayside station W, a “ switch ” S, consisting of three blocks of brass fixed to an insulating base, is sometimes used (not in Great Britain). W may be made the terminal station of L1 by inserting plug 3, and of L2 by inserting plug 2, or the instruments may be cut out of circuit by inserting plug 1. In ordinary circum­stances the messages from all stations are sent through the whole line, and thus the operator at any station may transmit, if the line is free, by manipulating his key.

The connexions for single-current working on the “ closed-cir­cuit ” system arc shown in fig. 17. It differs from the open circuit in only requiring one battery (although, as in the figure, half of it is often placed at each end), in having the re­ceiving instrument between the line and the key, and in having the battery continuously to the line. The battery is kept to the line by the bar *c,* which short-circuits the keys. When signals are to be sent from either station the operator turns the switch *c* out of contact with the stop *b,* and then operates precisely as in open circuit send­ing. This system is more expen­sive than the open-circuit system, as the battery is always at work ; but it offers some advantages on circuits where there are a number of intermediate stations, as the circuit is under a constant electro­motive force and has the same resistance no matter which station is sending or receiving. The arrangement at a wayside station is shown at W. When the circuit is long and contains a large number of stations, the sending battery is sometimes divided among them in order to give greater uniformity of current along the line. When only one battery is used the current at the distant end may be considerably affected by the leakage to earth along the line.

If long circuits were worked direct with ordinary instruments, high battery power would be required in order to send sufficient current to actuate the apparatus. In such cases it is usual to employ a local battery to produce the signals, and to close " the local battery circuit by means of a circuit-closing apparatus called a *relay,* which is practically an electromagnetic key which has its lever attached to the armature of the magnet and which can be worked by a very weak current. The arrangement at a station worked by relay on the “single-current’’ system is shown in fig. 18, where L is the line wire, joined through the key K to one end of the coil of the relay magnet R, the other end of which is put to earth. When a current passes through R the armature A is attracted and the local circuit is closed through the arma­ture at *b.* The local battery B1 then sends a current through the in­strument I and records the signal. In the form of relay indicated in the figure the armature is held against the stop *a* by a spring S.

“ Single-current ” working by means of a non-polarized relay (fig. 18), although general in America, is not adopted in England.

In the latter country, when such working is resorted to, a "polarized relay ’’ (fig. 20) with a bias is used, but on all important lines worked by sounders the “ double­current ” system is employed. In this the tongue of the relay is kept over to the spacing side by means of a current flowing in one direction, but on the depression of the signalling key the cur­rent is reversed, moving the relay tongue over to the marking side.

The Siemens polarized relay, shown in fig. 19, consists of an armature *a,* pivoted at one end Λ in a slot at one end N of a permanent magnet *m,* the other pole s of which is fixed to the yoke y of a horse-shoe electromagnet Μ. The armature is placed between the poles of the electromagnet, and being magnetized by the magnet *m* it will oscillate to the right or left under the action of the poles of the electro­magnet M according as the current passes through M in one direction or the other. This form of relay is largely used, but in Great Britain it has been entirely displaced by the form shown in fig. 20, which is the most modern pattern of relay used by the British Post Office, known as the "Post Office Standard Relay.” In this instrument there are two soft iron tongues, n, s, fixed upon and at right angles to an axle *a,* which works on pivots at its ends. These tongues are magnetized by the inducing action of a strong horse-shoe permanent magnet, S N, which is made in a curved shape for the sake of com­pactness. The tongue plays between the poles of two straight electromagnets. The coils of the electromagnets are differentially wound with silk-covered wire, 4 mils ( = ∙004 inch) in diameter, to a total resistance of 400 ohms. This differential winding enables the instrument to be used for “ duplex ” working, but the connexions of the wires to the terminal screws are such that the relay can be used for ordinary single working. Although the relay is a “ polarized " one, so that it can be used for “ double-current ” working, it is equally suitable for “ single-current ” purposes, as the tongue can be given a bias over to the “ spacing ” side, *i.e.* to the side on which no current passes through the local circuit. The standard relay will work single current with a current of 3 milliam­peres, though in practice about 10 would be used. Worked double current—that is, with the tongue set neutral, having no bias cither to the spacing or marking side—the relay will give good signals with 1½ milliampere of current, though in practice 10 milliamperes are provided. The lightness of the moving part enables great rapidity of action to be obtained, which for fast speed working is very essential. The relay tongue, being perfectly free to move, can be actuated by a comparatively weak current. Normally a swatch attached to the key cuts the battery off, and connects the line direct through the receiving relay; this switch is turned to "send" when transmission commences, and is moved back to “ receive " when it ceases: this movement is done quite mechani­cally by the telegraphist, and as it is practically never forgotten, automatic devices (which have often been suggested) to effect the turning arc wholly unnecessary.

Fig. 21 shows the general arrangement of the connexions for double current working; the galvanometer G is used for the purpose of