(No Model.) 2 Sheets—Sheet 1.

A. S. WILLIAMS.

TELEPHONE SIGNALING RELAY AND CIRCUIT.

No. 586,888. Patented July 20, 1897.

Fig. 1.

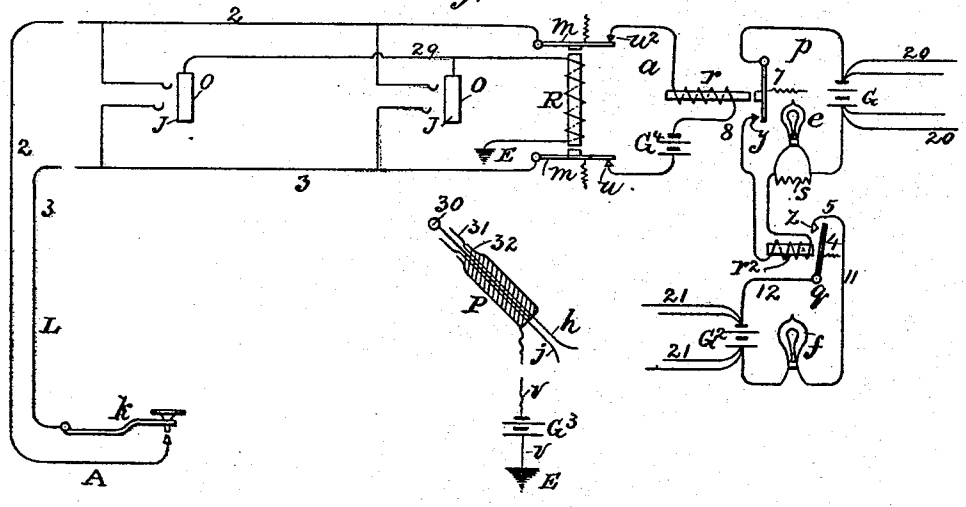


Fig. 2.

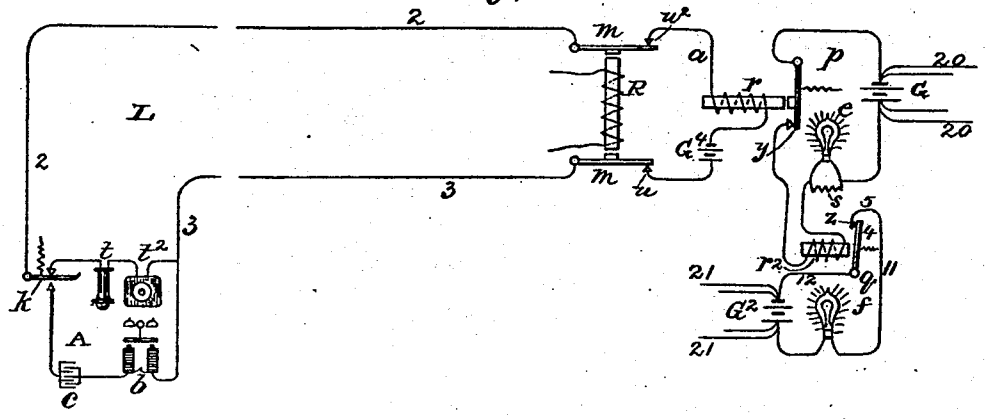
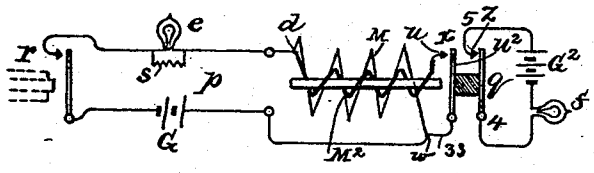


Fig. 3.



Witnesses.
W. Rees Edelen,
Percy Lewis

Inventor
Arthur S. Williams
by Foster Mann
his attorneys.

(No Model.) 2 Sheets—Sheet 2.

A. S. WILLIAMS.

TELEPHONE SIGNALING RELAY AND CIRCUIT.

No. 586,888. Patented July 20, 1897.

Fig. 6.

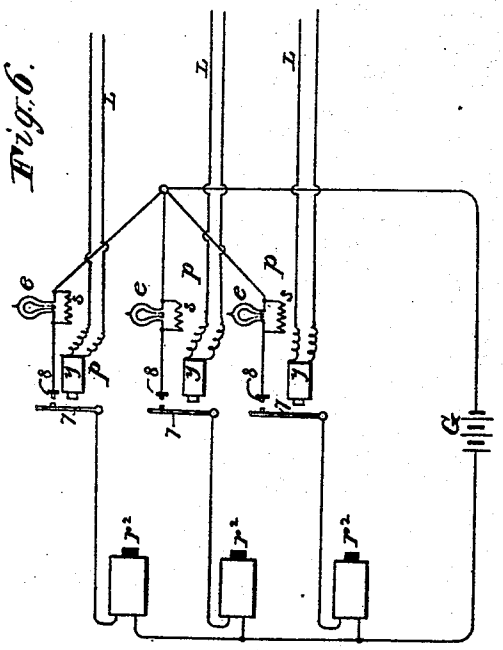


Fig. 7.

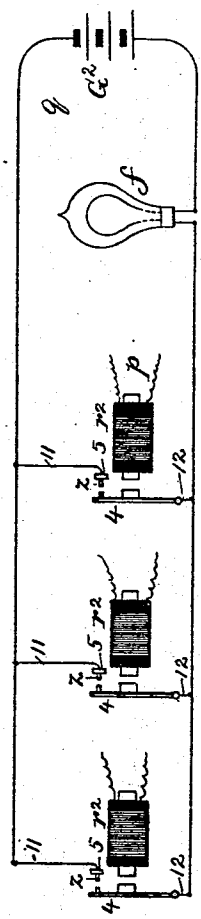


Fig. 4.

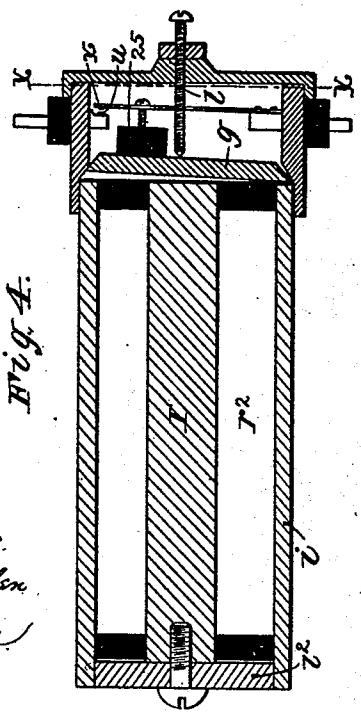
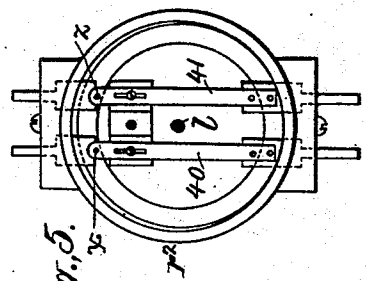


Fig. 5.



Witnesses.
W. Rees Edelen.
Percy Lewis

Inventor,
Arthur S. Williams
by Pollock Mauro
his attorneys

UNITED STATES PATENT OFFICE.

ARTHUR S. WILLIAMS, OF NEWTON, MASSACHUSETTS, ASSIGNOR TO THE AMERICAN BELL TELEPHONE COMPANY, OF BOSTON, MASSACHUSETTS.

TELEPHONE SIGNALING RELAY AND CIRCUIT.

SPECIFICATION forming part of Letters Patent No. 586,888, dated July 20, 1897.

Application filed May 20, 1897. Serial No. 637,436. (No model.)

To all whom it may concern.

Be it known that I, ARTHUR S. WILLIAMS, residing at Newton, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Telephone Signaling Relays and Circuits, of which the following is a specification.

This invention relates to the central-station signal-receiving appliances of the subscribers' lines of a telephone-exchange, and especially concerns an organization of such appliances wherein glow or incandescing lamps are employed as line-signals, one for each line, and in which a supplementary signal is associated with a group or series of such line-lamps and made common to the series.

In many telephone-exchange systems it has become an established and convenient practice to so arrange the subscribers' circuit connections that when not in use the main circuit shall be closed at the central station through a source of signaling current-supply, such as a voltaic battery or other well-known generator and a signal-receiving relay, and shall be left conductively open at the subscriber's station. When so arranged, the call-signal may be transmitted by means of a circuit-closer at such substation, which is operated either manually or by removing the receiving-telephone from its place of rest. This closes the circuit, and the current from the generator being thus permitted to traverse the said circuit excites the central-station relay, causing the same to become operative. The said relay is not ordinarily utilized to directly give the signal, but controls a local circuit containing a glow-lamp signal, which when the local circuit is closed by the action of the relay is traversed by the current of a suitable source, also included in said circuit, and becomes lighted, such illumination constituting the line-signal and indicating to the operator that the subscriber has sent a call. In addition to these call-signal lamps, one for each line, there is also provided for the assurance of prompt and good service a supplementary signal common to a series or group of the said line-signals. This is exhibited or manifested whenever a call-signal is received from any of the subscribers' stations of the group and continues to be displayed until by responding to the call and thereby opening the line-circuit the operator causes its disappearance. This signal is also preferably an incandescent or glow lamp, although any desired form of evanescent or self-setting signal-receiving appliance may be employed, and when a lamp is used it is sometimes technically termed a "pilot-lamp." The said supplementary signal is contained in an auxiliary local circuit, a suitable source of current being of course likewise included, and the said auxiliary circuit is provided with a number of pairs of branch terminals, at any or all of which it may be closed. It follows from this arrangement that the signal will be displayed when the circuit is closed at one or more of the pairs of branch terminals, and that if closed at more than one of said pairs the said signal will remain displayed until opened again at all of them.

To operate the supplementary signal, a special relay connected in and with the line-signal local circuit is employed, one relay being associated with every such local circuit in the series. The several pairs of branch terminals of the auxiliary local circuit are electrically united to the local points of the several relays of the series, respectively, so that each such pair of branch terminals is furnished with a circuit-closer or circuit-controller actuated by the vibrations of the armature of that relay to which it is united. Consequently when the line-signal local circuit of any particular one of the relays is closed by the action of the corresponding subscriber's station apparatus to operate the line lamp-signal contained therein the said relay likewise is excited and closes the auxiliary local circuit, operating the supplementary or pilot signal.

As soon as any line-signal is attended to the first local circuit is broken by the action of the switch apparatus and the line-lamp is then extinguished. It follows that the relay in the same local circuit must also lose its excitement and that its armature retracted in the usual way will separate the local points thereof, again, so far as that particular local-circuit controller is concerned, opening the auxiliary local circuit. If no other relay of the group has the said circuit closed through

its local points and the pair of branch terminals connected therewith, the supplementary signal will also disappear at the same time as the line-signal; but it frequently happens that two or more of the relays have closed the auxiliary local circuit through their respectively-controlled branch terminals simultaneously, or at any rate that their operations have overlapped. When such is the case, it is obvious that the auxiliary circuit is not opened and that the supplementary signal cannot disappear until the local points of all of the relays have separated—that is to say, until all of the call-signals have been answered. This being so, the supplementary signal, which commonly is placed in a conspicuous position, where it is visible both to the operator and to the monitor or supervisor, becomes available as a signal or indicator, disclosing any neglect or slowness in answering calls, or showing that the operator attending to the group of lines is for the present overloaded. As soon as all pending calls are answered the supplementary signal disappears.

There being two local circuits in the above-described organization, I term the first—that which contains the line-signal lamp and the special relay—the "primary" local circuit, and the second I term the "auxiliary" or "secondary" local circuit. This organization works satisfactorily as long as all circumstances are favorable, but is not wholly reliable in certain adverse circumstances.

When the light-giving filament or incandescing conductor of a glow-lamp signal is broken or burned out or the lamp otherwise disordered, the said lamp necessarily fails to respond to calls sent from the subscriber's station which it represents, and as it is difficult to detect the defective condition of such lamp from observation there is a liability of losing calls, resulting in impaired efficiency of service. When this occurs, the primary local circuit of course is not responsive to its controlling-relay and remains open, and the special relay contained therein is inoperative, so that even the association of the auxiliary circuit and supplementary signal can afford no aid in announcing a call unless some expedient for rendering the continuity or integrity of the primary local circuit independent of the state of its line-lamp signal be adopted. For this reason it is customary to establish a non-inductive shunt round or across the terminals of the said lamp, the resistance of said shunt being much greater than that of the lamp, to the end that the operation of such lamp under normal conditions shall not be interfered with. A resistance of sixty ohms has been found satisfactory with such small lamps as have so far been employed; but while the continuity of the primary local circuit is thus insured, and while its resistance is kept at a low figure as long as the line-lamp is in good order, in virtue of the parallel connection of the shunt and lamp, experience has shown that under the working conditions, which involve the occasional rupture of the lamp-conductor, the consequent increase in resistance as the shunt is brought into the circuit alone, and the likewise consequent drain of the working current of the primary local circuit into other similar circuits supplied from the same source, as such circuits engage in announcing other subscribers' calls, it is a matter of very great difficulty to so construct and adjust a relay of ordinary character that it shall operate perfectly to actuate the display of the supplementary signal while the line-lamp is in good order, and will also operate it when the said lamp is defective and the supplemental signal more necessary.

To meet these contingencies, my invention comprises a particular form or construction of relay and certain combinations thereof with the main and local subscribers' signal-circuits, the line-lamp signal, and the supplementary signal to which reference has been made, the said particularly-constructed relay being the characteristic feature of such combinations. The said relay has two magnetizing-helices of diverse resistance, one having many turns of fine wire, and therefore the higher resistance, permanently connected in the primary local circuit in series with the shunted lamp and the other formed of relatively few turns of coarser wire, attached at one end to the conductor of the said local circuit, but united to a front contact-stop of the relay at its other end, thus forming a normally-discontinuous branch of the circuit.

The relay-armature is electrically connected with the circuit-conductor in such a way that when it moves toward the magnet-pole in consequence of the magnetic attraction excited therein by the long fine-wire coil and makes contact with the said front stop it closes the said normally open branch constituted of the low-resistance winding, thereby practically establishing an additional path for the magnetizing-current in parallel with the high-resistance winding, reducing the total resistance of the local circuit and correspondingly increasing the strength of the current flowing therein. The contact-points of this local circuit, one fixed and the other carried by and moving with the armature, constitute a circuit-controller adapted to open and close the normally open branch winding, as required. The special relay therefore operates two circuit-controllers, one adapted to close and open its associated branch terminal loop of the secondary or supplementary signal-circuit, as previously described, and the other adapted to similarly control the condition of its normally-discontinuous winding.

It has been experimentally demonstrated that by the above-described arrangement of relay and circuit connections the relay-magnet can be relied upon to attract its armature into position to close the auxiliary local

circuit and operate the supplementary signal, whether the line signal-lamp be in order or defective, and to hold the said armature in such position, and thereby maintain the display of the said signal until the substation call originating the manifestation has been attended to, for by such an arrangement the primary local circuit is enabled at all times to conduct and fully utilize an operative amount of current, even when other local circuits supplied from the same source have also been closed and have thus established other channels, through which, were it not for the said arrangement, an undue portion of such current might be drained away.

In the drawings accompanying and illustrating this specification, Figure 1 is a diagram of a telephone subscriber's line in its resting condition, together with its central-station switching and signaling connections and a circuit-closer at the substation. Fig. 2 is a diagram of a similar circuit, showing the telephone and switch apparatus at the subscriber's station and the signal-receiving appliances at the central station, the latter being shown as having been put in action by the operation of the subscriber's telephone-switch. Fig. 3 is a diagram of the line or primary local circuit containing the shunted lamp-signal and the special relay which controls the auxiliary local circuit and signal and illustrating the characteristic feature of the invention. Fig. 4 is a longitudinal section of one form in which such a special relay may be constructed. Fig. 5 is a cross-section of the same on the line x x of Fig. 4, looking toward the circuit-closing contact-springs. Figs. 6 and 7 are diagrams of the primary and auxiliary or secondary local-circuit connections, indicating in Fig. 6 that several of the line local circuits may be supplied with current from a single source and in Fig. 7 that the auxiliary local circuit is controlled by the relays of any one or more of the said line or primary local circuits.

In the drawings, L is a subscriber's line or main circuit; 2 and 3, its two conductors; A, the subscriber's station, and C the central station.

At the central station R is a cut-off relay adapted to disconnect the extension a of the line-circuit when a call is answered by inserting a plug P in any of the line-jacks or plug-sockets J. r is the line-relay connected on such extension and organized to respond to incoming calls and to operate the call-receiving signal, and r^2 is the special relay, controlling the supplementary signal and the circuit in which it is included.

A local circuit p is associated with each main circuit L and contains the call-receiving glow-lamp e thereof, the said lamp being provided with a shunt s. G is a battery or other suitable source of current-supply for the said local circuit and lamp, and, as indicated by the wires 20, branching from its poles, in Figs. 1 and 2 and by Fig. 6, it may be common to a number of such circuits. One end of this local circuit p is united to the armature-lever 7 and the other to the front contact-stop 8 of the relay r, and the said relay thus is enabled to control the circuit p by the movements of its armature.

In Fig. 6 the central-station ends of three main circuits L and their associate local signal-circuits p are shown all supplied with current by the generator G and each containing the signal-lamp e for indicating calls sent from the substations of its own line, the shunt s thereof, the relay-points 7 8 constituting the circuit-controller y, and a special relay r^2, to which further reference will presently be made. The resistance of the lamp e may be some twenty ohms, and that of the shunt is considerably greater, sixty ohms having been found to answer satisfactorily.

It is evident that when the relay-points 7 8 come into contact the lamp e will be lighted and the relay r^2 excited.

A supplementary or "pilot" signal f, also by preference a glow-lamp, is provided, and serves in common a group or series of the primary-local-circuit lamps e, and hence is likewise a common and distinctive signal for the corresponding series of main or subscribers' lines L. It is intended to be displayed or manifested whenever any of the line-signals e of the series operate or tend to operate. Thus whenever a subscriber of any of the lines L sends his call his particular lamp e is lighted, and the common supplementary signal f is also lighted.

It follows that when several substations have called at the same time, or nearly so, the pilot-lamp f, having become illuminated at the same time as the first line-lamp, will continue so until all of the line-lamp signals on being responded to by the operator have disappeared.

The supplementary signal f of any series of main circuits L and local circuits p is in a secondary or auxiliary local circuit q, in which current from the generator G^2 (common to other circuits 21) may circulate. This auxiliary local circuit q, in order that it may be under the control of all of the primary local circuits p, has branch terminals 11 12 leading to the relay-points 4 5 of the special relays r^2, contained in the said circuits p, respectively, as shown clearly in Fig. 7. The said relay-points form the circuit-controller z.

In Fig. 1 are shown conventionally the spring-jacks or plug-sockets J, whereby the main line L may be switched, and a plug P. The said plug P has, as usual, three conducting-surfaces, two, 30 and 31, connected with the cord conductors h and j and adapted to engage the two jack-springs, respectively, and the third adapted to make contact with the conducting socket-frames o, the several socket-frames of each line L being all electrically united by a conductor 29 to one another and to ground at E through the cut-off

relay R. The said plug-surface 32 is attached to the third conductor v, which leads to the generator G^3, whose other pole is grounded.

Referring now to the substation A, Fig. 1 shows that the main line is there provided with a circuit-closer k. The preferred arrangement is that indicated by Fig. 2, where telephones t t^2 are in one normally-disconnected branch of the circuit and a call-bell b and condenser in the other. The automatic switch k maintains the normal circuit connection through the bell branch, but when the telephone t is removed therefrom, as shown, transfers the connection to the telephone branch. Owing to the presence of the condenser the normal circuit is conductively open, and consequently the transfer closes it. Thus the removal of the telephone from the hook operates the switch k as a circuit-closer and sends the call-signal.

In Fig. 1 the line is at rest and all three relays R, r, and r^2 remain unexcited, their armatures and armature-levers being in their several retracted positions.

In Fig. 2 the call has been sent from the substation A by removing the telephone t from the switch k. The main circuit L is thus closed and current from the generator G^4 permitted to traverse the same. The said current excites the line-relay r, which attracts its armature, closing the associated local circuit p, and by the current from the generator G lighting up the line-signal lamp e and giving the call. The said current necessarily flows through the coils of the special relay r^2, since these are connected in local circuit p, and as a consequence this relay also in turn is excited and attracts its armature to the forward position shown, closing the auxiliary circuit q and operating the supplementary signal f, which can be seen by a supervising operator, and which once lighted remains so until all calls are answered.

The switchboard operator answers calls by plugging into the spring-jack of the calling-line, and as soon as this is done the signal of the corresponding line-lamp is extingushed, as is also the supplementary signal, provided no other call is pending. This automatic extinguishment of the signal is brought about by closing the circuit 29 of the generator G^3, which includes the cut-off relay R at the conducting-surfaces o and 32 of the socket and plug, respectively, on the insertion of the latter, for when this is done the current of the said generator excites the cut-off relay R, which, attracting its armatures m, opens the main circuit at the points u and u^2. This of course opens consecutively the circuit-controllers y and z of the two relays r and r^2, and as a consequence effectuates the signal disappearance already mentioned.

To the end that the supplementary signal f shall certainly be displayed regardless of any abnormal conditions which, as considered in the earlier portion of this specification, may attend the line-signal lamp e, the shunt s is in the first place provided for the latter, and in the second place the special relay r^2 is peculiarly constructed.

The electrical arrangement of the relay r^3 is well indicated by Fig. 3, and Figs. 4 and 5 show a suitable form in which the said relay may conveniently be constructed. Fig. 3 indicates the entire local circuit p, the relay r controlling the same, and the supplementary local circuit q.

The relay r^2 has a fine-wire magnetizing-coil of many turns M and also a magnetizing coil or winding M^2 of coarser wire and fewer turns. The former winding M, as shown, is constantly included in the local circuit p; but the latter is or is in a normally open branch thereof, being attached to the circuit-conductor at any suitable point d and ended at a front contact stop or point u, where it is arranged to be formed into a closed branch parallel to the fine-wire winding by a spring 40, actuated by the armature of the relay and carrying a complementary contact u^2. This spring connects by wire 33 with the circuit-conductor at any point w on the opposite side of the generator to that where the attachment d is made, and therefore when the armature of the relay r^2 is attracted it not only operates the circuit-controller z to close the auxiliary circuit q and display the supplementary signal, but it also operates the circuit-controller x to close its own normally open branch winding.

Figs. 4 and 5 show that the relay is conveniently made in the form of a long cylinder. I is a central iron core. i is a cylindrical iron tube surrounding the core and forming the complementary pole thereof. i^2 is a heel-piece uniting the core and tube, and g is a beveled tilting-disk armature. This armature carries a non-conducting block 25, to which are secured the contact-springs 40 and 41, adapted to engage with the fixed contact-points u and 5, respectively, and to form in conjunction with said points the controllers x and z, governing the coarse-wire helix branch of local circuit p and the auxiliary circuit q. With this construction when relay r^2 is operated it controls and closes the auxiliary local circuit q, whereby the supplementary signal is actuated, and at the same time closes the normally open branch of its own circuit through the coarse-wire winding thereof, thereby reducing the resistance of such circuit and correspondingly increasing the current through it.

I have found a construction of relay satisfactory in which the coarse-wire winding consisted of two silk-covered wires, No. 16 Brown & Sharpe gage, wound first over the spool to a depth of four layers and having a resistance of .05 of an ohm, the fine-wire coil being composed of an external winding of eleven hundred and fifty-five turns of silk-covered wire, No. 24 Brown & Sharpe gage, and having a resistance of 9.41 ohms. Of course these proportions are arbitrary and a

very considerable range of variation is admissible.

By the arrangement herein described it is easy to provide a voltage sufficient to operate the relay r^2 at all times, even when the lamps e are broken or burned out, and to employ a sufficiently strong current to divide, as occasion may require, between a considerable number of relays, as six or seven subscribers may call simultaneously, without liability to damage any of the said relays at times when the current is not so divided.

It is of course evident to those skilled in the art that a single double-coil relay r^2 may be placed in the main conductor of the source of current-supply G, leading to all of the local lamp-circuits p, which in common control any given pilot-lamp circuit, and this mode of connection in many cases would be preferred, as it requires but one relay for a number of circuits.

Having fully described my invention, its object, and mode of operation, I claim—

1. In a telephone system, the combination of a subscriber's line or main circuit, a shunted signal-receiving glow-lamp therefor in an associated or primary local circuit controlled by a relay in said main circuit, and an auxiliary local circuit containing a supplementary signal; with a separate relay controlling the said secondary local circuit, and wound with two magnetizing-coils both connected with the said primary local circuit, one, comprising many turns of fine wire and constantly included in said circuit, and the other formed of relatively few turns of coarser wire constituting a normally open branch thereof, adapted to be closed by the relay itself when excited by the operation of the said fine-wire coil, substantially as set forth.

2. The combination with a primary local electric circuit containing a glow-lamp signal shunted by a resistance higher than its own, and an auxiliary local circuit containing a supplementary signal device; of a relay having two parallel magnetizing-windings, one, of many turns of fine wire permanently included in the said primary local circuit, and the other, of relatively few turns of coarser wire forming a normally-discontinuous branch thereof, the said relay being adapted to control the said normally open branch and the said auxiliary local circuit, closing both on the movement of its armature in one direction, and opening both on its reverse movement; substantially as and for the purposes specified herein.

3. In a telephone system, the combination of a series of subscribers' lines or main circuits; a series of associated or primary local signal-circuits, one for each main circuit, controlled by a relay therein, and each containing a shunted signal-receiving lamp; a normally open auxiliary local signaling-circuit common to the said series of main and primary local circuits, containing a supplementary or pilot signal arranged to be displayed on the operation of the said lamp-signals of any and all of the said series of circuits, and having a number of pairs of branch terminals, at any or all of which it may be closed; and a series of auxiliary relays, one for each series of primary local circuits, each wound with two magnetizing-helices, one, permanently included in such circuit and having many turns of fine wire, and the other, forming a normally open branch thereof, having relatively few turns of coarser wire, each relay being adapted to control by its armature vibrations, one of the pairs of branch terminals of said auxiliary local circuit, and also the terminals of its own normally open exciting-helix; whereby a subscriber's line call-signal may be manifested by the pilot-signal, whether the shunted lamp-signal of such line be in order or not, substantially as described.

4. An electromagnetic relay comprising an electromagnet with a central iron core, an iron casing, an interposed exciting-helix, an associated maintaining-helix, a tilting-disk armature resting on its edge in front of said core, and two circuit-closers actuated by said armature one controlling the continuity of said maintaining-helix, and the other adapted to control an independent local circuit, substantially as described.

5. The combination substantially as hereinbefore described with an individual-line local signal-circuit, and an auxiliary local circuit also including a signal, of a relay connected with the former local circuit and controlling the latter, the said relay having two magnetizing-coils of diverse resistance, that of higher resistance being permanently included in the said former circuit, and that of lower resistance in a normally open branch thereof, and two circuit-controllers actuated by the armature of said relay, and controlling the continuity of the normally open branch of the individual local circuit, and the auxiliary local circuit respectively, whereby on the operation of said relay the resistance of the former circuit may be reduced and its current correspondingly increased.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 13th day of May, 1897.

ARTHUR S. WILLIAMS.

Witnesses:
THOMAS D. LOCKWOOD,
JOSEPH A. GATELY.