(No Model.) 2 Sheets—Sheet 1.

A. R. BENNETT, G. J. SOMERVILLE & R. McLEAN.

TELEPHONE EXCHANGE SYSTEM AND SWITCHING APPARATUS.

No. 566,648. Patented Aug. 25, 1896.

Fig. 1.

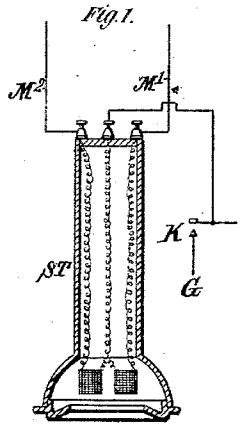


Fig. 2.

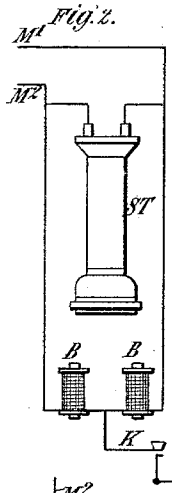


Fig. 3.

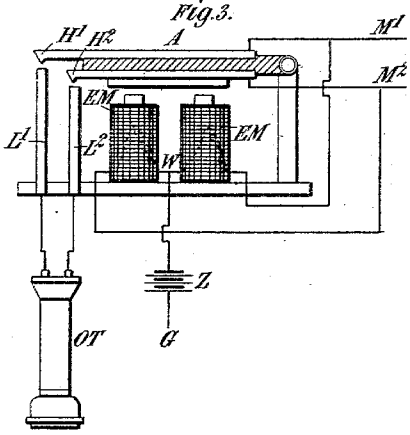


Fig. 4.

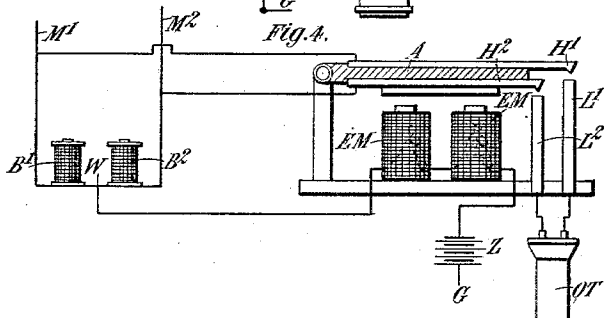


Fig. 11.

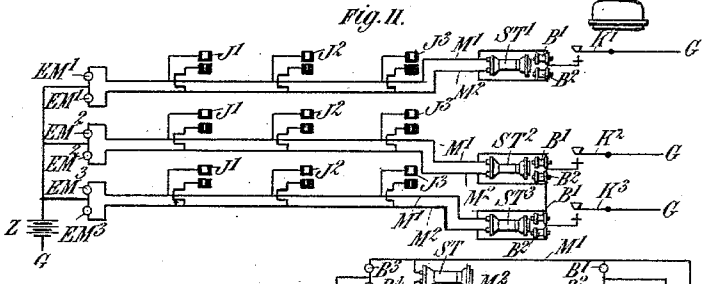


Fig. 12.

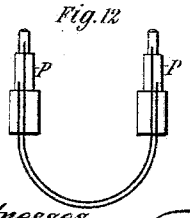
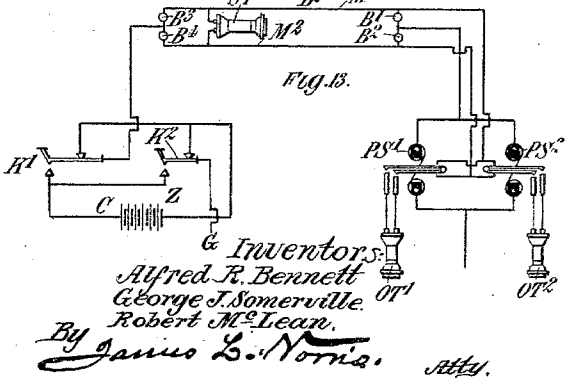


Fig. 13.



Witnesses,
Albert H. Norris.
Robert Everett.

Inventors:
Alfred R. Bennett
George J. Somerville
Robert McLean.
By James L. Norris. Atty.

(No Model.) 2 Sheets—Sheet 2

A. R. BENNETT, G. J. SOMERVILLE & R. McLEAN.

TELEPHONE EXCHANGE SYSTEM AND SWITCHING APPARATUS.

No. 566,648. Patented Aug. 25, 1896.

Fig. 5.

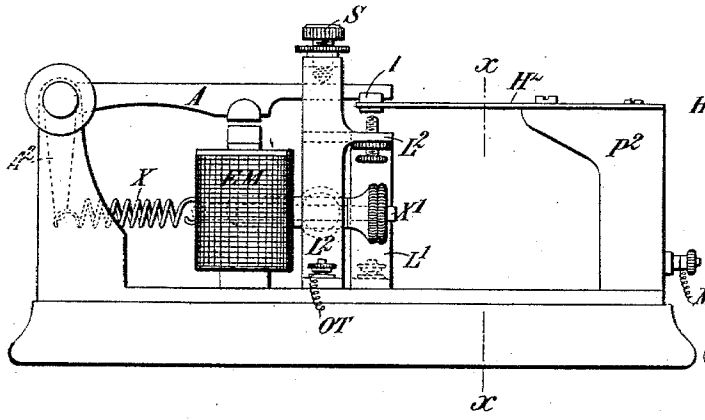


Fig. 7.

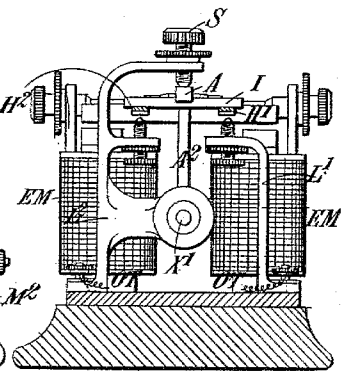


Fig. 6.

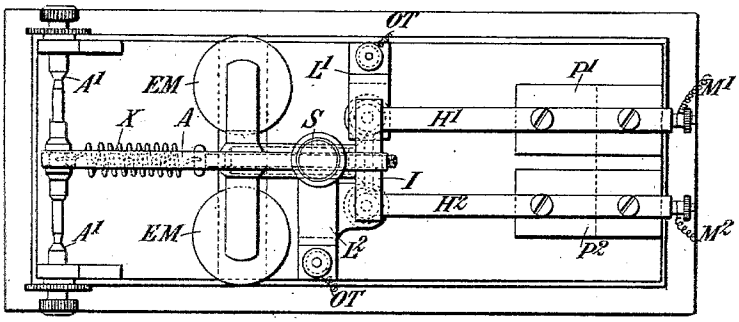


Fig. 10.

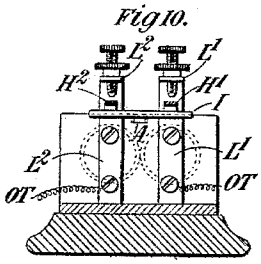


Fig. 8.

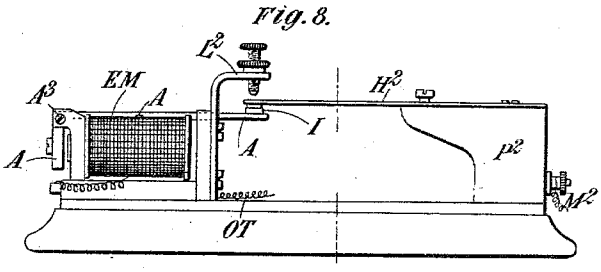
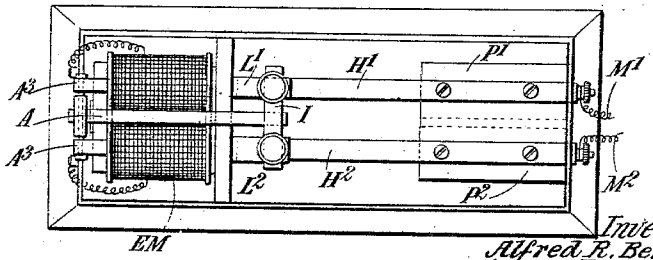


Fig. 9.



Witnesses.
Thos. A. Emmet
Robt Corrett.

Inventors
Alfred R. Bennett.
George J. Somerville.
Robert McLean.
By James L. Norris, Atty.

UNITED STATES PATENT OFFICE.

ALFRED R. BENNETT, OF LONDON, GEORGE J. SOMERVILLE, OF HEATON CHAPEL, AND ROBERT McLEAN, OF NOTTINGHAM, ENGLAND; SAID McLEAN ASSIGNOR TO SAID BENNETT AND SOMERVILLE.

TELEPHONE-EXCHANGE SYSTEM AND SWITCHING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 566,648, dated August 25, 1896.

Application filed March 20, 1896. Serial No. 584,178. (No model.)

To all whom it may concern:

Be it known that we, ALFRED ROSLING BENNETT, residing at 22 St. Albans Road, Harlesden, London, in the county of Middlesex, GEORGE JOHN SOMERVILLE, residing at 9 Tatton Road North, Heaton Chapel, in the county of Lancaster, and ROBERT MCLEAN, residing at 7 Alma Terrace, Dryden Street, Nottingham, in the county of Nottingham, England, electrical engineers, subjects of the Queen of Great Britain, have invented certain new and useful Improvements in Telephone-Exchange Systems and Switching Apparatus for Use Therein, of which the following is a specification, reference being had to the accompanying drawings.

Our invention relates to telephonic-exchange signaling and is applicable to those telephone systems which are worked with metallic circuits.

The object of our invention is to enable the subscribers to a telephone-exchange worked with metallic circuits to speak to the operator at will without any preliminary calling-signal or the use of a special service or calling wire.

In the telephone-exchange systems known as the "Law" and the "Mann" the operators are always listening at telephones connected with special service or calling wires onto which the subscribers switch their instruments temporarily for the purpose of giving instructions.

Our invention is worked in a similar manner to the Law and the Mann systems, but while yielding equal facilities with those systems dispenses with the special service or calling wire and does away with the trouble caused by currents in adjacent wires and also the high capacity due to the number of wires which, in the Mann system, although not in use, are generally connected to the operator's telephone.

We provide means at each subscriber's station whereby the subscriber, by pressing a key or lever, puts his speaking apparatus in connection with the operator's telephone or other apparatus temporarily switched on in place of the operator's telephone at the exchange. The subscriber's instrument, suitably connected, may be of any of the usual patterns. We, moreover, arrange the connection and switch-contacts at the exchange so that when a subscriber depresses his lever he puts his metallic loop in connection with the operator's telephone, or apparatus temporarily replacing the same, by means of a specially-constructed electromagnetic switch.

In order that our invention may be clearly understood, we will now proceed to explain the same with reference to the accompanying drawings, in which—

Figure 1 is a diagram showing one mode of connecting the subscriber's telephone. Fig. 2 is a diagram showing an alternative method of connecting the subscriber's telephone by means of a balanced shunt. Fig. 3 is diagram showing how the operator's telephone may be connected with the specially-constructed electromagnetic switch at the exchange. Fig. 4 is a diagram showing an alternative method of effecting the necessary connection at the exchange with the operator's telephone by means of an electromagnetic switch. Fig. 5 is a side elevation, and Fig. 6 is a plan, of one form which the aforesaid specially-constructed electromagnetic switch may assume in practice. Fig. 7 is a transverse section on the line x x, Fig. 5. Figs. 8, 9, and 10 are similar views showing another form which the special electromagnetic switch may take. Fig. 11 is a general scheme of the system when employed with a simple form of multiple switchboard, the connections of the operator's telephone being for the sake of clearness omitted. Fig. 12 is an enlarged view of a double plug and connecting-cord for making the necessary connections. Fig. 13 is a diagram of the arrangements when it is desired to allow the subscriber to put himself in connection at will with either of two operators at the exchange.

Referring to Fig. 1, ST is the subscriber's telephone, provided with two coils Q Q, of equal resistance or nearly so, from between which a branch or leg is taken through the lever-key K to earth at G. M' M^2 are the two wires of the subscriber's metallic loop. When the key K is depressed against its bot-

tom stop, the metallic loop is grounded through the equally-wound coils Q Q.

In Fig. 2, B B is a balanced resistance composed of two coils of equal resistance or nearly so, from between which a branch or leg is taken through the lever-key K to earth at G. ST is the subscriber's telephone, with its coil or coils arranged in the ordinary way without any branch or leg. It is connected across between the wires $M' M^2$ of the subscriber's metallic loop in shunt with the coil B B. Any ordinary type of telephone can be employed in this plan, so that existing instruments are by this method rendered suitable for use with our system without alteration.

In Fig. 3, EM EM are electromagnets the coils of which are of equal resistance or nearly so and are wound differentially, that is to say, the one left-handed and the other right-handed, so as to exert an equal and opposite effect on the armature when used in series. The two coils are joined at W, from which point a branch or leg is taken through the voltaic battery or other source of electricity Z to ground at G. The coils EM EM are furnished with soft-iron cores and pole-pieces and a soft-iron armature in the manner of an ordinary unpolarized electromagnet. A current entering at W and splitting between the coils will magnetize both cores in the same sense and attract the armature. On the other hand, a current passing successively through the coils will affect the cores equally and oppositely and no attraction will result. $M' M^2$ are the two wires of the metallic loop coming from a subscriber's office. They are connected to mutually-insulated metallic spring-strips $H' H^2$, attached to or moved by the armature A. When the armature becomes attracted, the strip H' makes contact with a metal post L' and the strip H^2 with a metal post L^2, which posts or pillars are in permanent connection respectively with the terminals of the operator's telephone OT. $M' M^2$ are also respectively in permanent connection with the coils EM EM of the electromagnetic switch.

In Fig. 4 $M' M^2$ are again the two wires of a metallic loop entering the exchange from a subscriber's office. The said wires are in permanent connection with metallic spring-strips $H' H^2$, attached to or moved by the armature A of the electromagnetic switch, and when the said armature becomes attracted the said strips make contact with posts $L' L^2$, which, as before, are permanently connected to the terminals of the operator's telephone OT. Across the metallic loop $M' M^2$ are joined two equally-wound resistance-coils $B' B^2$, and from the point W between the coils is taken a line to ground G through the coils EM EM of the electromagnetic switch and the battery or other source of electricity Z. In this case the coils of the electromagnetic switch are not differentially wound and no connection is taken off from between them.

In Figs. 5, 6, and 7 are shown the details of an electromagnetic switch suitable for effecting the purposes aimed at. EM EM are the coils. A is the armature, pivoted in bearings A' A', Fig. 6. S is an adjustable stop preferably tipped with an insulating substance for limiting the upward movement of the armature. X is a spiral spring one end of which is attached to an arm A^2 of the armature A and the other end of which is attached to an adjusting-screw X'. $L' L^2$ are the two posts or pillars which are in permanent connection with the operator's telephone. So far as yet described the electromagnetic switch closely resembles an ordinary unpolarized relay, but as there are two local contacts to be made and broken a modification of the ordinary armature and its connections is necessary. The armature may be built up of two mutually-insulated metallic strips, as indicated in Figs. 3 and 4, but as the connections through the pivots must also be kept mutually insulated such a built-up armature would be costly to make and not very satisfactory in practice. For these reasons we prefer to retain the armature in its simple form and to furnish it with an insulating cross-piece I, which, when the armature A becomes attracted, depresses the springs $H' H^2$ against the metallic adjustable stops which are in connection with the insulated metallic pillars $L' L^2$. In Fig. 7 the arrangement of the pillars $L' L^2$ with their contact-stops is clearly shown. The springs $H' H^2$ are mounted on two insulated supports or posts $P' P^2$, which are in permanent connection with the two wires $M' M^2$ of the metallic loop. The depression of the armature therefore brings the said wires $M' M^2$, through the pillars $P' P^2$, springs $H' H^2$, and pillars $L' L^2$, into connection with the operator's telephone.

In Figs. 8, 9, and 10 the same reference-letters indicate the corresponding parts of another form which the electromagnetic switch may assume. In this case the armature A is a bent lever pivoted at A^3. It supports an insulating cross-piece I, which, when the armature becomes attracted, lifts the springs $H' H^2$ against the stops in connection with the posts $L' L^2$.

Referring now to Fig. 11, which is a diagram of our system combined with a simple form of multiple switchboard, but with the operator's telephone connections (which are shown separately in Figs. 3 and 4) omitted, $ST' ST^2 ST^3$ are three subscribers connected by the metallic loops marked $M' M^2$ $M' M^2$ $M' M^2$ to an exchange or central station and by the levers or keys $K' K^2 K^3$ to earth at G G G. The subscriber ST' is shown provided with the specially-arranged telephone described with reference to Fig. 1, while subscriber ST^2 has an ordinary telephone with special balance-coils $B' B^2$, as described with reference to Fig. 2. At the exchange $J' J^2 J^3$ $J' J^2 J^3$ $J' J^2 J^3$ represent jacks or sockets connected in branches between the wires of each metallic loop. $EM' EM' EM^2 EM^2 EM^3 EM^3$

are the balanced coils of the electromagnetic switches arranged as in Fig. 3, and Z is the common battery or other source of electricity joined to earth at G. The subscribers' loops are connected together as desired by the connected double-conductor plugs P P, Fig. 12, which are adapted to fit into the sockets J' J^2 J^3.

In Fig. 13 are shown the arrangements necessary when it is desired to give any subscriber the power to switch his instrument at will onto that of either of two operators at the exchange, such as an operator who deals with local communications only, or one whose duty it is to establish trunk-line communications; or when, as is sometimes the case, the lines of the subscribers are divided between the two switchboards, the subscriber may connect himself at will to an operator having control of, say, numbers "1" to "4,000" or to one controlling numbers "4,001" to "8,000." M' M^2 is the metallic loop proceeding from the subscriber's office to the exchange, where B' B^2 are two equally-wound resistance-coils according to the plan shown in Fig. 4. In the circuit of the ground-wire G are joined two polarized electromagnetic switches constructed substantially according to the well-known principle of the polarized relay. One of these switches, say PS', is arranged to have its armature attracted by the passage through its coils of a positive current and repelled by a negative current, while the armature of the other switch, PS^2, is repelled by a positive current and attracted by a negative current. Both switches possess armatures and contact arrangements substantially the same as those already described in connection with Fig. 3 or Figs. 5, 6, and 7 or Figs. 8, 9, and 10. At the subscriber's office are the two equally-wound coils B^3 B^4 described in connection with Fig. 2 and an ordinary set of subscriber's speaking and signaling apparatus ST joined across the loop M' M^2. If the plan described in Fig. 1 be adopted, then the coils B^3 B^4 will represent the coils of the telephonic receiver, while the signaling apparatus only will be joined across the loop at ST. K' K^2 are two keys or contact-levers arranged substantially in the same manner as the signaling-keys in submarine telegraphy. When the key K' is depressed, the positive pole C of the battery CZ is joined to the metallic loop M' M^2, and the armature of the switch PS' being attracted the operator's telephone OT' is brought into circuit, while the armature of PS^2 is repelled against its idle stop and the operator's telephone OT^2 remains unaffected. When the subscriber presses the key K^2, the negative pole Z of the battery is joined to line and the armature of the switch PS^2 is attracted and that of the switch PS' is repelled. According to this plan the battery is situated at the subscriber's office instead of at the exchange, which, for a large number of subscribers, would be objectionable on the score of expense and inconvenience in maintenance, but it is only necessary to furnish such home batteries to those subscribers who make frequent use of the trunk lines or have some other occasion to communicate promptly with the second operator. For all the others the battery or other source of electricity may still be situated at the exchange; but the use of a voltaic battery at the subscriber's office may be dispensed with in any case if magneto or dynamo electric machines commutated so as to send continuous currents to line instead of the ordinary alternating currents are provided. For use in a subscriber's office they may be driven by hand, but more conveniently by clockwork, or by the descent of a weight, or by any water, gas, hot-air, electric, or other motor capable of being quickly started and stopped. The principle of such machines is well understood. They could be constructed by any competent electrical-machine manufacturer and form no part of the present invention except as a variation of the combination shown in Fig. 13.

From a consideration of the foregoing description and of the drawings it will be understood that when the subscriber's key is depressed the wires of the metallic loop M' M^2 are grounded at the subscriber's office through the balanced coils Q Q, Fig. 1, or B B, Fig. 2, as the case may be, and as at the exchange, Fig. 3, the wires M' M^2 are permanently grounded through the balanced coils EM EM of the electromagnetic switch and through the battery Z a current will traverse both wires of the loop M' M^2 and the earth so long as the key K is kept depressed. When this circuit is established, the armature A is attracted, because for a current entering and splitting between them the oppositely-wound coils have the same attractive effect on the armature. The springs H' H^2, Figs. 5, 6, and 7, are thereby brought into contact with the posts L' L^2 and the terminals of the operator's telephone become connected to line. The same description holds true for Fig. 4, except that the balance is made by the dummy-coils B' B^2, while the coils of the electromagnetic switch are not oppositely wound. The subscriber is thus enabled to establish communication with the operator at any moment for the purpose of demanding a connection, notifying the termination of a connection, or for any other purpose. Keeping his key depressed, the subscriber speaks his message to the operator, and as his speech, starting from ST', Fig. 11, travels around the metallic circuit his communication to the operator enjoys all the advantages of metallic-circuit speaking and is not interfered with by induction from other lines. Having received notification of the arrival of his message, the key K is allowed to rise. The armature A then ceases to be attracted, and the connection with the operator's telephone is broken, whereupon, the communication asked for having been established, the subscriber finds himself in metallic-circuit communica-

tion with his correspondent. The two connected subscribers may ring each other's bells without disturbing the exchange, since such ringing-currents pass around the metallic circuits and through the electromagnetic switch-coils in series, so that the armatures remain unaffected, the action of the two coils when in series on the armature being equal and opposite.

In practice an electromagnetic switch is required in the exchange for each ordinary subscriber and an additional switch for each subscriber who desires special trunk-line facilities or to call up more than one operator. The switches replace the annunciators or other indicators of an ordinary telephone-exchange, and an important feature of our invention is that it saves space on the switchboard. Ordinary annunciators must be in sight of the operator and their presence on the switchboard occupies space which could be usefully devoted to other purposes. Our electromagnetic switches may be mounted apart from the switchboard and even in another room or other building, since it is only necessary to lead to the switchboard for the operator's telephones a pair of wires from each group of switches. Each group may consist of from fifty to one hundred switches or thereabout, according to the frequency of the traffic. The switches should be mounted in cases with closely-fitting doors, and they should be disposed so as to admit of easy access for cleaning and adjustment.

The battery or other source of electricity Z at the exchange may be common to several or all of the switches and lines. If separate batteries are employed at the exchange, they should be of equal strength; otherwise the stronger will send currents through the weaker when two subscribers' circuits are connected.

The resistances of the coils employed may vary within wide limits, but for ordinary purposes the coils EM EM may be wound to five hundred ohms each and the coils B B to one thousand ohms each. The coils Q Q may be of the usual resistance of telephone-receiver coils. The coils B B may be provided with iron cores or arranged as self-induction bobbins, in which case their resistance may be much reduced, but this is not necessary.

In case of need, electromagnetic switches of the construction shown in Figs. 5, 6, and 7 or Figs. 8, 9, and 10 may be arranged to close more than two local circuits by providing additional insulated spring-strips to be depressed by the insulating cross-piece attached to the armature against contacts mounted on additional insulating pillars or stands.

Our invention enables the subscriber to perform all the operations of calling up and calling off possible on the Law or Mann systems, with the advantages of additional certainty and efficiency, for there is no supplementary call-wire to maintain, there is no interference by induction or cross-talk between the calling-circuits or between the calling-circuits and the speaking-circuits, and the indistinctness of speech sometimes caused by the large capacity of a number of Mann calling-circuits attached to one operator's telephone is avoided.

Should two subscribers whose switches are in the same group, that is to say, allotted to the same operator, depress their levers K at the same moment, both will find themselves in connection with the operator's telephone and with each other—that is, however, only what frequently happens with the Law and Mann systems without inconvenience. The operator receives their instructions consecutively, and as soon as the desired connections are established communication between the two subscribers through the operator's telephone-circuit ceases.

At night or during slack hours the operator's telephone may be replaced by an electromagnetic or other suitable indicator and a special battery interposed between the contacts $L' L^2$, Figs. 3 and 4, or an indicator only joined in the branch or leg between the battery Z and the switch-coils, Figs. 3 and 4. A call having been notified to the exchange, the operator switches in the telephone OT and receives the subscriber's instructions.

When the employment of a ground is for any reason undesirable, a return-wire may be substituted in order to complete the circuit of the battery Z and the key K.

What we claim is—

1. In a metallic-circuit telephone-exchange system, the combination with the subscriber's metallic loop, of a source of electricity together with means under the control of the subscriber for connecting in a ground-circuit the said source of electricity with both wires of the metallic loop at the central-station end of two operators' sets of speaking apparatus, any suitable switching, a pair of equally-wound resistance-coils and electromagnetic means for connecting the two wires of the metallic loop to the terminals of the operators' speaking sets, and at the subscriber's end a subscribers's telephone and signaling set of apparatus, a pair of equally-wound resistance-coils and the aforesaid means for closing the ground-circuit at will inserted in a leg connecting to ground a point of the metallic loop midway the two last-named resistance-coils, substantially as and for the purposes described.

2. In a metallic-circuit telephone-exchange system, the combination with the operator's set of apparatus, any suitable switching system, and the metallic loop of a pair of equally-wound resistance-coils, an electromagnetic switch, a source of electricity having one pole permanently connected to earth and the other pole connected to the metallic loop through the said switch and at the subscriber's end a pair of equally-wound resistance-coils, a subscriber's telephone and signaling set, and a contact-key placed in a leg connecting to

ground a point of the circuit midway between the two last-named resistance-coils, substantially as and for the purposes described.

3. In a metallic-circuit telephone-exchange system, the combination with the operator's set of apparatus, any suitable switching system and the metallic loop of a pair of equally-wound resistance-coils, an electromagnetic switch, a source of electricity having one pole permanently connected to earth and the other pole connected to the metallic loop through said switch, and at the subscriber's end a subscriber's telephone and signaling set the telephone-receiver having a pair of equally-wound coils for operating the diaphragm and serving as resistance-coils, and a contact-key placed in a leg connecting to ground a point of the circuit midway between the two last-named resistance-coils, substantially as and for the purposes described.

4. In a metallic-circuit telephone-exchange system, the combination with the operator's ordinary set of apparatus, any suitable switching system and the metallic loop of a pair of equally-wound coils for the purpose of operating the armature of an electromagnetic switch, and serving also as resistance-coils, a source of electricity having one pole permanently connected to earth and the other pole connected to the metallic loop through the said switch, and at the subscriber's end a pair of equally-wound resistance-coils, a subscriber's telephone and signaling set, and a contact-key placed in a leg connecting to ground a point of the circuit midway between the two last-named resistance-coils, substantially as and for the purposes described.

5. In a metallic-circuit telephone-exchange system, the combination with the operators' sets of apparatus, any suitable switching systems and the metallic loop of a pair of equally-wound resistance-coils, two polarized electromagnetic switches placed in a leg to ground taken from a point midway between the two resistance-coils, and at the subscriber's end two equally-wound resistance-coils, a subscriber's telephone and signaling set, two contact-keys, and a source of electricity all connected in a leg to ground taken from a point midway between the last-named pair of resistance-coils, substantially as and for the purposes described.

6. In a metallic-circuit telephone-exchange system, the combination with operators' sets of apparatus, any suitable switching system and the metallic loop of a pair of equally-wound resistance-coils, two polarized electromagnetic switches placed in a leg to ground taken from a point midway between the two resistance-coils, and at the subscriber's end of a subscriber's telephone and signaling set the telephone-receiver having a pair of equally-wound coils for operating the diaphragm and serving as resistance-coils, two contact-keys and a source of electricity all connected in a leg to ground taken from a point midway between the last-named pair of resistance-coils, substantially as and for the purposes described.

7. In a metallic-circuit telephone-exchange system, the combination with a metallic loop, of an electromagnetic switch comprising an electromagnet and armature of ordinary construction, an insulating cross-piece attached to the armature, a pair of mutually-insulated springs and two contact-points electrically connected to the two terminals of the operator's speaking apparatus, substantially as and for the purposes described.

In testimony whereof we, ALFRED ROSLING BENNETT and GEORGE JOHN SOMERVILLE, have hereunto set our hands this 24th day of February, 1896.

A. R. BENNETT.
GEO. J. SOMERVILLE.

Witnesses:
GEORGE HARRISON,
PERCY H. RUDGEN.

In testimony whereof I, ROBERT MCLEAN, have hereunto set my hand this 17th day of February, 1896.

ROBERT MCLEAN.

Witnesses:
T. B. COX,
ALFRED CLARKE.