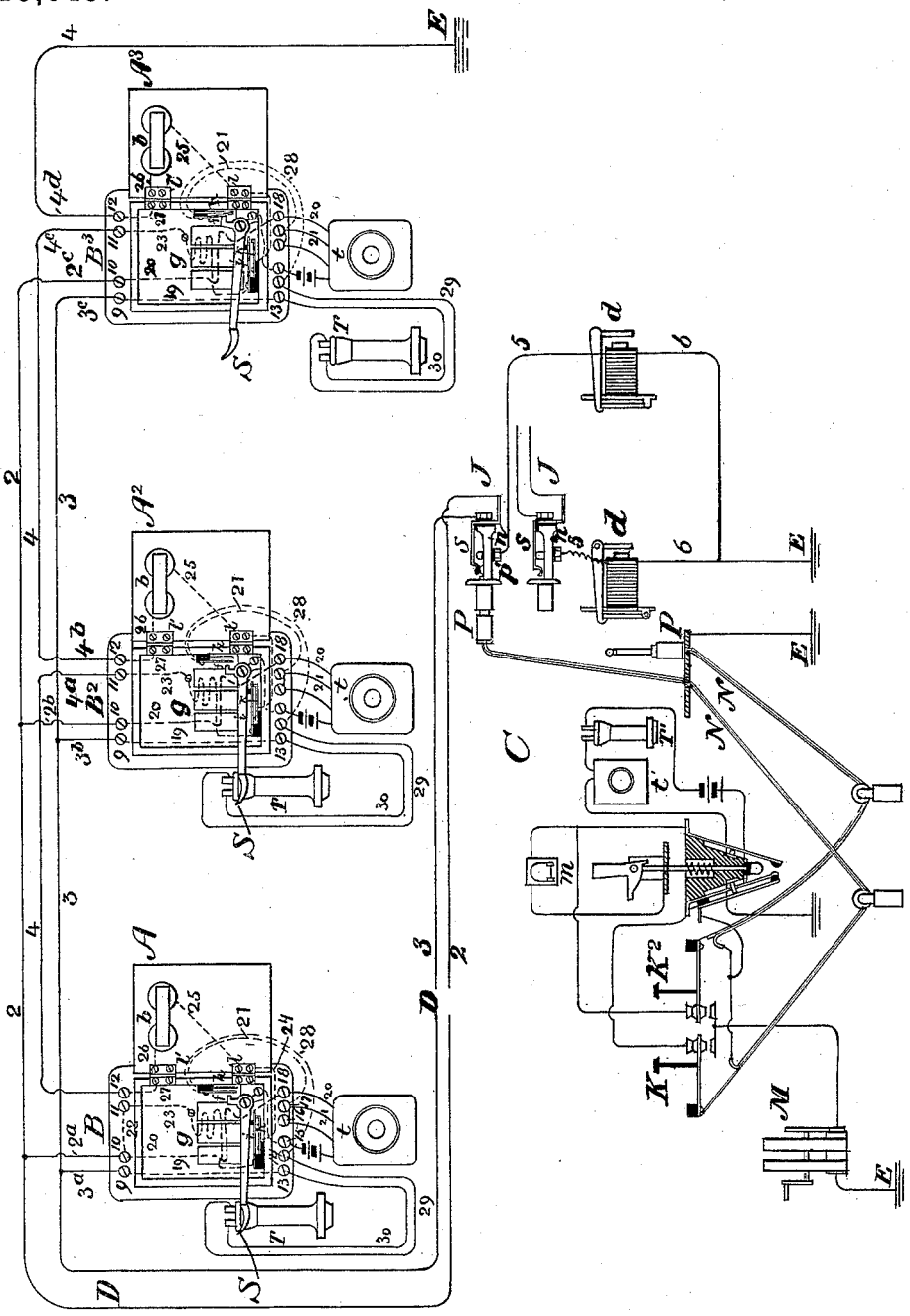
(No Model.) 3 Sheets—Sheet 1.

J. N. CULBERTSON.

TELEPHONIC CIRCUIT AND APPARATUS.

No. 419,645. Patented Jan. 21, 1890.

Fig. 1.



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(No Model.) 3 Sheets—Sheet 2.

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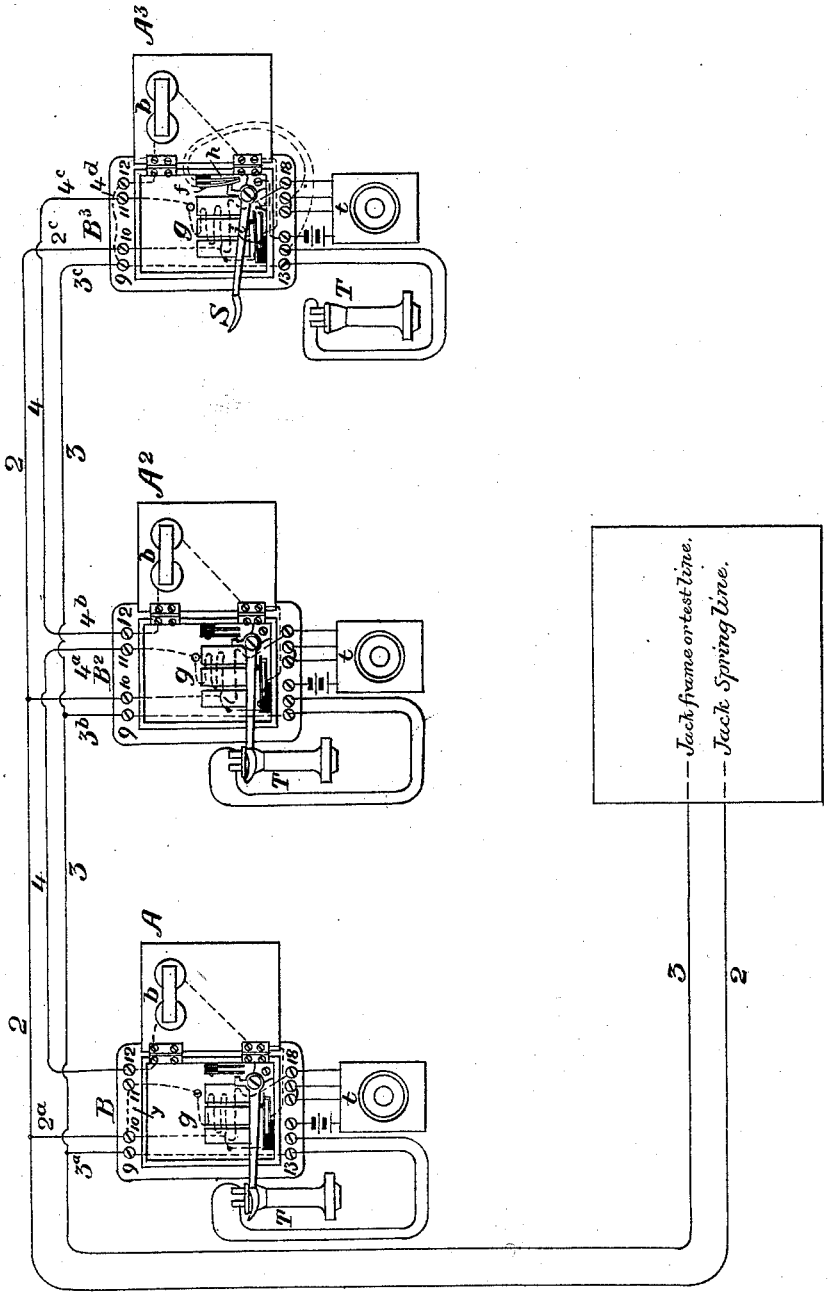
TELEPHONIC CIRCUIT AND APPARATUS.

No. 419,645. Patented Jan. 21, 1890.

Fig. 2.



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(No Model.) 3 Sheets—Sheet 3.

J. N. CULBERTSON.

TELEPHONIC CIRCUIT AND APPARATUS.

No. 419,645. Patented Jan. 21, 1890.

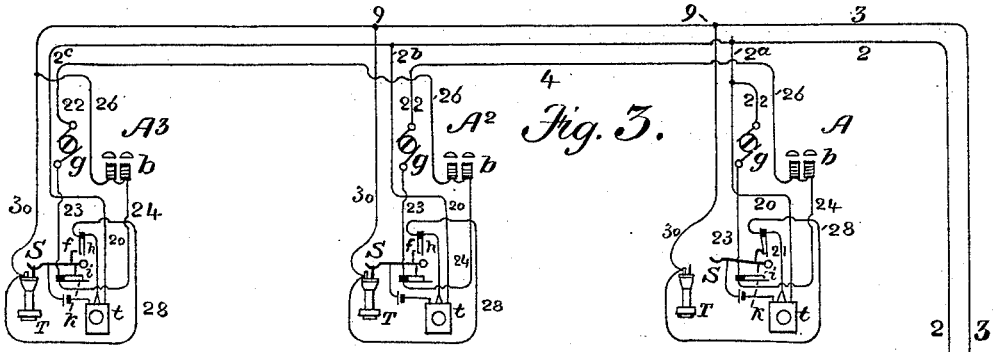

Fig. 3.

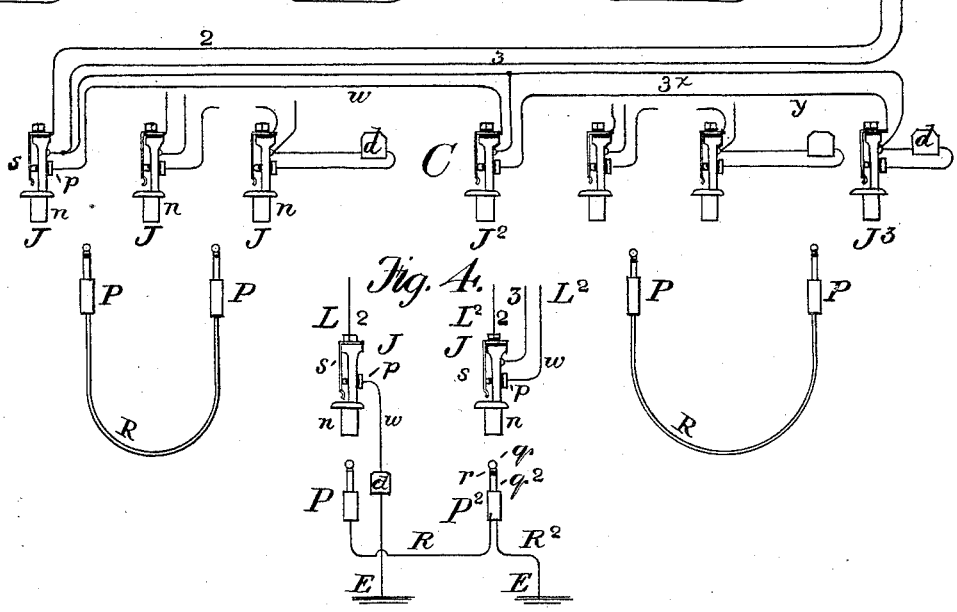

Fig. 4.

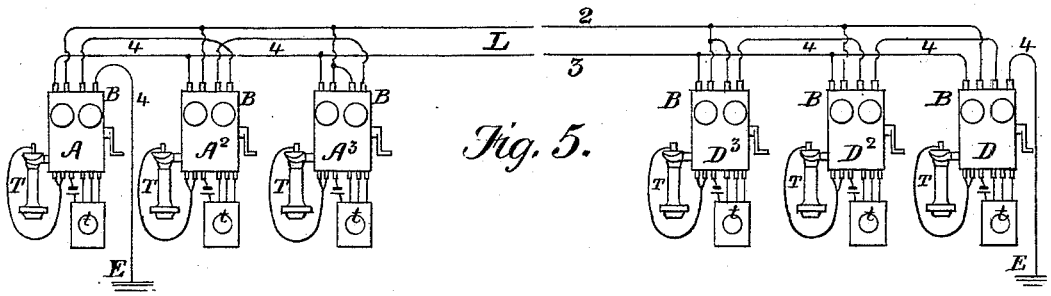

Fig. 5.

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UNITED STATES PATENT OFFICE.

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TELEPHONIC CIRCUIT AND APPARATUS.

SPECIFICATION forming part of Letters Patent No. 419,645, dated January 21, 1890.

Application filed May 29, 1889. Serial No. 312,506. (No model.)

To all whom it may concern:

Be it known that I, JOHN N. CULBERTSON, residing at Buffalo, in the county of Erie and State of New York, have invented certain Improvements in Telephone Circuits and Apparatus, of which the following is a specification.

This invention refers to the art of electrically transmitting speech, and comprises peculiar arrangements of circuits and apparatus, whereby certain advantages in economical construction and maintenance and also in operation may be attained.

Ordinary single-line or earth return telephone-circuits are (when of considerable length and when they pass in close proximity to circuits carrying other classes of currents) subject to inductive disturbance due to the presence and operation of the said foreign circuits, and are, moreover, always subject to disturbances arising from earth-currents. It is, however, now well known that a maximum degree of efficiency in operation and immunity from disturbance is reached when the telephone-circuits are each provided with a return as well as an outgoing wire, both wires being substantially parallel to each other and as close together as possible, so as to be practically equidistant from any adjacent disturbing circuit. Such an organization is technically styled a "metallic circuit," and its advantages arise from the fact that by its use disturbing currents due to induction are in a manner well understood neutralized, and that in consequence of the absence of earth-terminals earth-currents are prevented from traversing the circuit. In consequence of these decided advantages, which are inherent in the use of parallel wire metallic circuits, the employment of such circuits has of late largely increased, and especially so in the case of long lines and lines where the question of expense can be disregarded.

By reason of the fact that it is somewhat difficult to arrange and operate connecting apparatus for the interconnection of metallic and earth return-circuits when both classes enter the same central station, and also in view of the fact already stated of the improved results of the operation of metallic circuits, it would be decidedly advantageous if it were practicable to provide metallic circuits for all or a majority of the telephone-lines without regard to length. Since, however, the use of metallic circuits implies a materially increased cost of construction and maintenance, it has not so far been found practicable to universally adopt their employment, though their advantages, as recited above, have universally been acknowledged, because in relatively small towns the compensation paid for the use of telephones is rarely sufficiently large to make metallic circuit construction remunerative. In other words, the question of expense cannot be disregarded. To meet this condition of affairs it has heretofore been suggested that a metallic circuit common to several subscribers' stations and terminating with both of its ends at the central station could profitably be adopted, and that the several sub-stations connected with a central station could be in that case divided among a smaller number of metallic circuits, those assigned to each circuit being connected in series with one another thereon. In the employment of this plan, while it is true that each subscriber would to a certain extent participate in the benefits accruing from the metallic circuit, it is also true that the several subscribers connected with any line would be constantly disturbing and interfering with each other, as was found to occur in practice in the earlier years of telephonic communication, when it was customary to connect several sub-stations with each earth return-circuit. Not only so, but the call-bell magnets at the several sub-stations on such a combination line being actually in circuit while conversation is in progress impede the proper operation of the line by reason of their resistance and likewise of the counter electro-motive forces developed in them. This expedient, therefore, while not impracticable, is non-practical and impolitic.

The object of my invention is to enable each member or subscriber of a telephone system to participate in the improved transmission accruing from the utilization of metallic circuits by means which shall be sufficiently economical in cost for universal adoption, to provide that the subscriber at

any moment using the line shall be perfectly secured from the interruptions of other subscribers, and that the talking-circuit shall be maintained at its maximum efficiency by the elimination of unnecessary resistance and by the absence of electro-magnetic retardation and counter electro-motive forces arising from the passage of alternating currents through electro-magnets.

In the drawings which illustrate and form a part of this specification, Figure 1 is a diagram showing a telephone-circuit embodying one mode of carrying out my invention. Fig. 2 is a diagram illustrating a modified arrangement of circuits. Fig. 3 is a diagram indicating more fully the modification shown in Fig. 2, and particularly illustrating the central-office connections therefor. Fig. 4 is a detail indicating the applicability of my invention to mixed systems of metallic and earth return-circuits; and Fig. 5 shows its adaptation to single or independent circuits with which a large number of sub-stations may be connected, and in which no interruption can occur while any station is talking with any other station.

In Fig. 1, C represents a central telephone-station whereto any number of sub-station lines may converge, and A, A^2, and A^3 are respectively sub-stations located at different points upon any one of the said lines D. As will be seen, the said line D comprises two distinct wires 2 and 3, which each extend from the central station to each and all of the sub-stations. A third wire 4 extends from that one of the sub-stations which is nearest to the central station, and, passing through all of the sub-stations, terminates at the earth at the most distant one.

In the present case one of the main wires 3 is functionless, and is open or disconnected from the circuit at the central and at all sub-stations. Its business is to serve when the line is being actually used for conversation as one side of a metallic circuit. The other main wire 2, when the circuit is at rest, is connected at the central station by means of the contact-spring *s* of its final spring-jack J with the insulated contact-screw *p*, from whence the normal circuit passes inwardly by wire 5 to the call-receiving annunciator *d*, and thence by wire 6 to its central-station earth-terminal E. Tracing the same wire 2, still assuming the circuit to be at rest, it is found to lead to the most distant station, into which it is led by wire 2^c, while it also branches into the intermediate stations by branch wires 2^a and 2^b.

At each sub-station there may be the usual subscriber's outfit, comprising receiving and transmitting telephones, together with call-bell, call-sending generator, and automatic telephone supporting-switch, the latter three appliances being inclosed in the bell-box. The bell-box, as shown, has four screw-terminals, numbered, respectively, 9, 10, 11, and 12, at its upper end, and six, numbered 13, 14, 15, 16, 17, and 18, at its lower end, and these terminals are for the purpose of making the requisite connections between the circuits within the bell-box and the main lines on the one hand and the telephone-instruments and battery on the other hand. Resuming our consideration of the main wire 2, it will be observed that the said branches 2^a, 2^b, and 2^c, entering the sub-stations A, A^2, and A^3, all connect with the screw-terminals 10. At the first sub-station this terminal connects within the bell-box with two wires 20 and 22, while at the others it has but one—viz., the wire 20; but if we trace any of the said wires 20 we shall find that their circuits are discontinuous as long as the receiving-telephone remains upon its support. The normal circuit is clearly, therefore, to be followed over the remaining route by wire 22, which crosses over to terminal 11. Following this by wire 23, the circuit leads through the generator *g* and contact-springs *i* and *k*, which are normally held together by the depression of the hook-switch S, although insulated therefrom, to wire 24, which leads from the spring *k* to the lowest hinge 1, thence by wire 25, bell-magnet *b*, wire 26, upper hinge 1′, and wire 27 to terminal 12. Here a connection is made with the third main wire 4, which, continuing on to the more distant stations, is finally grounded at the last. Meanwhile entering station A^2 from A, it connects by branch 4^a with bell-box terminal 11, passes through the generator, contacts *i* and *k*, and bell, as before, and leaving by terminal 12. Leaving station A^2 by wire 4^b, it passes on to station A^3, which its branch 4^c enters at terminal 11. The calling appliances and contacts *i* and *k* are at this station also traversed, and the circuit, going on to terminal 12 at the last station, passes out by branch 4^d, and the third wire 4, furnishing the sub-station end of the calling-circuit, terminates finally and permanently at the earth E. Thus when all telephones are in place at the sub-stations calls may be transmitted between any of the said sub-stations and the central station—that is, when at the central station the plug P is not inserted in the spring-jack J, and the spring *s* therefore rests on the insulated pin *p*, any sub-station may operate its generator and affect the central-station annunciator at the central station, provided no other sub-station on the same circuit is using the line conversationally; and in like manner, if the telephones at the sub-stations are all in place, the operator at the central station may insert the plug P, press the call-key K, and operate the generator M, thus sending the call-signal to any desired station; but it is evident that if any sub-station be already using the line for conversation it will be impossible for any other to interrupt by the attempt to send a call-signal, for the reason that the several call generators and bells at all stations are in the circuit of the third main wire 4, and that if any station on either side of that desiring to

call be already using the line the circuit of the said third main wire or ground-extension 4 is automatically opened there at the contacts *i* and *k*, and it is also evident that for the same reason the central station cannot interrupt conversations if it should attempt to send call-signals, which, however, would rarely occur, since the central operator is usually informed by the position of plugs or by suitable tests of the condition of the line.

It remains to consider the state of the circuit when in use for conversation, and in this regard it will be noted that the circuit is in the drawings represented as being ready for use, the receiving-telephone T being at station A^3 removed from its support and the contacts *i* and *k* separated from each other, the calling-circuit of the series being thus opened.

If we trace the circuit now from the jack-spring *s* at the central station over wire 2, we shall find that its branch 2^a is at station A open, that leading through the telephones, because the receiver is still in place, and the springs *f* and *h* therefore out of contact, and that leading through the calling appliances, because, though closed at stations A and A^2, it is open at station A^3 at contacts *i* and *k*. Its branch 2^b at station A^2 is open for like reasons; but arriving at station A^3 we find a different state of affairs. The line 2 enters the bell B^3 there by wire 2^c and connects with terminal 10. From this point a wire 20 leads directly to the transmitting-telephone *t* by way of screw 18, and the circuit continues to the receiving-telephone T by way of wire 21, screw 17, contact-springs *h* and *f*, wire 28, and screw 14, the said telephone being connected by wires 29 and 30 to the screws 13 and 14. From the screw 13 a wire 19 leads directly to the screw 9 at the upper end of the bell-box, which connects by branch 3^c with main return-wire 3, leading back to the central station, where it is united to the metal frame *n* of the spring-jack J. A double conductor-plug P, made in a manner well understood for the interconnection of metallic circuits, can now be inserted, as shown, and when another similar plug attached to the other end of the connecting-cord N is likewise inserted in the jack of the line with which communication is desired the connection is complete, and the spring *s* makes contact with the extreme end of the plug, while the shank of the said plug, insulated from the said extreme end, makes contact in like manner with the frame of the jack, these representing, respectively, the central-station end of the lines 2 and 3. What has been described is equally the case, the telephone T being removed from its support at any of the sub-stations.

The screw-terminals 15 and 16 at the lower end of the bell-boxes are for the attachment of the primary transmitter-circuit and battery-wires. The central-station call, sending and talking appliances, including the magneto-generator M, the clearing-out annunciator *m*, the call-keys K and K^2, the telephones T′ and *t*′, are all connected, as shown at C, in a manner well understood, and fully described in Letters Patent issued to Charles E. Scribner, May 15, 1886, No. 383,018. For this reason and because they form no part of my invention, and may, in fact, be superseded by any other form and arrangement of apparatus adapted to perform like functions, I have not thought it necessary to describe them in detail; but it is obvious from what has been stated that each sub-station is provided with call, sending, and receiving appliances serially included in a normally-closed calling-circuit extending between the central and sub-stations; that the telephones of all stations are included in normally-open branches in multiple arc or parallelism with one another between the two main wires of a talking metallic circuit, and that the removal of the receiving-telephone at any of the sub-stations operates to automatically open the calling-circuit of all, and, furthermore, to close the talking metallic circuit through the telephones at its own station only.

In Figs. 2 and 3 no difference in principle is illustrated. The only differentiation is that the wire 4, which extends between the first and last sub-stations, is, instead of being grounded at the last station, there connected with the return talking-wire 3. This involves no change in function so far as the metallic talking-circuit is concerned; but it obviates the necessity of maintaining a ground connection both at the final sub-station and at the central station.

A consideration of Fig. 2 will show that all of the sub-station apparatus is connected as in Fig. 1, but that the third or calling-line extension 4, entering station A^3 at screw-terminal 11, after passing through the generator *g*, contacts *i* and *k*, and bell *b*, goes on to screw 12, from whence, instead of being connected to earth, it leads by a wire 4^d to a connection at screw 9 with the branch 3^c of return-line 3. Thus the calling-circuit as well as the talking-circuit is made metallic and uses both main wires 2 and 3 between the central station and the nearest sub-station, while it uses the third line 4 and a portion of the return-line 3 for the remaining line-section—viz., that between the first and last sub-stations. Thus, supposing that none of the sub-stations are using the line, and that consequently all receiving-telephones are in place, the central-station operator can, by uniting his calling appliances with the two ends of the outgoing and return wires 2 and 3, send call-signals and signal any desired station. The calling-circuit in that case is over line 2 to station A, thence by branch 2^a to screw-terminal 10, cross-wire *y*, and through the generator *g*, contacts *i* and *k*, and bell at said station A, and over wire 4 to the next and all succeeding stations, traversing at each their respective bells and generators and their lower switch-controlled contacts *i k* until the last station is reached, where circuit is made by wire 4^d with

the return-line 3, which now forms a part of the calling-circuit from this point back to the central station. The line 2 from the point 2^a at station A outwardly has no part in the calling-circuit and can be ignored, because, although it enters all stations, the several branches are all open at the switch-spring *h* of the upper pair of contacts as long as the telephones are in place and the switch-bars thereby depressed, and the line 3 is perfectly adapted to act as a call-circuit return, because, though it enters each station and normally is provided at each station with an open or disconnected terminal—namely, the other switch-spring *f*—these disconnections do not impair the continuity of the main wire being in multiple arc with each other. On the other hand, when the line is in use for conversation, as indicated by the removal of the receiver from the switch at station A^3, Fig. 2, the calling-line is opened, as in the case of Fig. 1, between the contacts *i* and *k*, and no station can therefore interrupt another by sending or attempting to send calling-signals, the calling apparatus being included in the circuit of the short additional line 4, which now is thrown out of use, and the contacts *f* and *h* in the same station being by the movement of the switch united, the main direct and return lines 2 and 3 are connected through the telephones at that station, thus completing the metallic circuit for conversation.

The sub-station connections are more clearly indicated in Fig. 3, where, however, station A is represented as using the circuit, and in which the central-station arrangements of the circuit are also shown. The main line 2, entering the central station, connects with the spring *s* of the spring-jack at a given section of the multiple switch-board. It goes on through the contact-spring *p* by wire *w* to the spring of J^2 at the next section, and from thence by wire *y* to the final spring-jack J^3. From the contact-screw of this jack it goes on to the annunciator *d*, and from the other terminal of said annunciator a wire $3^\times$ is led, which branches to and unites with the conducting-frames of all of the several spring-jacks. When a double plug P, forming the terminal of a double conductor-cord, is thrust into such a jack, the spring *s* is lifted from the insulated pin *p* and the original circuit is broken, but a new one is formed, the spring *s*, constituting the end of wire 2, making contact with the end of the plug, and the frame *n* of the jack forming the terminal of line 3 making contact with the metal shank of the plug. Such a circuit can now be connected with any other like line by inserting the plug P on the other end of the cord R into a spring-jack representing such line. Other jacks J indicating the presence of such other lines are shown; but for clearness their circuits are not carried out.

The organization shown in Fig. 4, strictly speaking, is not a part of my invention, but is, together with its description, introduced for the purpose of pointing out that the construction forming the essence of my invention is adapted alike for use in exchange systems composed entirely of metallic circuits and in exchanges which are compositely made up of both metallic and earth return-circuits. The same letters of reference are mainly employed as in the foregoing figures. L is an earth return-circuit, and L^2 a metallic circuit, each having spring-jacks J. Circuit L, entering the spring-jack J by its wire 2, is attached to the spring *s*, which rests upon the insulated pin *p*, and, it being assumed that this is the final spring-jack, the pin *p* is in turn connected by wire *w* with the earth at E after passing its annunciator *d*, where the circuit terminates. Circuit L^2, on the other hand, also enters its jack J by wire 2, which in this case is insulated from the metallic frame *n*, and, passing to the insulated screw *p*, leads by wire *w*, after passing its annunciator, to a connection with its frame-wire 3, this, as shown in full in Fig. 3, leading out to the sub-stations and serving as the metallic return. In effecting the union of such an earth-circuit and metallic circuit a plug-and-cord arrangement is used, as shown. The plug P on the earth-circuit side is of solid metal, and is connected by the cord R with the sleeve portion q^2 of the second plug P^2, adapted for connection with the metallic-circuit spring-jacks. This sleeve is, as indicated in all of the drawings, insulated from the central portion, which electrically is continuous with the end piece *q*. The said end piece connects with the wire R^2, leading to earth. Now, if this flexible conductor be caused to unite the two circuits L and L^2 by the insertion of its plugs into their respective jacks, the combined circuit will be as follows: Coming in on wire 2 of circuit L, which is grounded at a distant sub-station, it passes by way of spring *s*, which is raised from its pin, to plug P, conductor R, sleeve q^2 of plug P^2, frame *n* of the jack of line L^2, wire 3 of line L^2, out to the sub-stations of said line, and back over wire 2 to spring *s*, point *q* of plug P^2, and conductor R^2, to earth.

Fig. 5 is a diagram disclosing one of the most valuable and useful exemplifications of my invention—that is, there are many telephone-lines which are technically known as "private" or "club" lines. These may have their stations disposed irregularly; but it is often convenient to arrange them, as in the drawings, so that a number of stations A in one district may be placed in communication with a similar group D in another district. Heretofore, if this has been attempted either by means of earth return or metallic circuits, the stations have necessarily been arranged in series, and all connections have been subject to interruption from the calling apparatus of intermediate stations, and the efficiency of transmission has also been im-

paired by reason of the counter electro-motive forces developed by the intermediate electro-magnets.

It will be seen that by constructing a metallic circuit for the main line and by adding the third wire or calling-extension at both ends both of these disadvantages are avoided. This figure may be understood by reference to Figs. 1, 2, and 3 by noting that the metallic circuit, instead of leading to a central station, leads to a second group of sub-stations, and that both ends of the circuit are provided with the characteristic feature of the former figures—viz., the calling-extension—so arranged with reference to the two main wires that the removal of the receiving-telephone from its support opens the calling-circuit, so that no other station can send signals, and also automatically closes the metallic talking-circuit.

It does not seem necessary to describe the details of the internal connections of the bell-boxes, as they are in all respects similar to those already described. The main metallic circuit L has two wires 2 and 3. Both enter all stations by branches which are normally discontinuous, but which, when the switch is operated by the removal of the telephone, unite with each other to form a metallic loop including the telephones. The wire 2 at the outermost station of each group is connected permanently with the calling-extension 4, which traverses the stations of said group, passing through the bell, generator, and a pair of normally-closed contacts in each station, the said contacts being adapted to be separated when the telephone is removed from the switch. This calling-extension is either, as shown in the figure, grounded at the terminal stations, or may in lieu thereof, as in Figs. 2 and 3, be connected with the wire 3, thus completing the normally-open metallic talking-circuit.

Having thus described my invention in detail and with reference to the drawings, I will state that it comprises a telephone and signaling circuit in which the calling or signaling appliances are included serially in a normally-closed metallic or earth return-circuit when the line is at rest, whereby any station in the circuit is enabled to call directly any other station, and in which the telephones at the several stations are included in normally-open multiple-arc branches extending between the main outgoing and return wires, and means, as shown, for automatically closing the said telephone branches and for opening the calling-circuit, whereby a metallic talking-circuit can be constituted from any station to any other station free from interruption and from electro-magnetic retardation. It also comprises metallic circuits extending from a central station to and through a group of sub-stations and normally open at each of the said sub-stations, but adapted to be closed at any of the sub-stations through the telephones thereof for the purpose of establishing a metallic talking-circuit having no interposed electro-magnets, combined with a calling or signaling extension therefor including the calling appliances of all the stations in series, the said extension being permanently connected with one wire of the main circuit and serving to normally close the said circuit through the said signaling devices to earth or to the other wire of said main circuit, as described.

It will be obvious that by the operation of my invention a number of stations can be economically and efficiently operated upon the same metallic circuit, and that any station using the line has a metallic circuit to itself and is secure from interruption, its telephone-circuit being, moreover, absolutely free from electro-magnets. Since a branch line from each of the main lines 2 and 3 runs into each sub-station, and since these are when at work united through the telephones, it is evident that we may regard the two lines at each station as a loop.

I claim—

1. A multiple-station metallic telephone and signaling circuit comprising two main leads or wires extending from a central station to the several sub-stations, provided at each sub-station with telephones included in a normally-open multiple-arc branch, adapted, when closed, to unite the said main leads and to form a metallic circuit including the said telephones, and a normally-closed signaling extension-conductor connected with one of the said main wires at the sub-station nearest to the central station, extending therefrom serially through the signal sending and receiving appliances of all the sub-stations to the most distant sub-station, and being there united with a return-conductor, whereby when the line is at rest a calling-circuit with the calling apparatus of the several stations in series is constituted, the telephones being disconnected, and whereby when the said line is in use for conversation a metallic circuit through the telephones of any desired station may be constituted, the signaling-extension being disconnected.

2. A multiple-station metallic telephone and signal circuit comprising, substantially as hereinbefore described, two main leads or wires extending from a central station to the several sub-stations, a normally-open branch circuit at each sub-station including telephones, the branches at the several sub-stations being in multiple arc with each other, a normally-closed signaling-extension wire connecting permanently with one of the said main leads at the sub-station nearest to the central station and extending therefrom to a permanent connection with the return-conductor at the most distant sub-station, signal sending and receiving appliances at each sub-station, all connected in series in the circuit of said signaling-extension, and circuit-changing devices at each sub-station actuated automatically by the removal from its support

of the receiving-telephone at a given station to close the telephone branch there, and thus constitute a metallic talking-circuit, and to open the signaling-circuit and to restore the normal conditions by the replacement of said telephone.

3. The combination, substantially as hereinbefore described, of a central telephone-station, a series of sub-stations, a metallic circuit extending from the said central to the said sub stations, and provided at each with a normally-open loop-line, and telephones and a circuit-changer included therein, the several loops being in multiple arc with each other, a third or extension main wire permanently united with one of the metallic-circuit main wires at the sub-station nearest to the central station and extending outward therefrom through all of the stations to a connection with the return-conductor at the last station, signaling apparatus and a circuit-changer at each sub-station, all included serially in the said extension-wire, which is normally closed, and devices actuated automatically by the removal and replacement of the receiving-telephone at a given station from or in its support to open the said signaling-circuit and close the telephone metallic circuit at said station, or vice versa, whereby a metallic circuit may be used in common by a number of stations, each having a clear line, and each being secured from being interrupted by the others.

4. The combination, substantially as hereinbefore described, of a metallic telephone and signaling circuit extending between a series of telephone-stations and provided with signaling or calling appliances at each of the said sub-stations, all in series with each other, the said circuit being normally closed when at rest through the said signaling devices, whereby any station is enabled to directly call any other station, telephones at the several stations, each set being included in a normally-open multiple-arc branch extending between the two wires of the main circuit, and means, substantially as indicated herein, for automatically closing at any station the said telephone branches and for opening the circuit through the signaling apparatus, whereby a metallic talking-circuit free from intermediate electro magnets is constituted, and whereby it is made impossible for other stations on the same circuit to interrupt conversation by the transmission of call-signals.

5. In a telephone-circuit, two main lines, each forming one side of a metallic circuit and both extending from a central to a series of sub stations, a third or extension line normally closed, but capable of being broken at each station through the operation of the automatic telephone-supporting switch, the said third line including serially in its circuit the calling appliances of all stations and being arranged to unite one of the said main lines at the first station with the other main line at the last station, and a direct bridge or branch line at each station, each including the telephones of its own station and normally open, but adapted to be closed by the removal of the receiving-telephone, and thereupon to unite the two main wires together at the same station, the telephones of the said station being introduced into the metallic talking-circuit thus formed, substantially as and for the purposes described.

6. In a telephone system, a metallic circuit extending from a central station to and through a group of sub-stations, the two wires thereof being when at rest disconnected from each other at each of the said sub-stations, but adapted to be connected with each other through the station-telephones by the removal of the receiving-telephone from its resting position for the purpose of establishing a metallic talking-circuit having no interposed electro-magnets, combined with a calling or signaling extension-wire by means of which the main circuit is closed when at rest through the calling appliances of all the stations in series, which extension is adapted to be simultaneously broken for the purpose of preventing interrupting signals during conversation, also by the removal of the telephone from its support, the normal conditions being re-established by the replacement of said telephone.

7. The combination, in a telephone system, of a central station, a switch-board with spring-jacks located thereat, each spring jack having a movable spring-contact and a metallic frame-piece insulated therefrom, a metallic or two-wire circuit extending from the said central station to a series of distant sub-stations, one of the wires thereof being united to the said contact-spring and the other to said frame, an extension-line permanently connected at the sub-station nearest to the said central station with that one of the main lines which is at the central station united to said movable contact-spring and passing through the magnets of the calling appliances at each of the sub-stations successively to a permanent connection at the most distant sub-station with the main wire leading from the frame of the central-station spring-jack, a normally-open cross-wire at each station, including the telephones, adapted to be closed during conversation and when closed to unite the two main lines through the said telephones, and automatically-operated devices to effect the said closure and simultaneously to open the signaling-extension, substantially as described, and for the purposes specified.

8. The combination of a series of telephone-stations, a metallic or double-wire circuit connecting the said stations, telephones at each station, a bridge-wire or loop-line at each station in circuit with the said telephones, connected at its ends with the two main lines, respectively, and forming the local telephone-circuit of its own station, all of the said loop-lines being normally discontinuous, signal sending and receiving apparatus at

each station, an extension main line including in its circuit the signaling appliances of all of the stations serially and connecting at one of its ends with one of the main lines and at its other end with the other main line and normally closing the circuit of said main lines through the said signaling appliances, and means, as indicated, whereby the use of the telephone at any station is adapted to automatically close the metallic main-line circuit through the telephones at such station and simultaneously open the signaling-circuit of all stations, substantially as described.

9. A metallic telephone-circuit connecting a plurality of sub-stations, having the telephones at the several stations connected in loops—one at each station—of the two wires of the metallic circuit, and having the signaling-instruments of the several stations all connected in series in a third wire normally uniting the two main wires, the said telephone-loops being all normally open or discontinuous, and the said signaling-instrument-uniting wire being normally in closed circuit with the two main wires, and automatic switching devices adapted to open the circuit of said uniting signal-instrument wire when the telephone-loop at any station is closed for conversation.

10. A metallic telephone-circuit having a plurality of sub-stations, the telephones at the several stations being connected in multiple-arc branches between the two main wires, and the signaling appliances of the several stations being all in series in the said circuit.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 25th day of May, 1889.

JOHN N. CULBERTSON.

Witnesses:
H. C. PALMER,
H. C. ALDRICH.