No. 839,095. PATENTED DEC. 25, 1906.

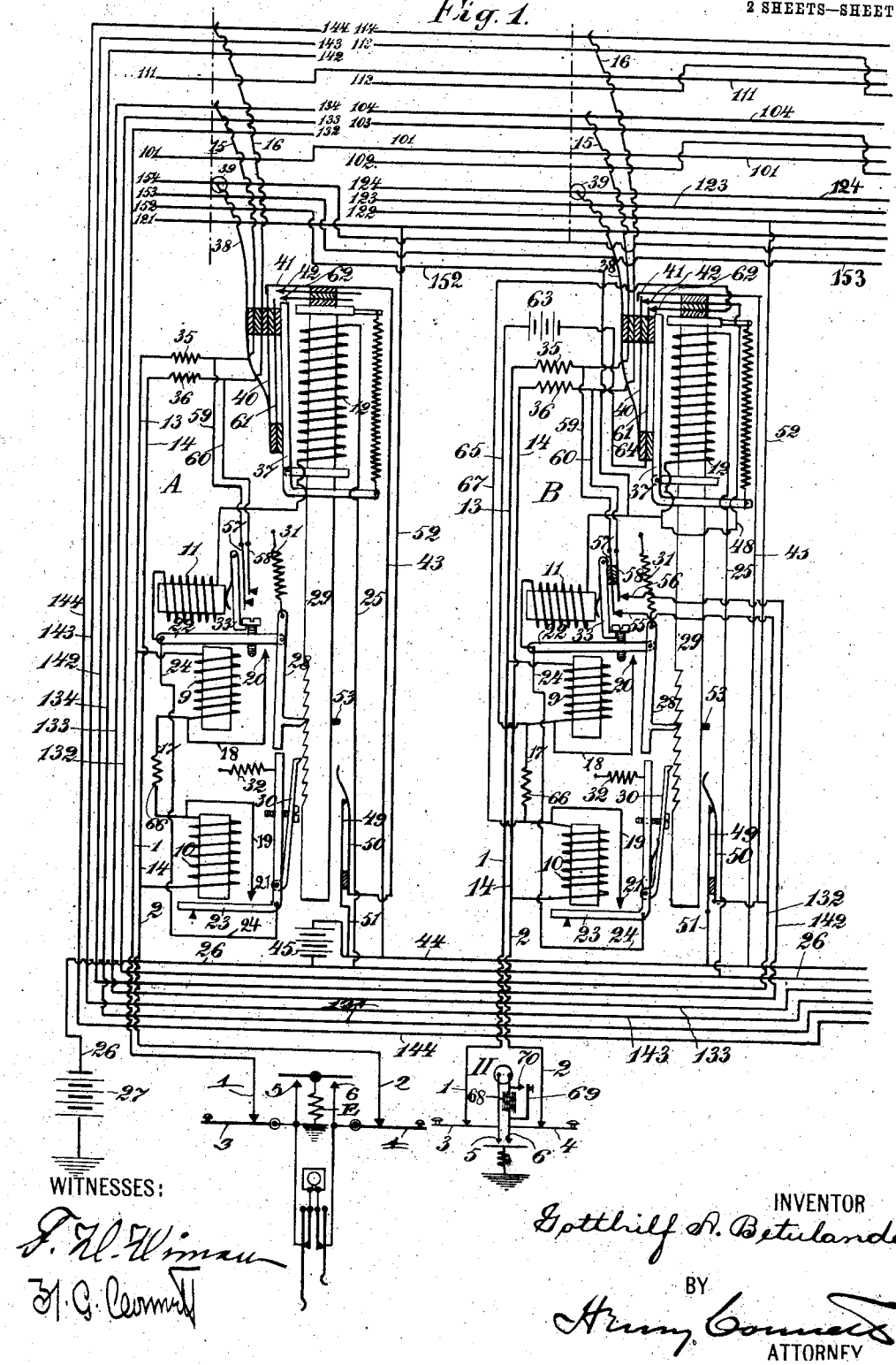
G. A. BETULANDER

AUTOMATIC TELEPHONE EXCHANGE FOR DOUBLE WIRE TELEPHONE SYSTEMS.

APPLICATION FILED MAR. 9, 1903.

2 SHEETS—SHEET 1.

Fig. 1.



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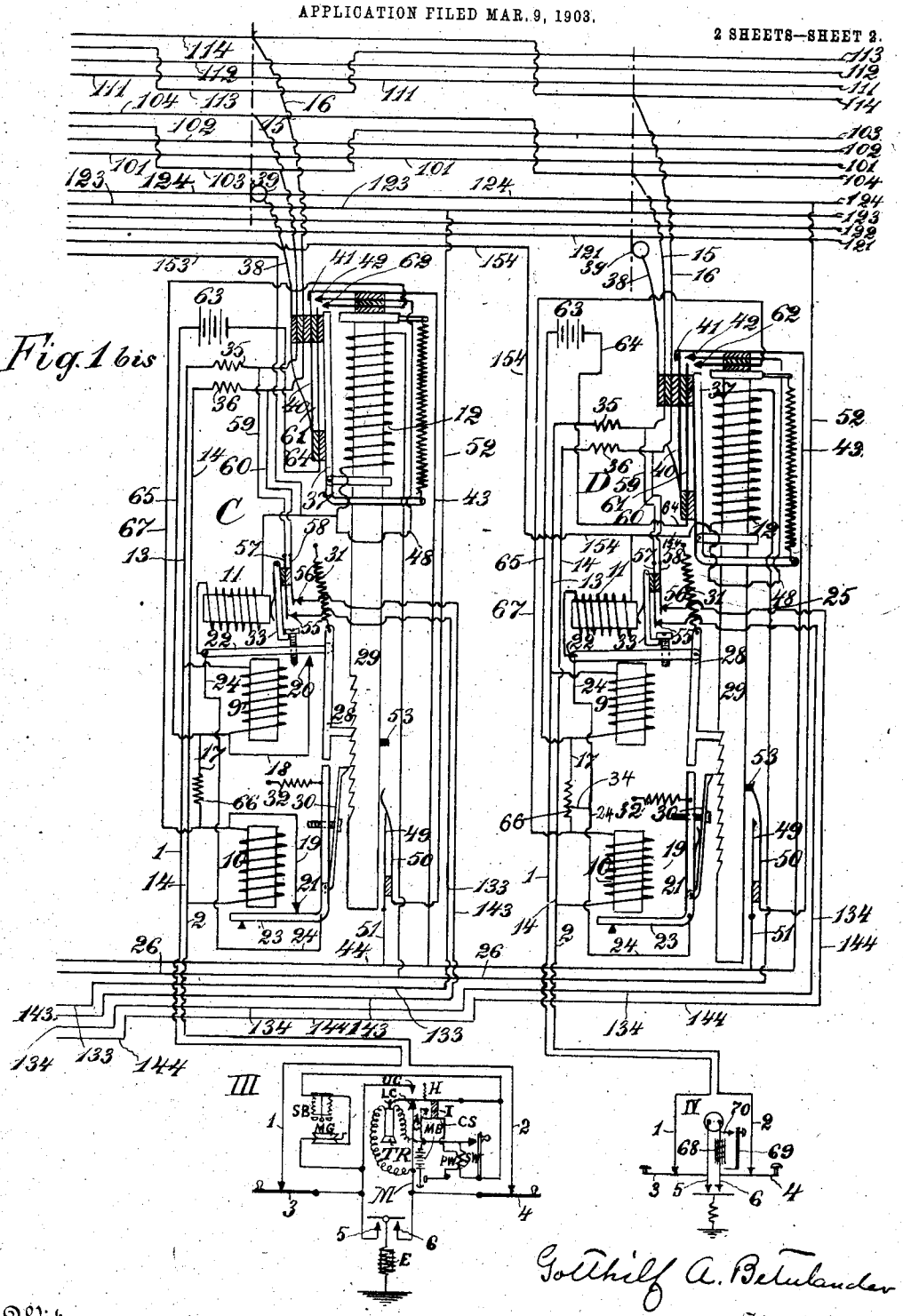
2 SHEETS—SHEET 2.

Fig. 1 bis



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UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE-EXCHANGE FOR DOUBLE-WIRE TELEPHONE SYSTEMS.

No. 839,095. Specification of Letters Patent. Patented Dec. 25, 1906.

Application filed March 9, 1903. Serial No. 146,804.

To all whom it may concern:

Be it known that I, GOTTHILF ANSGARIUS BETULANDER, a subject of the King of Sweden, and a resident of Stockholm, in the Kingdom of Sweden, have invented certain new and useful Improvements in Automatic Telephone-Exchanges for Double-Wire Telephone Systems, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to automatic telephone-exchanges for double-wire telephone systems of that kind where an earth connection is employed at the exchange during all the time used in automatically establishing telephonic communication between telephone-stations in the same or different communities and where a common battery placed at the automatic telephone-exchange supplies the current for establishing the desired connections. As is usual in such telephone systems, the arrangement comprises a connecting apparatus placed at the automatic telephone-exchange and a controlling apparatus placed at the substation. The connections are such that the desired connection of one substation with any other is performed by successive interruptions or breaks in one line branch and the disconnection by one interruption or break in the other line branch.

The drawings Figure 1 and Fig. 1bis show a diagram of an automatic telephone-exchange system arranged according to this invention.

The diagrams Figs. 1 and 1bis comprise four telephone apparatus I, II, III, and IV, each connected by double wires with a connecting apparatus A, B, C, and D, respectively, at the telephone-exchange. The arrangement is such that at every substation each line branch 1 and 2 before entering the telephone apparatus includes a switch or circuit-breaker 3 4, contacts 5 6 being provided for connecting the said switches with the earth when required. One switch 3, hereinafter called the "connecting-switch," is used for establishing the desired connections and the other switch 4, hereinafter called the "disconnecting-switch," for disconnection. One of the earth-contacts 5 and 6 may be dispensed with, in which case the corresponding line branch is connected with the earth through the telephone apparatus or through a conductor forming a short circuit about the said apparatus. Preferably automatic controlling apparatus are used at the substations, said apparatus being constructed and arranged in such a manner that in order to establish a desired connection the controlling apparatus first closes one of the earth contacts 5 and 6 at the substation, then alternately breaks and makes the connecting-switch, and, finally, breaks the earth contacts 5 6 before the last closing of the said switch. The telephone apparatus is then connected with the desired substation. In disconnecting, the controlling apparatus at the substation first closes one of the earth contacts 5 6, then breaks the disconnecting-switch 4, then breaks the earth contacts 5 6, and, finally, closes the disconnecting-switch 4. The specific form of automatic controlling apparatus preferred is not essential and does not form any subject of the present invention, and the switches and earth contacts are therefore shown merely diagrammatically.

The arrangement at the substation may be as follows: Normally (*i. e.*, when the telephone-receiver TR is hanging upon its hook H) the following parts are bridged between the line branches 1 and 2, switch 3, magneto-generator MG, signal-bell SB, switch-hook H, lower contact-anvil LC, and switch 4. The secondary winding SW of the induction-coil and the telephone-receiver TR are connected in parallel with hook H and short-circuited through same. The primary circuit, comprising the microphone-battery MB, the microphone M, the primary winding PW of the induction-coil, the contact-spring CS, and the contact C′, is now broken, since the insulating-piece I at the hook H keeps the contact-spring CS pressed down. When, however, the telephone-receiver is removed from its switch-hook, the latter is pressed by its spring against the upper contact UC, by which the magneto-generator MG and the signal-bell SB are short-circuited through the hook H, whereas the secondary winding SW of the induction-coil and the telephone-receiver TR are bridged between the line branches 1 and 2. At the same time the primary circuit is closed through the contact-spring CS and contact-piece C′. The described arrangement at the substation is not essential, as it will be understood that it can be modified in various ways without departing from the spirit and scope of this invention.

The connecting apparatus connected with the subscriber's telephone apparatus com-

prises a connecting-electromagnet 9, a disconnecting-electromagnet 10, a locking-electromagnet 11, whose armature 33 normally prevents the armature 22 of the connecting-electromagnet from being attracted by the latter, and a cut-out electromagnet 12, serving to prevent the connecting-springs during the connection operation from making contact with connecting-wires leading to the connecting apparatus of subscribers with which no connection is desired. Of the two line branches 1 2 the one, 1, is connected with the connecting-electromagnet 9, as also through a wire 13, with one of the connecting-springs 15, and the other line branch 2 is connected with the disconnecting-electromagnet 10, as also through a wire 14, with the other connecting-spring 16. The windings of the connecting and disconnecting electromagnets are connected together by a wire 17, and each of the said windings is, further, connected by a wire 18 19 with a contact 20 21, as shown in the drawings. The armatures 22 23 of the electromagnets 9 10 are electrically connected togther by a wire 24 and, further, connected through the windings of the locking and cut-out electromagnets 11 12 and wires 25 26 with one pole of the connecting battery 27, the other pole of which is connected with the earth.

The armature 22 of the connecting-electromagnet 9 is provided with a feeding-pawl 28 or the like, engaging the notches of a bar 29 or other movable part carrying the connecting-springs 15 16, connected with the line branches 1 2. The movable part 29 is adapted to slide up and down, but not to be turned. The armature 23 of the disconnecting-electromagnet 10 carries a locking-pawl 30, that when the disconnecting-electromagnet is energized and keeps its armature 23 attracted engages the notches of the movable part 29 to prevent its falling down. When the current ceases to flow through the electromagnets 9 10, the armatures 22 23 are retracted by their springs 31 32 in the positions shown in the drawings.

Suppose the subscriber at substation III wishes to put himself in communication with substation IV. He then closes one of the earth contacts 5 6 at his telephone apparatus III and rotates the armature of the magneto-generator of said apparatus. Both contacts 5 and 6 must not be closed simultaneously, since the current from the magneto-generator would then be short-circuited through the earth contacts, and thus would not energize the electromagnets 9 and 10. It does not matter, however, if contact 5 or contact 6 be closed. If, for instance, contact 5 be closed, the current from battery 27 after the electromagnets 9 10 having been excited by the magneto-generator current and the electromagnet 10 having attracted its armature 23, the armature 22 of the electromagnet 9 being still kept engaged by the armature 33 of the electromagnet 11, flows through the electromagnets 12 and 11 in series, wire 24, armature 23, (which is attracted against its contact 21,) contact 21, and wire 19, from whence it divides, one path being through wire 17, electromagnet 9, line branch 1, and contact 5, the other path being through electromagnet 10, line branch 2, telephone apparatus of the calling subscriber, and contact 5 to earth, and from thence back to battery 27. Interposed between the armature of the contacts 5 and 6 at one side and the earth at the other side is an electromagnet E, that is excited by the battery-current and attracts its armature, which then closes contact 6. In case contact 6 be closed instead of contact 5 the battery-current would flow from battery 27 through electromagnets 12 and 11 in series, wire 24, armature 23, (which is attracted against its contact 21,) contact 21, and wire 19, from whence it divides, one path being through the disconnecting-electromagnet 10, line branch 2, and contact 6, the other path being through wire 17, connecting-electromagnet 9, line branch 1, subscriber's telephone apparatus, and contact 6 to earth and from thence back to battery 27. The electromagnet E when energized by the battery-current attracts its armature and in this instance closes contact 5. It will thus be found that only one (5 or 6) of the earth contacts is closed by hand, the other one being automatically closed after the magneto-generator crank has been rotated by the current from battery 27. The object of the closing of the other earth contact is merely to short-circuit the magneto-generator current through earth immediately after the contact 21 has been closed, the only purpose of the magneto-generator current being to close the said contact 21, so that the movable part 29 cannot be unintentionally fed forward by the magneto-generator current, alternately increasing and decreasing the current from battery 27 through the connecting-electromagnet 9. The rotating of the armature of the magneto-generator at a substation after one of the earth contacts 5 6 has been closed causes an alternating current to pass through the telephone apparatus III, one line branch 1, electromagnet 9, wire 17, electromagnet 10, and the other line branch 2 back to the telephone apparatus. The electromagnet 10 then attracts its armature 23, thereby establishing the following circuit: earth, battery 27, wire 26, wire 25 of connecting apparatus C, electromagnets 12 and 11 in series, wire 24, armature 23, contact 21, wire 19, from which the circuit divides into two branches, one comprising the wire 17, electromagnet 9, line branch 1, switch 3, contact 5, and earth, the other comprising the electromagnet 10, line 2, switch 4, contact 6, and earth. The electro-

magnet 11 being energized attracts its armature 33, thus releasing the armature 22, which is now attracted by its electromagnet 9. The current from battery 27 then after having passed the electromagnet 11 divides in two branches, one comprising the armature 22, contact 20, wire 18, electromagnet 9, line 1, and earth, the other comprising the armature 23, contact 21, wire 19, electromagnet 10, line 2, and earth, the electromagnets 9 and 10 thus continuing holding their armatures in attracted positions. On account of the electromagnets 9 10 having attracted their armatures the feeding-pawl 28 has passed the uppermost tooth of the bar 29 and entered into the notch beneath the said tooth, while the pawl 30 engages and aids in keeping the bar 29 in position. The lower end of the feeding-pawl has now passed the upper end of the armature 23, whose upper end has entered between the bar 29 and the feeding-pawl. If the connecting-switch 3 at substation III is now broken, the current from battery 27 ceases to flow through the electromagnet 9, and the armature 22 with its feeding-pawl 28 are retracted by the spring 31, the tension of which is so adjusted that the pawl 28 raises the bar 29 a distance corresponding to the length of a tooth which is equal to the distance between the connecting-wires. When the bar 29 is raised, the end of the pawl 30 slips over a tooth at the bar and enters the notch nearest below that tooth, thus holding the bar in its raised position in case the connecting-switch 3 should again close the circuit through the electromagnet 9.

It follows from the preceding that if it be desired to raise the bar 29 say four teeth four interruptions are to be made with the switch 3, the earth contacts 5 6 being broken before the switch 3 is allowed to return and make contact after the fourth interruption. On account of the break at the earth contacts 5 6 the battery 27 ceases to supply current to the electromagnets and the armature 23, with its pawl 30, is retracted by the spring 32, so that the pawl 30 is brought out of engagement with the bar 29, which is now kept in its raised position only by the pawl 28.

When it is desired, after the conversation has been finished, to restore the connecting apparatus to its normal or resting position, this is performed by closing one of the earth contacts 5 6, rotating the magneto-generator MG, breaking the disconnecting-switch 4, breaking the earth contacts 5 and 6, and allowing the disconnecting-switch to return in its closing position. By closing one of the contacts at 5 6 and rotating the magneto-generator of the telephone apparatus the electromagnets 9 and 10 are caused, as before described, to attract their armatures 22 23, respectively, and the lower end of the pawl 28 then, as before, passes the upper end of the armature 23. By breaking the switch 4 an interruption is made in that branch of the circuit of battery 27 comprising the electromagnet 10, and the armature 23 is thus retracted by its spring 32; but as the upper end of the armature 23 projects between the bar 29 and the pawl 28 the latter is caused to follow, so that the said pawl is withdrawn from engagement with the bar, which is brought back by its own weight or by any other force into its normal position. Before the switch 4 is allowed to return and make contact the contacts 5 6 are broken, whereby the branch of the circuit of battery 27, comprising the electromagnet 9, is also broken. The armature 22 is then retracted by its spring 31 and pulls the pawl 28 upward, and when the upper end of the armature 23 releases the end of pawl 28 the latter enters into and engages the uppermost notch in the bar 29.

The described arrangements can be modified by connecting the battery 27 through the electromagnets 12 and 11 directly with the electromagnets 9 and 10. This modification of the connection is shown at the connecting apparatus D, where the wires 18 and 19 and the contacts 20 and 21 have been substituted by a wire 34, connecting wire 24 with wire 17. In this case the subscriber at substation IV for establishing a desired connection or for disconnecting need not send current from the magneto-generator through the line, because when one of the contacts 5 6 is closed a circuit for the battery 27 is established through the earth, battery 27, wires 26 and 25, electromagnets 12 and 11 in series, wire 24, wire 34, wire 17, and in parallel through the electromagnets 9 and 10 and the line branches 1 and 2 back to the earth.

If the battery 27 is not permanently connected with the electromagnets 9 and 10, arrangements should be provided to enable any subscriber to break his connection with another subscriber in case the lines of the latter have accidentally been short-circuited. To this end resistances 35 36 are interposed in the conductors between the subscribers, suitably in the conductors 13 and 14, leading to the connecting-springs 15 and 16, said resistances allowing a sufficiently strong current to pass from the magneto-generator at the subscriber's telephone apparatus through the electromagnets 9 and 10 also when the lines of the subscriber with which connection has been made are short-circuited. If the battery 27 is permanently connected through the wire 17 with the electromagnets 9 and 10, the resistances 35 and 36 are obviously superfluous.

By interposing between the battery 27 and the electromagnets 9 10 a third electromagnet 11 the armature 33 of which when in position of repose locks the armature 22 of the electromagnet 9 the armature 22, with the feeding-pawl 28, is prevented from being

actuated when the subscriber, after having established the desired connection, rotates the magneto-generator of his telephone apparatus to produce a calling-signal. On this occasion the contacts 5 6 are open, so that although the armature 23 is attracted by its electromagnet 10 and the contact 21 is closed the circuit of the battery 27 remains open.

The electromagnet 12, interposed between the battery 27 and the locking electromagnet 11, has for its purpose to prevent the contact-springs 15 16, during the operation of establishing the desired connection, from making contact with the wires over which the springs have to pass before they reach the wire of the desired subscriber. To this end the electromagnet 12 is placed at the upper end of the bar 29 and provided with an armature 37, carrying the insulated contact-springs 15 16. As the raising of the bar 29 can take place only during the time the armature 33 of the locking-electromagnet 11 is attracted, and as the current from battery 27 through the electromagnet 11 has to first pass the cut-out electromagnet 12, it is obvious that on account of the attraction of the armature 37 by its electromagnet 12 the contact-springs 15 16 are kept away from the wires 101 102 103, &c., and 111 112 113, &c., respectively, when passing the said wires. Further, inasmuch as the contacts 5 6 at the telephone apparatus are kept closed, and thus the electromagnet 12 is supplied with current from the battery 27 only during the time necessary to establish the desired connection, the contact-springs 15 16 are kept in elevated positions only while being brought opposite the contact-wires of the desired subscriber, after which they are allowed to make contact with these wires.

The connecting apparatus is, further, arranged in such a manner that while a conversation between two subscribers takes place any third subscriber is debarred from disturbing or overhearing the conversation. For this purpose an insulated spring 38 is attached to the armature 37 of the electromagnet 12, said spring having such a position as to make contact with one after the other of a number of wires 121 122 123, &c., each belonging to one of the connecting apparatus A B C D, &c. The spring 38 can suitably be provided at its free end with a small wheel 39, rolling during the rising of the bar 29 on the wires 121 122 123, &c. It should be observed that as soon as the bar 29 has been raised from its position of repose the spring 38 is always in contact with one of the wires 121 122 123, &c., (thus also during the connection operation when the armature 37 is attracted by its electromagnet.) The spring 38 has an extension 40, that is in contact with one or the other of two contacts 41 42, according as the armature 37 is at rest or attracted, one of said contacts 41 being connected by the wires 43 and 44 with one pole of a battery 45, whose other pole is connected through the wires 26 and 25, electromagnet 12, and wire 48 with the other contact 42. Placed upon the connecting apparatus are, further, two springs 49 50, one of which, 49, is connected through wires 51 and 44 with the battery 45 and the other, 50, through a wire 52 with one of the wires 121 122 123, &c. The bar 29 further carries a knob 53 or the like, of insulating material, said knob having such a position that when the bar 29 takes up its lowest position (see apparatus D) the springs 49 50 are kept apart by the knob 53, whereas when the bar 29 is raised the knob 53 leaves the spring 50 and allows the latter to make contact with the spring 49.

In order to be clearly understood in what manner a third subscriber is debarred from disturbing or overhearing a conversation between two other subscribers, it may be supposed, as before, that the subscriber at substation III has put himself in connection with substation IV. The metallic circuit established between the substations III and IV is then formed by the telephone apparatus III, switch 3, line 1, wire 13, spring 15, wire 104, spring 15 at the apparatus D, wire 13, line 1, switch 3, telephone apparatus IV, switch 4, line 2, wire 14, spring 16, wire 114, spring 16 of the apparatus C, wire 14, line 2, and switch 4 back to the telephone apparatus III. Now suppose the subscriber at substation II desires to put himself in communication with substation IV. During the raising of the bar 29 of the apparatus B the electromagnet 12 keeps its armature 37 attracted, so that the extension 40 of spring 38 bears upon the contact 42, as shown at B. When the bar 29 has reached its desired position, the armature 37 at the apparatus II, in case the apparatus IV were not busied, would be released by the electromagnet and return to its normal position, whereby the springs 15 and 16 would come in contact with their contact-wires 104 and 114, respectively. Now this is not the case, because a circuit is closed for the battery 45 through wire 26, wire 25 at the apparatus B, electromagnet 12, wire 48, contact 42, spring 40 38, contact-wheel 39, wire 124, contact-wheel 39 at the apparatus C, spring 38 40, contact 41, and wires 43 and 44 to the other pole of the battery 45. The electromagnet 12 of the apparatus B is, therefore, still supplied with current, but now from battery 45, which supplies the electromagnet with current in the same direction as before from the battery 27. The subscriber at substation II cannot, therefore, disturb the conversation between the subscribers at substations III and IV by an attempt to put himself in communication with substation IV. If, on the other hand, he tries to put himself in communication with substation III, a circuit is closed from battery 45

through wire 26, wire 25 at the apparatus B, electromagnet 12, wire 48, contact 42, spring 40 38, contact-wheel 39, wire 123, wire 52 at the apparatus C, springs 50 and 49, and wire 44 back to the battery 45. It will thus be found that the apparatus C that has established the metallic connection between the substations III and IV connects that pole of the battery 45 which is not connected with the electromagnet 12 partly through wires 44 and 43, contact 41, and spring 40 38 with a cut-out wire 124, entering the connecting apparatus D of the desired substation IV, and partly through wire 44, wire 51, springs 49 50, and wire 52 with the cut-out wire 123 of the connecting apparatus that establishes the connection, thus preventing all other subscribers from connecting themselves with any of the two substations III and IV connected together for conversation. Further arrangements are provided to enable the operator at the long-line station I or the connecting apparatus A of the long line to interrupt local conversations within the range of the automatic exchange and to connect itself with any of the substations either busied or not. For this purpose the connecting-wires 102 103 104, &c., and 112 113 114, &c., do not enter the connecting apparatus A, but are there substituted by other wires 132 133 134, &c., and 142 143 144, &c., respectively, two of these wires 132 and 142, one of each series, being connected with contacts 55 and 56, respectively, at the connecting apparatus B, two other wires 133 and 143, one of each series, with contacts 55 and 56, respectively, at the connecting apparatus C, and so on. Each pair of contacts 55 56 is connected, through springs 57 58, wires 59 60, and wires 13 and 14, with the lines 1 and 2 of the corresponding substation. Also the cut-out wires 122 123, &c., do not enter the connecting apparatus A of the long-distance line, but are substituted at this apparatus by wires 152 153, &c., each connected in such a manner with the cut-out electromagnet 12 of one of the other connecting apparatus that the cut-out electromagnet 12 corresponding to the substation with which the long-distance line has been connected is energized by current from the cut-out battery 45. If the substations III and IV are connected together for conversation and the long-distance line is connected by the connecting apparatus A with substation IV, a current will flow from battery 45 through wire 26, wire 25 at the connecting apparatus D, electromagnet 12, wire 154, contact-wheel 39 at the connecting apparatus A, spring 38 40, contact 41, wire 43, and wire 44 back to the cut-out battery 45. The armature 37 of the cut-out electromagnet 12 at the connecting apparatus D will thus be attracted, whereby the metallic circuit between substations III and IV is broken, the springs 15 16 at the connecting apparatus D being lifted away from the wires 104 and 114. A complete metallic circuit is established between substations I and IV through the telephone apparatus I, switch 3, line 1, wire 13, spring 15, wire 134, contact 55 at the connecting apparatus D, contact-spring 57, wire 59, wire 13, line 1, switch 3, telephone apparatus IV, switch 4, line 2, wire 14, wire 60, contact-spring 58, contact 56, wire 144, spring 16 at the connecting apparatus A, wire 14, line 2, and switch 4 back to the telephone apparatus I. At the connecting apparatus A the contact-wheel 39, carried by the spring 38, is not allowed during the connecting operation, while the armature 37 is attracted to make contact with any of the wires 152 153, &c., (in opposition to the case in the other connecting apparatus B C, &c.) Further, each connecting apparatus is arranged in such a manner that while a subscriber operates his connecting apparatus for the purpose of connecting himself with another subscriber the main line connected to the telephone apparatus of the first subscriber is broken, so as not to prevent the continued connection operation of the said subscriber. The break is made at the contact-springs 57 58, attached to the armature 33 of the locking-electromagnet 11 in such a manner as to be moved away during the connection operation from their contacts 55 and 56, respectively. Obviously the break can be made at any other point of the connecting-wires 132 133, &c., and 142 143, &c., of the main apparatus.

In the connecting apparatus B C D, &c., means are further provided to signify a line connected for conversation to be busied. In the form of carrying out the invention illustrated in the drawings the armature 37 of the cut-out electromagnet 12 carries an insulated contact-spring 61, having such a position that, when the armature is attracted, said spring 61 bears upon a contact 62, thereby closing a circuit for a test-battery 63, one pole of which is connected through a wire 64 with the contact-spring 61, while the other pole is connected, through a wire 65, a resistance 66 interposed between the electromagnets 9 and 10, and a wire 67, with the contact 62. When the armature 37 is attracted, a current will thus flow partly through wire 65, resistance 66, wire 67, contact 62, contact-spring 61, and wire 64 back to the battery and partly through wire 65, electromagnet 9, line 1, switch 3, telephone apparatus, switch 4, line 2, electromagnet 10, wire 67, contact 62, spring 61, and wire 64 back to the battery 63. As before stated, the cut-out electromagnet of a connecting apparatus—say B—will still hold its armature 37 attracted after the connecting operation has been performed in case the desired substation is busied. A part of the current from the test-battery 63 will then flow through the telephone-receiver

at substation II. If the shunt-circuit through the telephone apparatus is broken—for instance, at 3 or 4—a click will be heard in the telephone-receiver announcing the desired substation to be busied, or an impedance-coil 68 can be interposed in one line branch 2 between the switch 4 and the telephone apparatus, said coil being connected in parallel with a key 69, coöperating with a contact 70, so that the coil 68 can be short-circuited by depressing the key 69. On account of the varying resistance in the shunt-circuit, due to alternately short-circuiting and cutting in the impedance-coil 68, clicks will be heard in the telephone-receiver when the desired substation is busied.

A great advantage of the arrangements described is that each separate connecting apparatus can be removed as a whole by loosening one or more screws and then be substituted by a new one without interfering with any connections for the other apparatus, due to the fact that the whole system of connecting-wires is completely separate from the connecting apparatus. Further, the arrangement offers the advantage that no more apparatus need be installed at the automatic exchange than to correspond to the number of subscribers, and when this number is increased the number of connecting apparatus is increased accordingly.

It may be explained that the magnets 9 and 10 are constructed, as indicated in the drawings, as ordinary coils or solenoids with an iron core, and their armatures 22 and 23 are of soft iron, whereby they will be attracted when the magnets are energized by either alternating or direct currents.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. A double-wire telephone system with automatic exchange, comprising at the substations two switches 3, 4, one included in each line branch, and contacts 5, 6 for grounding the line branches through the said switches and further comprising two electromagnets 9, 10 interposed in series between the line branches, a battery 27 supplying current for establishing the desired connections, one pole of said battery being grounded, the other connectible with the adjacent ends of the electromagnets 9, 10, means through which such connection may be made, armatures 22 and 23 actuated by the electromagnets, a feeding-pawl 28 attached to the armature 22 of one electromagnet (called the connecting-electromagnet), a movable part 29 engaged by the feeding-pawl 28 in such a manner that, when the connecting-electromagnet 9 is deprived of current and its armature 22 is retracted, the said movable part 29 is fed forward, connecting-springs 15, 16 carried by the said movable part, each spring being connected with one line branch of the corresponding substation, connecting-wires corresponding to the different substations, and a pawl 30 attached to the armature 23 of the other electromagnet (called the disconnecting-electromagnet) in such a manner that, when the said electromagnet 10 is supplied with current and its armature 23 is attracted, said pawl engages the movable part 29 to prevent it from return movement, substantially as described.

2. A double-wire telephone system with automatic exchange, comprising at the substations two switches 3, 4, one included in each line branch, and contacts 5, 6 for grounding the line branches through the said switches, and further comprising two electromagnets 9, 10 interposed in series between the line branches, a battery 27 supplying current for establishing the desired connections, one pole of said battery being grounded, the other connectible with the adjacent ends of the electromagnets 9 and 10, means through which such connection may be made, armatures 22 23 actuated by the electromagnets, a feeding-pawl 28 attached to the armature 22 of one electromagnet (the connecting-electromagnet,) a movable part 29 engaged by the feeding-pawl 28 in such a manner that, when the connecting-electromagnet 9 is deprived of current and its armature 22 is retracted, the said movable part is fed forward into its successive positions to establish the desired connection, connecting-springs 15, 16 carried by the said movable part, each spring being connected with one line branch of the corresponding substation, connecting-wires corresponding to the different substations, a pawl 30 attached to the armature 23 of the other electromagnet (the disconnecting-electromagnet) in such a manner that, when the said electromagnet 10 is supplied with current and its armature 23 is attracted, said pawl engages the movable part 29 to prevent it from return movement, and resistances 35, 36 interposed in the conductors 13, 14 between the substations, substantially as described.

3. A double-wire telephone system with automatic exchange, comprising at the substations two switches 3, 4, one included in each line branch, and contacts 5, 6 for grounding the line branches through the said switches, and further comprising two electromagnets 9, 10 interposed in series between the line branches, one of said magnets 9 serving to establish the desired connections and the other 10 for disconnection, a battery 27 one pole of which is grounded, the other connectible with the adjacent ends of the electromagnets 9, 10, means through which such connection may be made, armatures 22 and 23 actuated by the electromagnets, a movable part 29 adapted to be fed forward in successive positions by the armature 22 of the connecting-electromagnet 9 whenever the latter is deprived of current and its armature

is retracted, connecting-springs 15, 16 carried by the said movable part, each spring being connected with one line branch of the corresponding substation, connecting-wires corresponding to the different substations, means controlled by the armature 23 of the disconnecting-electromagnet 10 to prevent the movable part 29 from return movement during the connection operation, and a locking-electromagnet 11 interposed between the battery 27 at one side and the connecting and disconnecting electromagnets at the other side, the armature 33 of the locking-electromagnet being arranged to normally lock the armature 22 of the connecting-electromagnet 9 in position until the said locking-electromagnet is supplied with current, substantially as described.

4. A double-wire telephone system with automatic exchange, comprising at the substations two switches 3, 4, one included in each line branch, and contacts 5, 6, for grounding the line branches through the said switches, and further comprising two electromagnets 9, 10 interposed in series between the line branches, one of said magnets 9 serving to establish the desired connections and the other 10 for disconnection, a battery 27 one pole of which is grounded, the other connectible with the adjacent ends of the electromagnets 9 and 10, means through which such connection may be made, armatures 22 and 23 actuated by the electromagnets, a movable part 29 adapted to be fed forward in successive positions by the armature 22 of the connecting-electromagnet 9 whenever the latter is deprived of current and its armature is retracted, means controlled by the armature 23 of the disconnecting-electromagnet 10 to prevent the movable part 29 from return movement during the connection operation, a locking-electromagnet 11 interposed between the battery 27 at one side and the connecting and disconnecting electromagnets 9 and 10 at the other side, the armature 33 of the locking-electromagnet being arranged to normally lock the armature 22 of the connecting-electromagnet 9 until the said locking-electromagnet is supplied with current, a cut-out electromagnet 12 interposed between the battery 27 and the locking-electromagnet 11, said cut-out electromagnet being carried by the movable part 29, connecting-springs 15, 16 carried by the armature 37 of the said cut-out electromagnet 12, each spring being connected with one line branch of the corresponding substation, and connecting-wires corresponding to the different substations, substantially as described.

5. A double-wire telephone system with automatic exchange, comprising at the substation two switches 3, 4, one included in each line branch, and contacts 5, 6 for grounding the line branches through the said switches, and further comprising two electromagnets 9, 10 interposed in series between the line branches, one of said magnets 9 serving to establish the desired connection and the other 10 for disconnection, a battery 27 one pole of which is grounded, the other connectible with the adjacent ends of the electromagnets 9 and 10, means through which such connection may be made, armatures 22 and 23 actuated by the electromagnets, a movable part 29 adapted to be fed forward in successive positions by the armature 22 of the connecting-electromagnet 9 whenever the latter is deprived of current and its armature is retracted, means controlled by the armature 23 of the disconnecting-electromagnet 10 to prevent the movable part 29 from return movement during the connection operation, a locking-electromagnet 11 interposed between the battery 27 at one side and the connecting and disconnecting electromagnets 9 and 10 at the other side, the armature 33 of the locking-electromagnet being arranged to normally lock the armature 22 of the connecting-electromagnet 9 until the said locking-electromagnet is supplied with current, a cut-out electromagnet 12 interposed between the battery 27 and the locking-electromagnet 11, said cut-out electromagnet being carried by the movable part 29, connecting-springs 15, 16 carried by the armature 37 of the said cut-out electromagnet 12, each spring being connected with one line branch of the corresponding substation, connecting-wires corresponding to the different substations, cut-out wires 121, 122, 123 &c. extending along the different connecting apparatus, a cut-out spring 38, 40 traveling over one after the other of the said cut-out wires, said spring being attached to the armature 37 of the cut-out electromagnet 12, contacts 41, 42 arranged in proximity to the cut-out spring 38, 40 in such a manner that the said spring is caused to make contact with one or the other of the said contacts 41, 42 according as the armature 37 of the cut-out electromagnet is attracted, or not, one contact (the reposing contact 41) being connected with one pole of a cut-out battery 45 while the other contact (the working contact 42) is connected through the cut-out electromagnet with the other pole of the said battery 45, cut-out springs 49, 50, one 49 connected with the first pole of the cut-out battery 45 and the other 50 connected with the cut-out wire of the corresponding connecting apparatus, and means for keeping the said cut-out springs 49, 50 apart until the connecting apparatus is put in action, substantially as described.

6. A double-wire telephone system with automatic exchange, comprising at the substations two switches 3, 4, one included in each line branch, and contacts 5, 6 for grounding the line branches through the said switches, and further comprising two electro-

magnets 9, 10 interposed in series between the line branches, one of said magnets 9 serving to establish the desired connections and the other 10 for disconnection, a battery 27 one pole of which is grounded, the other connectible with the adjacent ends of the electromagnets 9 and 10, means through which such connection may be made, armatures 22 and 23 actuated by the electromagnets, a movable part 29 adapted to be fed forward in successive positions by the armature 22 of the connecting-electromagnet 9 whenever the latter is deprived of current and its armature is retracted, means controlled by the armature 23 of the disconnecting-electromagnet 10 to prevent the movable part 29 from return movement during the connection operation, a locking-electromagnet 11 interposed between the battery 27 at one side and the connecting and disconnecting electromagnets 9 and 10 at the other side, the armature 33 of the locking-electromagnet being arranged to normally lock the armature 22 of the connecting-electromagnet 9 until the said locking-electromagnet is supplied with current, a cut-out electromagnet 12 interposed between the battery 27 and the locking-electromagnet 11, said cut-out electromagnet being carried by the movable part 29, connecting-springs 15, 16 carried by the armature 37 of the said cut-out electromagnet 12, each spring being connected with one line branch of the corresponding substation, connecting-wires corresponding to the different substations, cut-out wires 121, 122, 123 &c. extending along the different connecting apparatus, a cut-out spring 38, 40 traveling over one after the other of the said cut-out wires, said spring being attached to the armature 37 of the cut-out electromagnet 12, contacts 41, 42 arranged in proximity to the cut-out spring 38, 40 in such a manner that the said spring is caused to make contact with one or the other of the said contacts 41, 42 according as the armature 37 of the cut-out electromagnet is attracted, or not, one contact (the reposing contact 41) being connected with one pole of a cut-out battery 45 while the other contact (the working contact 42) is connected through the cut-out electromagnet with the other pole of the said battery 45, cut-out springs 49, 50, one 49 connected with the first pole of the cut-out battery 45 and the other 50 connected with the cut-out wire of the corresponding connecting apparatus, means for keeping the said cut-out springs 49, 50 apart until the connecting apparatus is put in action, and a special connecting apparatus A for a long-distance line, substantially as described.

7. A double-wire telephone system with automatic exchange, comprising at the substations two switches 3, 4, one included in each line branch, and contacts 5, 6 for grounding the line branches through the said switches, and further comprising two electro-

magnets 9, 10 interposed in series between the line branches, one of said magnets 9 serving to establish the desired connections and the other 10 for disconnection, a battery 27 one pole of which is grounded, the other connectible with the adjacent ends of the electromagnets 9 and 10, means through which such connection may be made, armatures 22 and 23 actuated by the electromagnets, a movable part 29 adapted to be fed forward in successive positions by the armature 22 of the connecting-electromagnet 9 whenever the latter is deprived of current and its armature is retracted, means controlled by the armature 23 of the disconnecting-electromagnet 10 to prevent the movable part 29 from return movement during the connection operation, a locking-electromagnet 11 interposed between the battery 27 at one side and the connecting and disconnecting electromagnets 9 and 10 at the other side, the armature 33 of the locking-electromagnet being arranged to normally lock the armature 22 of the connecting-electromagnet 9 until the said locking-electromagnet is supplied with current, a cut-out electromagnet 12 interposed between the battery 27 and the locking-electromagnet 11, said cut-out electromagnet being carried by the movable part 29, connecting-springs 15, 16 carried by the armature 37 of the said cut-out electromagnet 12, each spring being connected with one line branch of the corresponding substation, connecting-wires corresponding to the different substations, cut-out wires 121, 122, 123 &c. extending along the different connecting apparatus, a cut-out spring 38, 40 traveling over one after the other of the said cut-out wires, said spring being attached to the armature 37 of the cut-out electromagnet 12, contacts 41, 42 arranged in proximity to the cut-out spring 38, 40 in such a manner that the said spring is caused to make contact with one or the other of the said contacts 41, 42 according as the armature 37 of the cut-out electromagnet is attracted, or not, one contact (the reposing contact 41) being connected with one pole of a cut-out battery 45 while the other contact (the working contact 42) is connected through the cut-out electromagnet with the other pole of the said battery 45, cut-out springs 49, 50, one 49 connected with the first pole of the cut-out battery 45 and the other 50 connected with the cut-out wire of the corresponding connecting apparatus, means for keeping the said cut-out springs 49, 50 apart until the connecting apparatus is put in action, and the special connecting apparatus A for a long-distance line substantially as described.

8. A double-wire telephone system with automatic exchange, comprising at the substations two switches 3, 4, one included in each line branch, and contacts 5, 6 for grounding the line branches through the

said switches, and further comprising two electromagnets 9, 10 interposed in series between the line branches, one of said magnets 9 serving to establish the desired connections and the other 10 for disconnection, a battery 27 one pole of which is grounded, the other connectible with the adjacent ends of the electromagnets 9 and 10, means through which such connection may be made, armatures 22 and 23 actuated by the electromagnets, a movable part 29 adapted to be fed forward in successive positions by the armature 22 of the connecting-electromagnet 9 whenever the latter is deprived of current and its armature is retracted, means controlled by the armature 23 of the disconnecting-electromagnet 10 to prevent the movable part 29 from return movement during the connection operation, a locking-electromagnet 11 interposed between the battery 27 at one side and the connecting and disconnecting electromagnets 9 and 10 at the other side, the armature 33 of the locking-electromagnet being arranged to normally lock the armature 22 of the connecting-electromagnet 9 until the said locking-electromagnet is supplied with current, a cut-out electromagnet 12 interposed between the battery 27 and the locking-electromagnet 11, said cut-out electromagnet being carried by the movable part 29, connecting-springs 15, 16 carried by the armature 37 of the said cut-out electromagnet 12, each spring being connected with one line branch of the corresponding substation, connecting-wires corresponding to the different substations, and a circuit comprising a test-battery 63, a resistance 66 interposed between the connecting-electromagnet 9 and the disconnecting-electromagnet 10, a stationary contact 62, and a coöperating movable contact 61 carried by the armature 37 of the cut-out electromagnet 12, substantially as described.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

GOTTHILF ANSGARIUS BETULANDER.

Witnesses:

ERNST SVANQVIST,

AUG. SORENSEN.