No. 646,692. Patented Apr. 3, 1900.

W. D. GHARKY.

TELEPHONE EXCHANGE SYSTEM.

(Application filed June 16, 1898.)

(No Model.) 3 Sheets—Sheet 1.

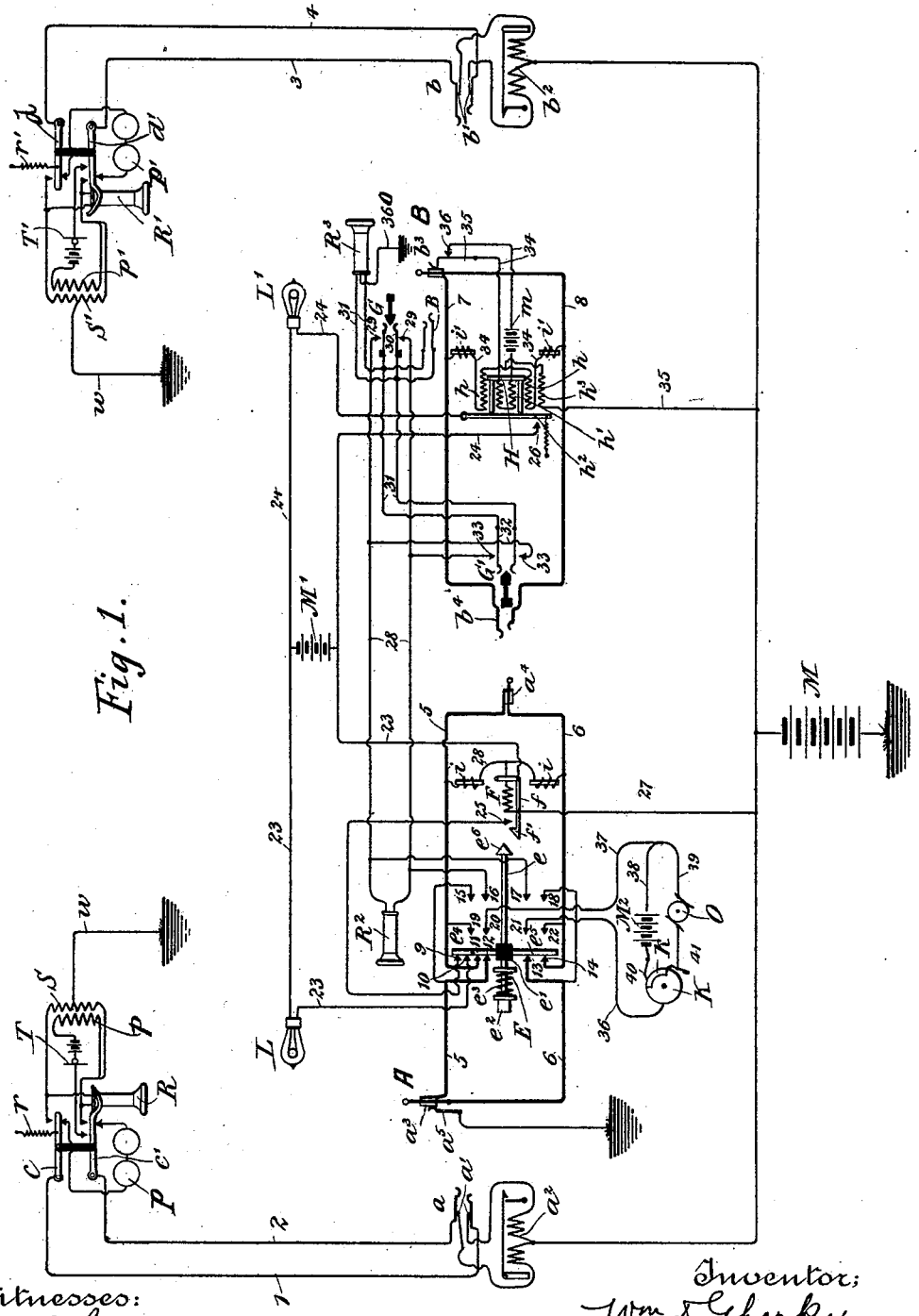

Fig. 1.

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(No Model.) 3 Sheets—Sheet 2.

Fig: 2.

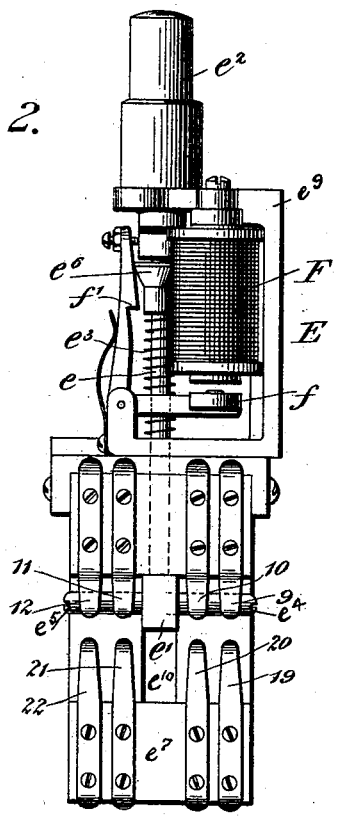


Fig: 3.

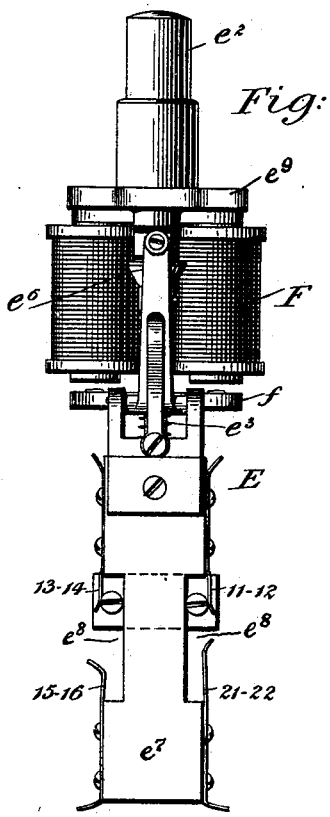


Fig: 4.

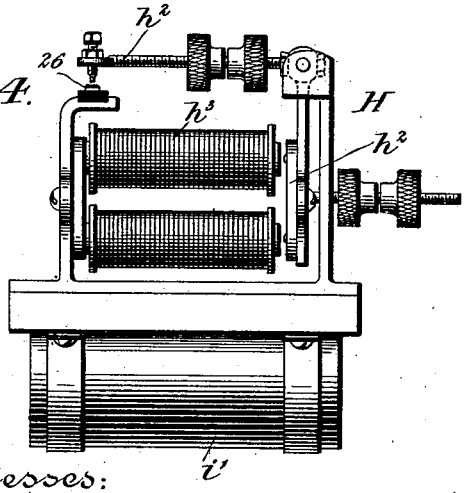
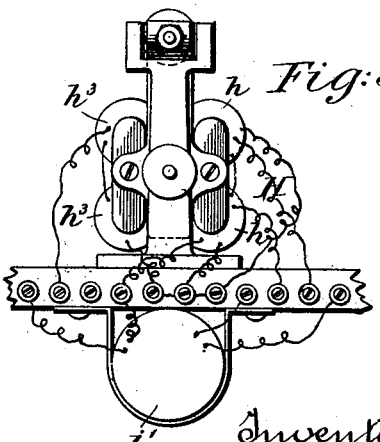


Fig: 5.



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TELEPHONE EXCHANGE SYSTEM.

(Application filed June 16, 1898.)

(No Model.) 3 Sheets—Sheet 3.

Fig: 6.

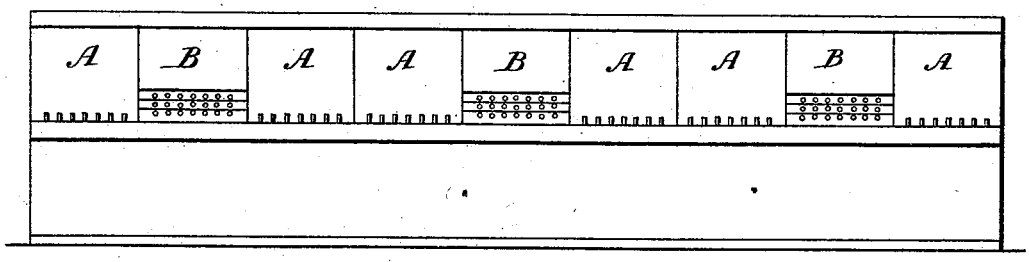
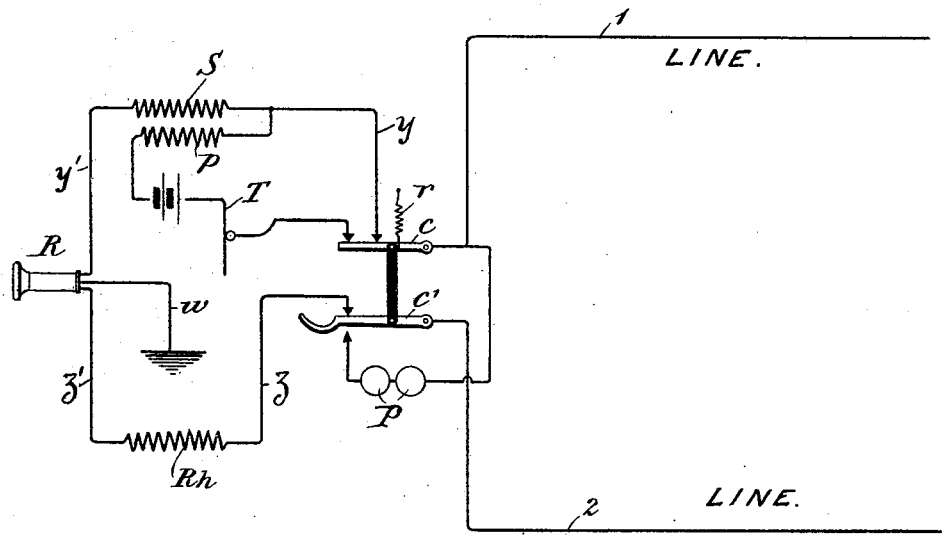


Fig: 7.



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TELEPHONE-EXCHANGE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 646,692, dated April 3, 1900.

Application filed June 16, 1898. Serial No. 683,634. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM D. GHARKY, a citizen of the United States, residing in the city and county of Philadelphia, State of Pennsylvania, have invented certain Improvements in Telephone-Exchange Systems, of which the following is a specification.

My invention relates to the central-office apparatus, some of the subscribers' apparatus, and the circuit connections therebetween, which are employed in what are known as "exchange systems"—*i. e.*, systems of telephone service wherein the subscribers' lines are all handled at one or more central points, through which all interconnection is obtained.

The general problem presented is that of so connecting different telephone subscribers to a common central station or stations that any one of them may signal to the central station that he desires connection with any other, that the operator at the central station may with the least labor answer the signal of the calling subscriber and, having ascertained the number of the subscriber with whom he desires conversation, connect his line with that of the calling subscriber and by the simple act of connection transmit a call forward to the called subscriber, and that upon the termination of the conversation subscribers with the least labor on their part and on the part of the operator may indicate to the central station that they have finished. My solution of this problem involves the use of automatic calling means throughout, both for the subscriber and for the operator, and the provision likewise of "automatic" (so called) supervisory signals. The subscribers' line-terminals at the central station or stations are supposed to be grouped upon a number of separate switchboards or "switchboard-sections," each section containing the line-terminals and also the line-annunciators of a given number of subscribers. Flexible cords terminating in plugs are provided at each switchboard or switchboard-section, which constitute in themselves complete means for the interconnection of subscribers upon that board or section. Inasmuch as each subscriber has a line-terminal upon one section only, further means are provided for interconnecting the sections, so that a subscriber whose line terminates at one section may be connected with another whose line terminates at another section. This means consists of trunk-lines so arranged that they connect each board or section with every other board or section. In considering the operation of my system it is only necessary to take the operation of connecting subscribers on different boards, because the connection of two subscribers on the same board involves the use of part of the same apparatus in a manner that will be obvious from the description.

Each subscriber is provided with a metallic circuit which terminates in movable switch-arms at the subscriber's station and in jack-springs at the central station upon the proper terminal board or section. The arrangement is such that when the subscriber removes his telephone-receiver from the hook a calling-circuit, composed of the line-wires in parallel, is completed through his hook-switch and the annunciator at central, which thereupon displays its signal. The answering operator inserts a plug, which connects the cord-circuit with the line and disconnects the line-annunciator. I provide the cord-circuit with a combination instrument which performs three functions. Upon operation by the operator it breaks the through-cord circuit, connects the listening set to the calling subscriber, and connects a ringing-generator to the plug, which is yet to be inserted in the jack of the subscriber wanted. Having ascertained the number of the subscriber wanted, if on the same board with the calling subscriber the operator simply inserts the forward plug in the desired line-jack. The generator being already connected to that plug, a calling-current immediately passes out upon the line and rings the subscriber's bell. If, however, the subscriber wanted is upon another board, the operator inserts the calling-plug in the terminal jack of a trunk-line leading to the board upon which he is to be found, notifies the operator thereat of the number wanted, and leaves her to complete the connection, the ringing-current, as before, being thrown automatically upon the called-subscriber's line. In any case the ringing-current continues to actuate the bell of the called subscriber until he answers the call by

removing his telephone-receiver from the hook, whereupon means self-contained in the instrument before referred to automatically disconnects the generator from the line and recompletes the through-cord circuit. Supervisory and clearing-out signals are provided which are automatically operated when both subscribers have returned their telephone-receivers to the hooks.

Such is a general statement of the apparatus and functions of my system, which I shall now proceed to describe specifically. It will be apparent that some of the apparatus may be changed or removed and other forms substituted therefor without destroying either the identity or the efficiency of the system as a whole. Such changes and substitutions are contemplated as being within the scope of my invention.

Referring to the accompanying drawings, wherein the same letters and numerals of reference indicate the same parts throughout, Figure 1 is a diagrammatic view of my system as a whole, two subscribers' stations being shown connected upon different sections of a central-office switchboard. Fig. 2 is a side view of a plunger-switch performing the functions of listening-in and calling, also serving as a signal. Fig. 3 is an edge view thereof. Figs. 4 and 5 are side and end views, respectively, of a trunk-line relay controlling the supervisory signals. Fig. 6 is a diagram of my switchboard arrangement. Fig. 7 is a diagram of circuits at the subscriber's station.

Referring to Fig. 1, the subscriber at the left of the figure is supposed to be the calling subscriber and the subscriber at the right the called subscriber. Both the subscribers' instruments and the central-office apparatus are shown in their normal position of disuse. It will be observed that 1 2 and 3 4 are circuits leading from the subscribers' stations to the central office, where they terminate in spring-jacks a and b, respectively. The springs of these jacks normally rest upon anvils a' and b', from which wires are led to the windings of the line-annunciator magnets a^2 and b^2, respectively, and thence both circuits are continued to the main battery M and to ground. At the subscribers' stations wires 1 2 and 3 4 terminate in switch-arms c c' and d d', respectively. These switch-arms are controlled as to their position by the telephone-receivers R R' and the springs r r'. When the receivers are upon the hooks, as shown, the switch-arms are held down in contact with anvils connected to the circuits of the ringers or polarized bells P P'. When the receivers are off the hooks, the springs r r' cause the hooks to rise, closing the circuit from the line-wires through the secondaries S S' of the respective induction-coils and the local circuits through the transmitters T T' and the primaries p p', each local circuit of course containing a suitable battery. From the middle point of each secondary winding a wire w is led to ground. This ground connection is permanent so far as the coil is concerned. With this construction it will be apparent that alternating current thrown upon any pair of line-wires in series while the subscriber's switch-hook is in its normal position of disuse will cause the ringer or bell to sound, while the removal of the telephone-receiver from the hook will cause the same to rise under the influence of its spring, and a circuit will immediately be completed from the ground through both line-wires in parallel through the central-office annunciator and the main battery M to ground, which will operate the line-annunciator as desired. This constitutes the entire operation as far as signaling in the lines themselves is concerned. For the operation of this system I provide at the central office two sets of switchboard-operators, whom I designate, respectively, "A" and "B" operators. I divide the entire board into a number of sections, and upon each section I terminate a number of subscribers' lines, (assumed to be, for the purpose of description, one hundred.) These terminal sections are grouped in pairs and between each two pairs is inserted a section containing no line-terminals, but merely plugs, constituting the terminals of trunk-lines. This arrangement is clearly shown in Fig. 6, where A A represents in each case a double section containing line-terminals—that is, drops and jacks. B in each case represents the trunk-plug section. The A operators are stationed at these A sections, two operators to each double section. The B operators are stationed one at each single trunk-plug section. It will be observed that each A operator has within her reach all the jacks on a double section, while each B operator has within her reach on the right hand and on the left one-half of an A double section. With this in mind the general operation of the system will be easily understood. Each call caused by the subscriber taking down his telephone-receiver, and consequently throwing his drop, is answered by an A operator. If upon inserting the answering-plug and ascertaining the number of the subscriber with whom conversation is desired the A operator finds that subscriber to be upon her own double section, she will immediately complete the connection by inserting the other plug of the pair she is using into the desired subscriber's spring-jack. If, however, the wanted subscriber is located upon another section of the switchboard, the answering A operator inserts her second plug into the jack of a trunk-line, by this act notifying the B operator, who is stationed at the B section upon which the other terminal of that trunk-line is located. The B operator so selected communicates with the A operator and learns the number of the wanted subscriber and then inserts the trunk-plug in the required jack of the section to her right or to her left, as the case may be. The B operators communicate with the subscriber directly only when they find

that the wanted lines are busy—that is, when a plug already occupies the desired spring-jack. Ordinarily all their communication is held with and their instructions are received from the A operators. Fig. 1 shows diagrammatically the circuits of an A operator's plug-cord with her listening and calling means, a trunk-line leading from the A operator's section to a B operator's section, and the B operator's apparatus at the terminal thereof. The two sides of the plug-cord circuit at the A section are numbered 5 and 6, respectively, the line 5 connecting the sleeves of the plugs a^3 and a^4 and the line 6 connecting the tips thereof. Similarly the two sides of the trunk-line are numbered 7 and 8, and they connect the springs of the trunk spring-jack b^4 on the A section with the sleeve and tip, respectively, of the plug b^3 on the B section. In continuing the description of this single chain of circuits I shall proceed as though it were complete in itself for every purpose without reference to the rest of the switchboard. It will be understood, however, that certain apparatus and circuits are common to all of the plug-cords of one section or to all of the sections of the exchange and that in order to amplify the single chain into a complete switchboard mere multiplication is required.

In the position shown in Fig. 1 the plug a^3 is supposed to occupy its normal position of rest in the plug-seat. The sleeve of this plug to which the circuit 5 of the plug-cord is connected bears a metallic heel-piece, which while the plug is in its seat makes contact with a spring a^5, connected to ground. The purpose of this will be explained later. Included in the circuit of each plug-cord and forming a part thereof is a combination listening-in and calling switch E. This switch is shown full size in Figs. 2 and 3, but the circuits are best seen in Fig. 1. The switch consists, essentially, of a supporting-frame, within which reciprocates a spindle or plunger e, carrying a block of insulation e'. Supported upon the upper end of the spindle is a push-button head e^2, which forms an abutment, as shown in Fig. 1, for a spiral spring e^3, which tends constantly to force the plunger into its extreme position, as shown in Fig. 1. In practice the plunger or spindle is vertical and the retracted position is its uppermost position, the spring being compressed when the plunger is moved downwardly by pressure upon the push-button e^2.

Secured to the insulating-block e' are contact arms or bars e^4 e^5. In practice, as shown in Figs. 2 and 3, there are four of these bars insulated from each other. For ease of illustration in the diagram, however, they are shown as two only. Now both of these arms e^4 and e^5, which move with the reciprocating spindle, are arranged to engage with various contacts, numbered from 9 to 22, inclusive. Of these 9 and 10 form the terminals of the supervisory-lamp circuit. 11, 12, 13, 14, 15, 18, 19, and 22 are terminals of the plug-cord. 20 and 21 are the terminals of a generator-circuit. 16 and 17 are the terminals of an operator's listening-in set. These terminals are arranged in such positions that a certain number of them will be closed in each of three positions of the plunger, which positions are arranged to be assumed in regular sequence. In the normal position shown in Fig. 1 a plug-cord circuit is complete from the plug a^3 through the cord-circuits 5 and 6 and the terminals 11 12 and 13 14, respectively, and the plug a^4. In addition the supervisory-signal circuit 23 is completed at the terminals 9 and 10. This supervisory-signal circuit contains the lamp or other indicator L and is supplied with current by a battery M'. Connected in multiple therewith and supplied with current by the same battery is a twin-signal circuit 24, containing a lamp or other indicator L'. The lamp L is located at the A section of the switchboard and the lamp L' at the terminal of the trunk-line 7 8 upon the B section. The circuit 23 includes beside, the terminals 9 10, terminal 25 and the armature f of a magnet F. This magnet F is included in a circuit 27, leading from the middle point of a bridge 28 of the plug-cord circuit 5 6 to the main battery M and ground. The bridge 28 contains impedance i i in order that it may not short-circuit voice-currents which are passing over the metallic circuits.

The magnet F through its armature f controls the position of the plunger-switch E. This is accomplished by means of a hooked portion f' on the armature f which engages an enlarged portion or head e^6 on the plunger e. The operation of these parts will be described later.

Leading from the A section to the B section is a circuit 28, in which at the A section is included a telephone set, (indicated diagrammatically by the receiver R^2.) The terminals 16 17 of the plunger-switch E are connected to the two sides of this circuit 28. At the B section of the switchboard the circuit 28 terminates in two contact-anvils 29, with which are adapted to engage springs 30 of a switch G. Leading from the springs 30 is a circuit 31, which terminates in springs 32 of a similar switch G', located within the trunk-jack b^4 of the A section and adapted to be operated by the insertion of the plug a^4 therein. The contact-anvils of this switch G' are connected to the two sides of the circuit 28.

Connected across the trunk-line circuit 7 8 is a bridge-wire 34, containing impedance i' i' and having connected between the impedance the coils h h of a relay H, which is shown in detail in Figs. 4 and 5. This relay has a double function, acting to control the circuit 24 of the lamp L' in such a manner as to make it available both as a clearing-out signal and also as a trunk-line advance-signal. The armature h^2 when retracted closes upon a back contact 26, and in order that it may be held away from this contact when the trunk-line is disconnected in its normal con-

dition of disuse I provide an extra winding h' for the relay-magnet, said winding, together with a small battery m, being included in a circuit 34, which terminates in spring-contacts 35 36, adapted to be closed when the plug b^3 is in its seat. It will be observed upon referring to Figs. 4 and 5 that the relay H consists of two magnets mounted upon the same base. The winding of the second magnet is represented in Fig. 1 by the coil h^3, which is included in a circuit 35, leading from the middle point of the windings h h to the battery M and ground. This magnet h^3 acts upon the same armature-lever as the magnet h h and in fact forms an integral part of the relay H. Its function will appear later in the description of operation.

Connected to the terminals 20 21 of each plug-cord circuit 5 6 are wires 36 37, the wire 36 leading to a commutator K, provided with an insulated segment k, and the wire 37 being divided into two branches 38 and 39, which terminate in contact-springs 40 and 41, respectively, and which bear upon the periphery of the commutator K. Included in the branch 38 is a battery M^2. Included in the branch 39 is an alternating-current generator O.

In describing the operation of my system as shown in Fig. 1 I shall imagine a call to originate with the subscriber at the left-hand side of the figure and that he desires to converse with the subscriber at the right of the figure. I shall then follow the successive steps which are taken both by the subscribers and the operators at the central office from the beginning of the connection until the subscribers have finished their conversation and the apparatus is restored to its normal condition. A subscriber desiring to call removes his telephone-receiver from the hook and places it to his ear. The switch c c' rises under the influence of the spring r, completing the circuit of line-wires 1 and 2 through the two halves of the secondary S of the induction-coil and the wire w to ground. Current from the battery M will then immediately flow out through the annunciator-coils a^2 and the spring-jack a through the line-wires in parallel and the annunciator will exhibit its signal. The A operator upon observing the signal inserts the plug a^3 in the spring-jack a. The immediate effect of this is to force the springs of the jack a away from the anvils a' and to connect the line-wires 1 2 to the cord-circuit 5 6 through the plug a^3. The operator then depresses the plunger-switch E by placing her finger upon the push-button head e^2 until it occupies its lowermost position. It will be observed that with the plunger in this position the cord-circuit 5 6 is broken at the terminals 11, 12, 13, and 14 and that the operator's set R^2 is connected through the terminals 16 17, the arms e^4 and e^5, and the terminals 15 and 18 to the plug a^3. Being thus placed in communication with the subscriber she ascertains the number of the subscriber with whom he desires to converse. Having this information, the operator relaxes her pressure upon the plunger-head e^2, allowing the switch to assume its midway position, where it is detained by reason of the engagement of the hook f' with the projection e^6. It will be observed that in order to permit this engagement the magnet F must be deënergized. When the plug a^3 is first inserted in the jack a, a complete circuit is formed from the ground at the subscriber's station through the wire w, through the line-wires in parallel, through the two sides of the plug-cord circuit 5 6 in parallel, through the two impedance-coils i i, through the magnet F, and through the wire 27 to the battery and ground. Thus the armature f is held up and the lamp L does not light. The same effect is produced during the disuse of the apparatus by means of the contact a^5 in the plug-seat, the circuit then being formed through one side 5 of the plug-circuit, one impedance-coil i, one-half of wire 28, the magnet F, and the wire 27 to battery and ground. With the plug in the jack, however, when the operator depresses the plunger-switch E for the purpose of listening-in the through-plug circuit is broken at the terminals 11, 12, 13, and 14, as before stated. This has the effect of deënergizing the magnet F, and but for the terminals 9 10 in the circuit 23 that circuit would immediately be closed at the contact 25 and the lamp L would light. This, however, is avoided, because when the plunger-switch is depressed the circuit 23 is broken at the said terminals 9 10. When the operator relaxes her pressure upon the push-button head e^2, the plunger or spindle assumes its midway position, as before stated. This causes the arms e^4 and e^5 to leave the terminals 15, 16, 17, and 18 and make connection with 19, 20, 21, and 22. It should be observed that the switch E will remain in this position until the called subscriber shall have removed his telephone-receiver from its hook to answer the call. In this position of the switch the two sides of the cord-circuit 5 6 leading from the terminals 19 and 22 to the plug a^4 are connected to the generator-circuit 36 37 through the terminals 20 and 21. Now if the wanted subscriber is upon the A operator's own section she would simply insert the plug a^4 in said subscriber's jack. We have assumed, however, that the right-hand subscriber shown, who is upon another section, is the one required. The A operator therefore inserts the plug a^4 in the jack b^4, pushing the plug far enough in to actuate the switch G', closing the springs 32 against the anvils 33, and thereby crossing her own talking-circuit 28 with the talking-circuit 31 of the B operator having charge of that trunk-line. As soon as the plug a^4 makes contact with the jack-springs b^4 current from the generator-circuit 36 37 begins to circulate through the trunk-line 7 8, the bridge-wire 34 thereof, and the windings h h of the relay H. This

relay, it will be remembered, is normally energized by the winding a'. As the commutator K in the generator-circuit revolves it throws first a direct current from the battery M^2 and then an alternating current from the generator O in alternate intervals upon the circuit. The alternating current has no effect upon the relay H; but the intervals produced by the commutator recur with sufficient frequency to permit the battery-current circulating in the coils h to neutralize the effect of the oppositely-wound coils h' and thereby deënergize the relay H. Thereupon the armature h^2 is retracted and closes the circuit 24 through the contact 26, causing the lamp L' to become incandescent, announcing to the B operator that a connection is desired with some one on that trunk-line. Upon observing the trunk-line signal the B operator lifts the plug b^3 from its seat, and as she is already in connection with the circuit 28 of the A operator, because of the actuation of the switch G', she can immediately speak to the A operator and receive from her the number of the subscriber wanted. Having obtained this information, the B operator inserts the plug b^3 in the jack b of the wanted subscriber and turns to other duties. It will be observed that when the B operator lifts the plug b^3 from its seat she breaks the circuit 34, thus stopping the current from circulating in the coils h' h'. The relay H becomes energized, therefore, by the coils h h, and the armature h^2 is again drawn up, causing the lamp L' to become extinguished. There can now be traced a complete circuit from the commutator K through the wire 36, contact-point 21, arms e^5, wire 6, plug a^4, spring-jack b^4, wire 8, plug b^3, one spring of the jack b, line-wire 4, switch-arm d, polarized bell P', switch-arm d', line-wire 3, jack b, plug b^3, wire 7, jack b^4, plug a^4, wire 5, contact 19, arm e^4, contact 20, wire 37, and generator O. The generator-current is thrown upon this circuit in short constantly-recurring intervals and continues to ring the polarized bell P' until the subscriber answers the call by removing his telephone-receiver from the hook. When the subscriber answers the call, he permits the switch-arms d d' to rise, and a circuit is immediately closed from the ground through the battery M, the wire 27, the magnet F, wire 28, through both impedances i i, the wires 5 6, plug a^4, jack b^4, wires 7 8, plug b^3, jack b, line-wires 3 4, switch-arms d d', the two halves of the secondary S', and wire w to ground. This causes the energization of the magnet F, which thereupon attracts its armature f, disengaging the hook f' from the projection e^6, permitting the plunger-switch E to be retracted by the spring e^3, so that the push-button head e^2 rises to its normal position and notifies the A operator that the called subscriber has answered. As the relay H is dependent for its energizing-current upon the battery M^2, so long as the called subscriber has not answered of course this retraction of the plunger-switch E and the consequent removal of the battery M^2 from the circuit would cause the armature h^2 to retract and falsely signalize the B operator were it not for the winding h^3, which is provided for this express purpose. Thus when the called subscriber takes his telephone-receiver off the hook, closing the circuit through his wire w, current flows from the battery M, through the wire 35 and the winding h^3, as well as the winding h, and the impedance-coils i' i' out upon the line-wires in parallel. This keeps the magnet h^3 energized and retains the armature h^2 in its attracted position so long as the conversation is proceeding. During the conversation the position of the parts and the condition of the lamps L L' remain the same as in their condition of disuse—that is to say, as shown in Fig. 1, of course, with the exception that the plugs remain in the jacks. When, however, both subscribers have finished their conversation and have hung up their receivers circuit through the wires w w is interrupted. Inasmuch as both the magnets F and H are dependent for their energization during the conversation on this circuit, it is apparent that they will both allow their armatures to retract, thus closing both lamp-circuits L L' and notifying both operators that disconnection is desired. Upon receiving this notification both operators withdraw their plugs and the parts reassume the normal position shown.

It frequently happens that unforeseen contingencies arise, so that the course of a connection and disconnection between subscribers is not as smooth as outlined above. I have provided, however, for ordinary contingencies as follows: It frequently happens that the called-subscriber's line is already busy. In the present system this does not become known until the B operator, having received her orders from the A operator, endeavors to insert the plug b^3 in the jack b and finds another plug already there. In such a case it becomes necessary for her to inform the calling subscriber of the state of affairs. For this purpose I provide a jack B, which I call the "busy" jack, the springs of which are connected to the circuit 31 and the B operator's talking set R^3. Upon finding that the wanted subscriber is busy the B operator simply inserts the plug b^3 in the jack B, when she is enabled to inform the calling subscriber directly that the line called is busy. In so doing it becomes necessary that the plunger-switch E should be released in order that the plug-cord circuit may be reunited at the contacts 11 12 and 13 14. Otherwise the B operator could not talk through to the subscriber. For this purpose I provide a ground-tap 360, leading from the middle point of the winding of the B operator's induction-coil or from the middle point of the B operator's telephone-receiver, as shown in Fig. 1. This ground-tap 360 produces the same effect when the plug

b^3 is inserted in the jack B that the wire w does when a subscriber answers.

In case a B operator should not have received her instructions correctly or should not have heard them at all it is necessary to provide her with means for calling back to the A operator. It is the function of the switch G to do this, which when actuated by the B operator crosses her circuit 31 directly with the A operator's circuit 28 and enables them to communicate. After she has inserted the plug b^3 in any jack b the B operator can no longer communicate with either subscriber. If, therefore, the wanted subscriber should not answer, the B operator will not be aware of that fact. It will be noticed, however, that the A operator will be aware of it, because the plunger-switch E will remain depressed. If this continues for any length of time, she withdraws the plug a^4 from the jack b^4 and depressing the button e^2 to its lowermost position informs the calling subscriber that no answer can be obtained. As soon as the plug a^4 is removed from the trunk-jack the relay H will be deënergized, its armature will retract, the lamp L′ will light, and the B operator, observing this as a clearing-out signal, will remove the plug b^3.

Referring to Figs. 2 and 3, the plunger-switch E is shown full size. It consists, essentially, of a frame e^9, of metal, carrying the block of insulation e^7; both the frame and block being centrally bored to receive the spindle or plunger e. The cross-head e' carries the arms e^4 and e^5, which as the plunger is reciprocated make and break contact with the various spring-terminals. The cross-head e' is of hard rubber preferably and slides in an orifice e^{10}, cut in the rubber block. The arms e^4 e^5 travel in opposite parallel depressions e^8. In the diagram the projection e^6 is shown at the lower end of the spindle. In practice, as seen in Figs. 2 and 3, it is mounted at about the middle point and forms an abutment for the spring e^3.

Figs. 4 and 5 show the relay H as it actually appears. It will be observed that the two magnets h h and h^3 h^3 are placed side by side and act upon the same armature h^2. The two impedance-coils i' i' are wound upon the same core and for convenience are mounted on the same support as the relay.

Fig. 7 shows the circuits at the subscriber's station as they are actually wired up in practice, the arrangement illustrated in Fig. 1 being adopted in order to render the diagram simple. In Fig. 7 the line-wires 1 and 2 are connected to the switch-arms c c', which when the telephone-receiver is hung up complete the metallic circuit through the polarized bell P′. When the receiver is removed from the hook, the bell-circuit is opened and the line-wires 1 and 2 are connected to the wires y z, leading to the secondary winding S of the induction-coil and to a balancing resistance Rh, respectively. From the secondary and the resistance wires y' z' lead to the receiver R, the middle point of whose winding is connected to ground through the wire w. The primary circuit through the transmitter T, the local battery, and the primary p is also closed at the same time. By this arrangement I obtain a balance between the two sides of the line without either bridging the receiver or using expensive form of double-wound induction-coil, with the receiver included between the two halves of its winding. A perfect balance is required, and perhaps the greatest advantage of the present arrangement lies in the fact that to obtain that balance I have only to insert a resistance at Rh of sixteen ohms instead of the much higher resistance of the receiver as ordinarily used. Thus the current flowing from the common battery M through the line-wires in parallel finds a path of lower aggregate resistance, the joint resistance of the two branches at the subscriber's station being only eight ohms. I am not aware that this has before been accomplished without specially-prepared and expensive apparatus.

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

1. In a telephone-exchange system, a central-office switchboard carrying subscriber's-line terminals, operator's connecting lines or cords adapted to be fitted to the subscriber's terminals to connect calling and called lines, a switch for each operator's line or cord having a set of normally-open contacts adapted to be closed, when the switch is actuated, to connect the operator's telephone to the calling-subscriber's portion of said line or cord, and having other contacts normally closed to preserve the continuity of the cord-circuit, but adapted to be opened when said switch is actuated; and means under the control of the called subscriber to restore said switch to its normal position, whereby when an operator has once communicated with the calling subscriber she loses control of the connected lines, and cannot again connect her telephone in the circuit without interrupting the conversation, substantially as described.

2. In a telephone-exchange system, a central-office switchboard carrying subscriber's-line terminals, operator's connecting lines or cords adapted to be fitted to the subscriber's terminals to connect calling and called lines, a switch for each connecting line or cord adapted to separate the same into two portions, connecting an operator's telephone with that portion leading to the calling-subscriber's terminal and a source of calling-current to the portion leading to the called-subscriber's terminal; and means controlled by the called subscriber to restore said switch and again complete the line for conversation, substantially as described.

3. In a telephone-exchange system, a central-office switchboard divided into sections each carrying the line-terminals of a number of subscribers, connecting lines or cords at

each section and trunk-lines interconnecting the sections, a switch for each connecting-cord adapted to break the cord-circuit and connect an operator's talking and calling apparatus to the severed portions, means for connecting the calling portion of said cord-circuit through any trunk-line with an operator at the terminal section thereof, and means controlled alike by the called subscriber or by the last-named operator to restore the cord-switch and renew the continuity of the talking-circuit, substantially as described.

4. In a telephone-exchange system, subscribers' lines terminating on a switchboard, connecting cords and plugs at said board, a switch for each cord consisting of a movable part which when actuated breaks the cord-circuit and connects the operator's talking and calling apparatus to the severed portions thereof, and a magnet controlling the return of said movable part, said magnet adapted to be energized through the called line only, substantially as described.

5. In a telephone-exchange system, a switchboard cord-circuit terminating in connective means, and a switch therein, bearing a set of normally-closed terminals keeping the cord-circuit intact, and normally-open generator and talking-set terminals, a manually-operated switch arm or arms adapted to open the said closed terminals, thereby breaking the cord-circuit, and to close the open terminals, thereby connecting the generator and talking set with the severed portions of the cord, and with the respective terminal connective means, and a lock for said arms adapted to be released from a called line only, substantially as described.

6. In a telephone-exchange system, a switchboard divided into sections, subscriber's-line terminals grouped upon each section, connecting lines or cords at each section, and trunk-lines interconnecting the sections, a combined ringing and listening key or switch for each connecting-cord, which in its operation severs the cord-circuit, a magnetic lock for said ringing key or switch included in a circuit terminating at a circuit-closer in the called-subscriber's station, and means controlled by the trunk-line operators for closing the same circuit and actuating said magnetic lock, substantially as described.

7. In a telephone-exchange system, a central-office switchboard divided into sections, subscriber's-line terminals grouped upon each section, connecting cords and plugs at each section and trunk-lines interconnecting the sections, a switch for each cord-circuit which when actuated severs the cord-circuit and connects the answering-operator's listening and calling apparatus with the severed portions thereof, a lock adapted to retain said switch in its actuated position, a magnet to control the said lock, the circuit of said magnet leading from the ground to both sides of the calling end of the cord-circuit through bridged impedance-coils, a source of current in said ground-circuit, and means provided both at the called-subscriber's and at the trunk-operator's apparatus whereby a double ground is connected with the line to complete the circuit of said magnet whenever either of their respective talking-circuits is switched in, substantially as described.

8. A switch, consisting of a block of insulating material centrally bored and having upon opposite faces parallel depressions, contact-springs carried upon the block and extending over said depressions, a spindle or plunger fitted to reciprocate in the central bore, and arms carried by said spindle and traveling in the depressions, substantially as described.

9. A switch comprising the following instrumentalities, viz., a frame, a block of insulation mounted upon said frame and provided upon opposite faces with parallel depressions, contact-springs mounted upon said insulation and extending over the depressions therein, a central spindle carrying arms adapted to reciprocate within said depressions, a magnet and its armature mounted upon the frame, and a projection on the spindle and a coöperating catch upon the armature, whereby the magnet controls the position of the arms, substantially as described.

10. In a telephone-exchange system, a central-office switchboard carrying subscriber's-line terminals, connecting plugs and cords at said boards, a switch for each cord adapted to be manually operated, to connect an operator's set and a calling-generator to the respective connecting-plugs, a projection upon the movable part of said switch, an armature carrying a coöperative catch, a magnet acting upon said armature when energized, a source of current-supply connected to said magnet by the operation of the switch, and means at each subscriber's station to complete the circuit from said source of current, thereby energizing the magnet and restoring the switch to its normal or inoperative position, when a call is answered, substantially as described.

11. In a switch the combination of the following instrumentalities, viz., a frame, a block of insulation mounted upon said frame and provided upon opposite faces with parallel depressions, a central reciprocating spindle or plunger passing through said frame and block, and provided at one end with a push-button and at the other with cross-arms working in said depressions, a spring adapted to maintain the spindle or plunger normally in one position, a magnetically-controlled latch for holding it in another position, different circuits being closed by the plunger-arms in their two positions, whereby the position of the push-button may be utilized as a signal to indicate the changing of the circuit, substantially as described.

12. A switch comprising the following in-

strumentalities, viz., a frame, a block of insulation carried upon said frame, three sets of springs upon said block, a central spindle or plunger carrying arms adapted to coöperate with said springs, manually-operated means to cause the arms to assume one position with regard to the springs, a spring and a detent to cause the arms to assume and maintain a second position, and a magnet mounted upon the frame and adapted to release the detent and permit the arms to assume their third position, substantially as described.

13. In a telephone-exchange system, a trunk-line connecting two switchboard-sections and terminating in a jack at one section, and an instruction-circuit permanently connected to the operator's set at one section and passing thence to the other section, and means in the trunk-jack actuated upon the insertion of a plug to connect the operator's talking set at said other section to said instruction-circuit, substantially as described.

14. In telephone-exchange systems, a switchboard divided into sections, trunk-lines interconnecting said sections, each trunk-line terminating in a plug, a relay included in a circuit of high impedance bridged across the two sides of said trunk-line, a local circuit including a signal adapted to be closed upon the deënergization of said relay, and an extra winding upon the relay included in a local circuit connected with a battery and a circuit-closer in the trunk plug-seat, whereby said relay is maintained active during the disuse of the apparatus, substantially as described.

15. In a telephone-exchange system, divided switchboard-sections, metallic trunk-lines interconnecting the same, and a relay for each trunk-line, each relay consisting of two magnets acting upon the same armature, the first magnet provided with a normally-closed winding controlled by the adjacent trunk-terminal, and a second winding bridged across the two sides of the trunk-line, and the other magnet having a single winding connected in a circuit leading from the central point of the second winding of the first magnet through a battery to ground, and a local circuit containing a supervisory signal adapted to be closed upon the deënergization of the entire relay, whereby with the apparatus in a position of disuse a signal remains undisplayed, becoming displayed when connection is made with the trunk-line so as to throw current through the second winding of the first magnet, to be restored by a change in the position of the trunk-terminal and thenceforth to remain under the control of the subscribers during conversation, substantially as described.

16. In a telephone-exchange system, divided switchboard-sections, plugs and connecting-cords for each section and trunk-lines interconnecting the sections, a generator-circuit adapted to be connected through the cord-circuit with any trunk-line, means included in said generator-circuit for throwing alternately direct and alternating current upon the circuit, a signal connected in the trunk-line circuit and responsive to direct current, and a signal at each subscriber's station responding only to alternating current, substantially as described.

17. In a telephone-exchange system, divided switchboard-sections and trunk-lines interconnecting the same, a signal-relay for each trunk-line comprising a differentially-wound magnet, one winding of which is included in a local circuit containing battery and a circuit-closer operated by the trunk-plug, and the other winding of which is included in the trunk-circuit, and means for throwing onto the trunk-circuit in the act of connecting therewith current of sufficient strength to neutralize the effect of the winding through which current is normally circulating, whereby the relay will be operated by deënergization upon making connection with the trunk-line and will be restored by being again energized when said connection is broken or the trunk-plug removed from its seat for the purpose of connection with a subscriber's line, substantially as described.

18. In a telephone-exchange system, a switchboard, subscriber's-line terminals thereon, connecting cords and plugs for the same, listening and ringing switches adapted to be manually operated and magnetically released, and supervisory signals for the cord-circuits, a relay connected to each cord-circuit for controlling the listening and ringing switches and also the circuit of the supervisory signal, said relay adapted to be energized while subscribers' circuits are connected, and means in the seat of one plug of the cord for closing circuit of said relay, whereby both the switch and the supervisory signal are rendered inoperative while the plug is in its seat, substantially as described.

19. In a telephone-exchange system, a subscriber's metallic circuit having both sides normally connected through an annunciator, upon a switchboard at a central office, and through a main source of current to ground; connective circuits and supervisory signals connected therewith and adapted to be placed under the control of the subscriber during a connection; a switch at the subscriber's station adapted normally to disconnect the line from the ground, but when the line is in use to connect the two sides thereof to ground through two equal divisions of the windings of a telephone-receiver, an induction-coil at the subscriber's station having its primary winding included in a local circuit with the subscriber's transmitter, and its secondary winding included in a line-circuit, between the receiver and the switch, on one side of the receiver; together with a balancing resistance equal to said secondary winding in-

cluded in the circuit on the other side of the receiver, substantially as described, whereby although current is flowing through the line-wires in parallel at all times after the receiver is taken up for use, it is kept balanced and no disturbing noises are apparent in the receiver.

In witness whereof I have hereunto set my hand and seal this 4th day of June, A. D. 1898.

WM. D. GHARKY. [L. S.]

Witnesses:
E. E. CLEMENT,
MORTIMER A. JONES.