(No Model.)

3 Sheets—Sheet 1.

H. V. HAYES.

TELEPHONE SWITCHBOARD.

No. 586,685. Patented July 20, 1897.

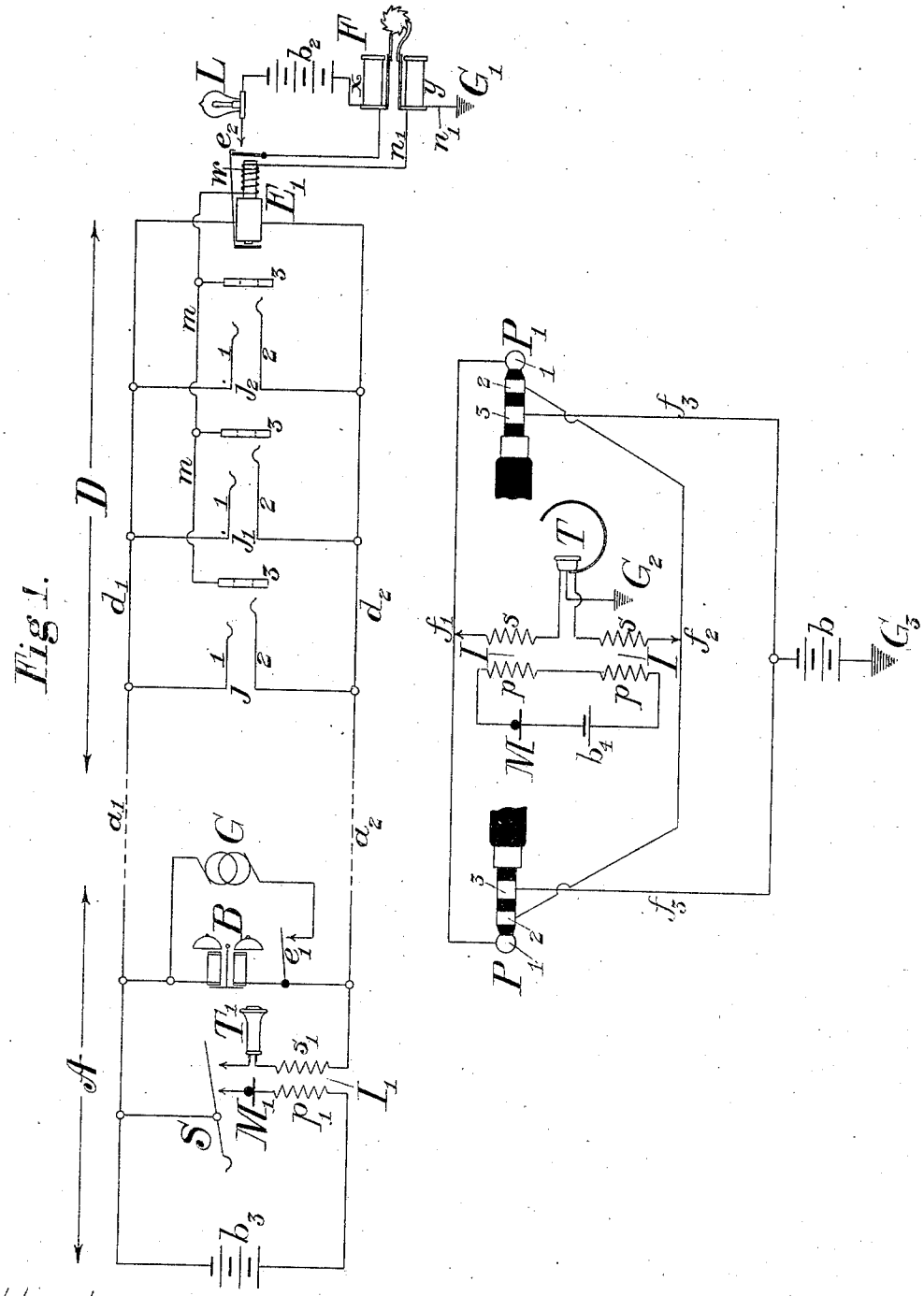

Fig. 1.

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(No Model.)

3 Sheets—Sheet 2.

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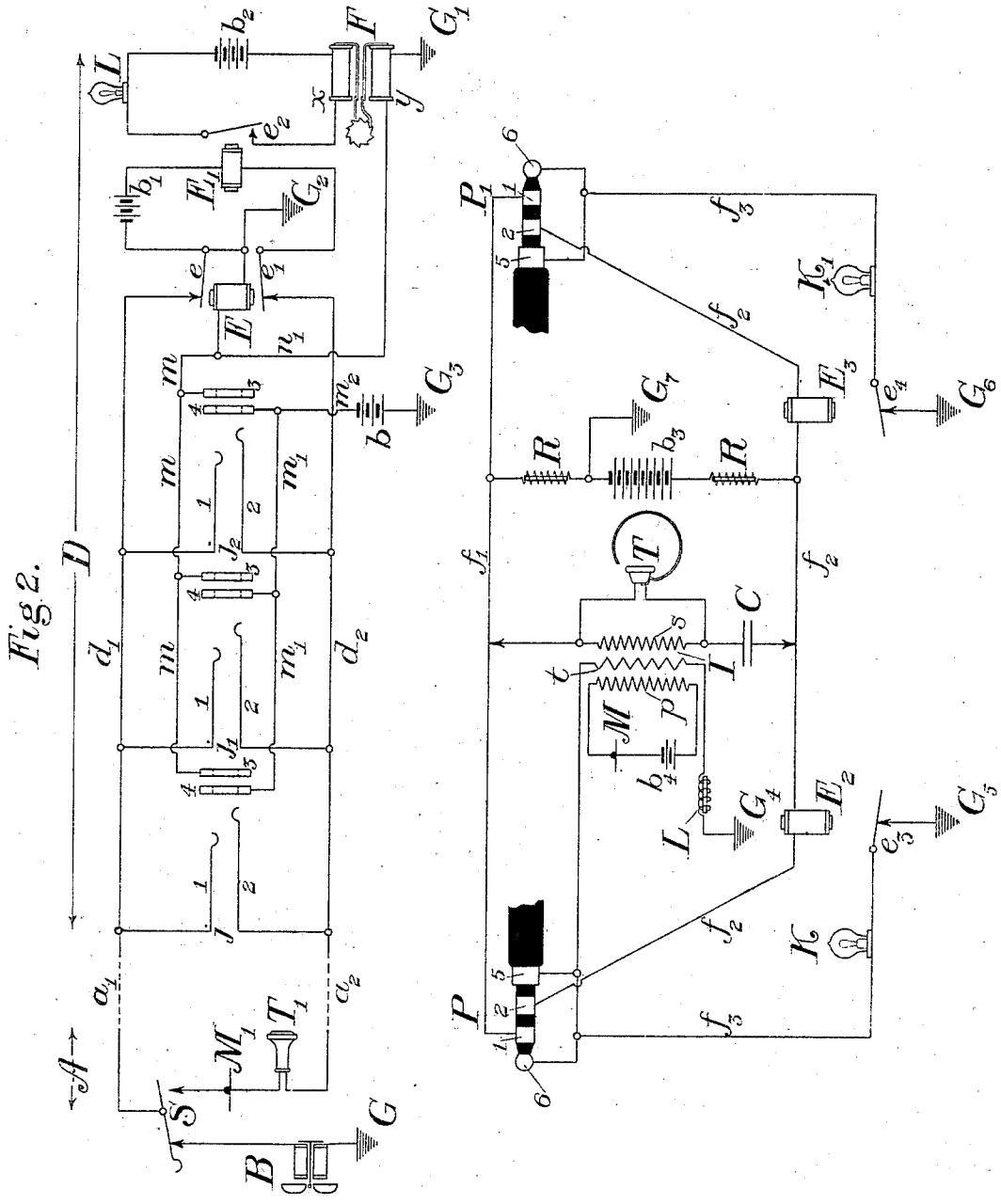

Fig. 2.

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(No Model.)

3 Sheets—Sheet 3.

H. V. HAYES.

TELEPHONE SWITCHBOARD.

No. 586,685. Patented July 20, 1897.

Fig. 5.

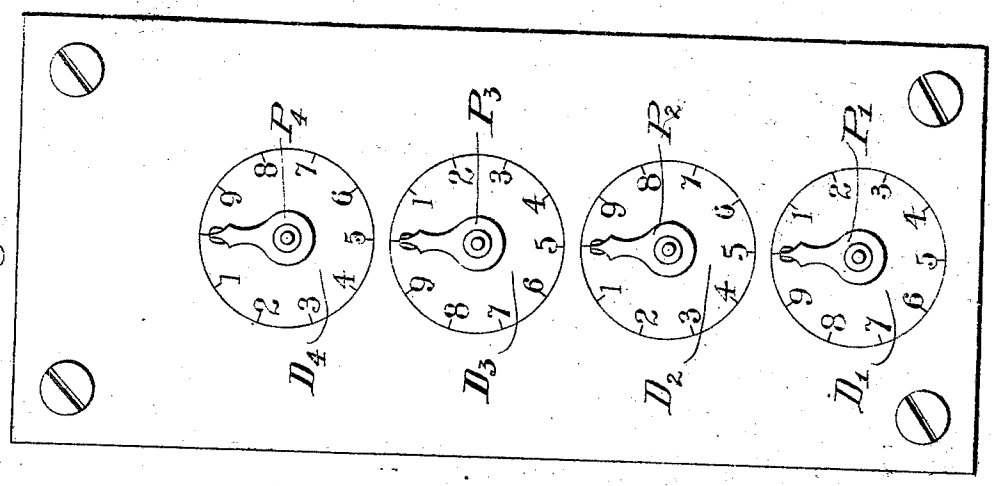


Fig. 4.

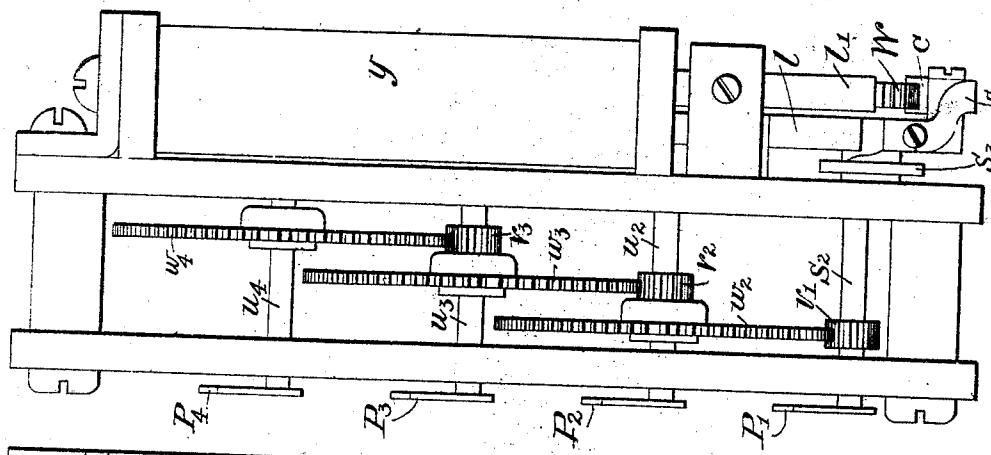
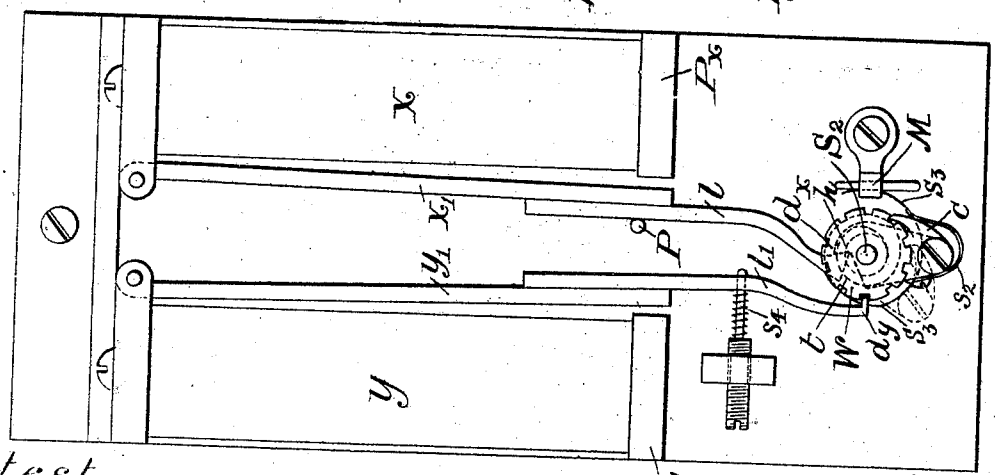


Fig. 3.



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UNITED STATES PATENT OFFICE.

HAMMOND V. HAYES, OF CAMBRIDGE, MASSACHUSETTS, ASSIGNOR TO THE AMERICAN BELL TELEPHONE COMPANY, OF BOSTON, MASSACHUSETTS.

TELEPHONE-SWITCHBOARD.

SPECIFICATION forming part of Letters Patent No. 586,685, dated July 20, 1897.

Application filed January 29, 1897. Serial No. 621,163. (No model.)

To all whom it may concern:

Be it known that I, HAMMOND VINTON HAYES, of Cambridge, in the State of Massachusetts, have invented a new and useful Improvement in Telephone-Switchboards, of which the following is a specification.

The invention is applied to a telephone-exchange system known technically as a "measured-service system;" and its object is to provide suitable means whereby all calls for connections sent in from a telephone-substation and answered by the operator at the telephone central office may be automatically recorded and whereby calls sent in from the substation, which for any reason are not answered by the operator at the central office, shall not affect the record. To make a record, the concerted action of the operator and the subscriber is required, and provision is made that no unaided act, either on the part of the subscriber or of the operator at the central office, shall be capable of affecting the record. Thus only such calls as the subscriber may be justly charged for can be recorded, and no opportunity is given either to the subscriber or to the operator at the central office to falsify the record by the manipulation of their apparatus.

For the purposes described above I associate a recording mechanism or counter with the substation-line at a convenient point within the telephone central office, the mechanism being so constructed and associated with the substation's circuit within the switchboard that it can only be caused to make a record by the cycle of operations which result when a signaling-current is sent in over the line from the substation and an operator at the central office switches into the circuit to answer the call.

By the invention existing telephone systems may be brought under the measured-service system—that is, the invention may be operated in connection with widely-different telephone systems. For instance, it is applicable to the old systems, in which each substation is provided with a separate local battery for the supply of current to the transmitter, and where the subscriber sends in his calling or disconnecting signal to the central office by operating by hand a local magneto-generator. It is likewise applicable to the new system, in which the current necessary for the operation of the substation-transmitters is supplied by a common centralized battery located at the central office and in which all the signals are entirely automatic.

The circuits and apparatus by which the invention is carried into effect are best described by having reference to the accompanying drawings.

Figure 1 is a diagrammatic sketch of circuits, illustrating the application of the invention to a branch-terminal multiple switchboard in the old system in which local transmitter-batteries are employed and in which the calling and disconnecting signals are not operated automatically. Fig. 2 is a diagrammatic sketch of circuits illustrating the application of the invention to a branch-terminal multiple switchboard in a common battery system with automatic calling and disconnecting signals. Figs. 3, 4, and 5 are drawings illustrating the recording device or counter and so much of the electrical mechanism by which the recording device or counter is operated as is not sufficiently shown in the diagram sketches at Figs. 2 and 3, the said Figs. 3, 4, and 5 being, respectively, as relative to each other, a rear, a side, and a front elevation.

So far as practicable the same lettering is followed in the different figures. Any departure from the rule will be readily understood.

In Fig. 1, A is a telephone-substation connected with the central office D by the line wires a' and a^2 of a metallic circuit. At the substation b^3 is a local battery for the supply of current to the variable-resistance transmitter M'. p' and s' are the primary and secondary helices of the transmitter induction-coil I'. T' is the telephone-receiver. S' is the gravity or hook switch. G is the hand magneto call-generator, of which e' is the automatic cut-out, and B is a high-impedance call-bell in a permanent bridge across the line. At the central office the substation's line is continued through the switchboard, past the various multiple sections, by the wires d' and d^2, and is closed through the operating-winding of an electromagnetic annuncia-

tor E′ of the self-restoring drop type. At each multiple section a jack is permanently bridged across the line. These jacks are indicated in a purely conventional way in the diagram at j, j', and j^2, three sections being shown. The ring-contacts 3 of the jacks are connected, by means of the wire m, through the restoring-winding w of the electromagnet E′, and by the wire n' to earth G′ through the second or releasing magnet y of or associated with the call-registering device or counter F. L is a lamp line-signal. b^2 is the line-signal battery. x is the first magnet of the call-registering mechanism F, and e^2 is a contact normally open and which is controlled by the gravity-shutter of the electromagnet E′. In the lower part of this figure is shown the operator's cord, which consists, essentially, of three wires f', f^2, and f^3, terminating, respectively, at both ends in the contact-surfaces 1, 2, and 3 of the cord-plugs P and P′, and the wire f^3 being connected to the ground G^3 through the battery b.

If now a call-signal be sent in over the line from the substation, the generator G is operated. The contact e' is thereby automatically closed. A signaling-current passes from the generator over the circuit a' d' E′ d^2 a^2 e'. This current passing through the operating-winding of the electromagnet E′ causes its gravity-shutter to fall, thereby closing the circuit of the line-signal battery b^2 at the point e^2. This causes the lamp-signal L to light and attracts the attention of the operator to the call. The closing of the circuit of the battery b^2 at the point e^2 also causes a current to flow from the battery through the winding of the first magnet x of or associated with the call-registering device F. The passage of this current through the magnet x causes it to draw up its armature, thereby setting in tension a small spiral spring, (see s^3, Fig. 3,) which is maintained in tension after the armature of the magnet x is released by a click or detent which engages in a ratchet-wheel. This ratchet-wheel is itself held stationary by a detent attached to the armature of the second magnet y of F. The details of this mechanism are shown in Fig. 3 and are explained hereinafter in connection with that figure.

When the operator sees the line-signal L light, she inserts the answering-plug P of her cord in the jack of the substation's line, which is at her section of the board and which is known as the "answering-jack." A result of this act is to close a circuit extending from the ground G^3, through the battery b, wire f^3, plug-contact 5, jack-contact 3, wire m, restoring-winding w of electromagnet E′, wire n', winding of magnet y, to ground G′. The passage of the resulting current from the battery b through the restoring-winding w of the magnet E′ draws up and restores the shutter of this electromagnet to its normal position. This opens the circuit of the line-signal battery b^2 at the point e^2, thereby extinguishing the lamp line-signal L and releasing the armature of the first magnet x. The armature of the magnet x falls back to its normal position, leaving the spring to be held in tension by the click or detent and ratchet-wheel already mentioned. The passage of the resulting current from the battery b through the winding of the second magnet y causes the armature of this magnet to be drawn up, disengaging the detent-catch from the ratchet-wheel, thereby releasing the mechanism of the call-register, which, owing to the tension in the spring, is caused to move ahead one step and register an answered call. As long as the plug of the operator remains in the substation's jack a current from the battery b flows through the restoring-winding of the electromagnet E′, keeping its shutter drawn up and the circuit through the magnet x open. In consequence of this as long as the operator's cord-plug is in the jack the magnet x cannot be influenced by any currents sent over the subscriber's line, whether these currents be calling or disconnecting-signal currents. Therefore when the subscriber has obtained the desired connection and completed his conversation he sends in his disconnecting-signal current in the usual way by operating the hand magneto-generator G without danger of operating the magnet x of his call-register. The operator at the central office seeing the disconnecting-signal withdraws her cord-plug from the substation's line-jack. This removes the battery b from the circuit of the magnet y, causing it to release its armature, which returns to its normal position. The mechanism F is thus restored to its normal position, in which it is ready to record another call when made and answered.

In Fig. 2, A is a subscriber's station connected with the telephone central office D by a metallic circuit composed of the wires a' and a^2. At the substation B is the call-bell. S is the gravity hook-switch. M′ is the microphone or variable-resistance transmitter. T′ is the telephone-receiver, and G is a ground. The circuit is continued through the switchboard by the wires d' and d^2 and through the contacts e and e' to the battery b' and line-relay E′. At each multiple section of the switchboard a branch-terminal jack is permanently bridged, these jacks being shown at j, j', and j^2. L is the lamp line-signal. b^2 is the line-signal battery. e^2 is a normally open contact which is controlled by the line-relay E′. E is a relay which controls the normally closed contact e and e'. The outermost contacts 3 of the line-jacks are connected by the wire m, through the relay E, to the ground G^3 and through the wires m and n' and the coil of the second magnet y, of or associated with the call-register F, to the ground G′. The contacts 4 of the line-jacks are connected by the wires m' and m^2, through the battery b, to the ground G^3. In the lower part of this figure is represented the operator's cord, consisting of the two wires f and f^2, terminating, respec-

tively, at each end in the contact-surfaces 1 and 2 of the cord-plugs P and P'. The contact-surfaces 5 and 6 of the cord-plug P' are connected together and by the wire f^6 through the lamp disconnecting-signal K' through the contact e^1 to the ground G^6. The contact-points 5 and 6 of the cord-plug P are connected together and by the wire f^5 through the disconnecting lamp-signal K and contact e^3 to the ground G^5. The contact-points 5 and 6 of the plug P are also connected through a tertiary winding l of the operator's induction-coil I and through a small retardation-coil L to the ground G^4. b^3 is the common transmitter current-supply battery permanently bridged between the wires f' and f^2 of the operator's cord-circuit through the two windings of a retardation-coil R. T is the operator's telephone-receiver. M is her transmitter; b^4, her transmitter-battery; p and s, the primary and secondary windings of her induction-coil I, and C is a condenser. E^2 and E^3 are electromagnetic relays which control the contacts e^2 and e^4, already mentioned. In this system when the subscriber wishes a connection he removes his telephone from the hook-switch, which automatically closes his circuit through his transmitter and receiver. A current then flows from the battery b' through the contact e, the switchboard-wire d', the line-wire a', transmitter M', receiver T', line-wire a^2, switchboard-wire d^2, contact e', winding of electromagnet E', and back to the other pole of the battery b'. This current energizes the electromagnet E', which, by attracting its armature, closes the circuit of the line-signal battery b^2 through the lamp line-signal L and also through the winding of the magnet x. This causes the lamp-signal to light and attract the attention of the operator to the call, while it also, by energizing the magnet x, causes it to attract its armature, and thereby puts in tension the spring s^3, (see Fig. 3,) by which the call-register is set ahead, when the detent-catch of the armature of the second magnet y releases the ratchet-wheel, as will be fully described in connection with Fig. 3. The operator's attention having been called to the fact that the subscriber wishes a connection by the lighting of the line-signal lamp L inserts the answering-plug P' in the substation line-jack, the contact-strip 5 of the plug being thereby caused to short-circuit the contact-points 3 and 4 of the jack. A current then flows from the ground G^3 in series through the battery b, wire m^2, wire m', contact 4 of jack, contact-strip 5 of plug, contact 3 of jack, wire m, and in parallel to earth G^2 and G', respectively, through electromagnet E and electromagnet y. The result of the current from the battery b passing through the magnet E is to cause it to draw up its two armatures and open the circuit of the battery b' at the two points e and e'. The current from the battery b' which was flowing through the windings of the magnet E' is thereby interrupted, and as a result the armature of the magnet E' is released and the circuit of the battery b^2, through the lamp line-signal L and through the first magnet x, is open at the point e^2. The cessation of the current through the line lamp-signal extinguishes it and the cessation of the current through the magnet x causes it to release its armature. The passage of the current from the battery b through the coil of the magnet y causes it to attract its armature, thereby withdrawing its detent-catch from the ratchet-wheel of the recording mechanism, as more fully shown in connection with Fig. 3. This permits the mechanism under the action of the spring s^3, Fig. 3, placed in tension by the movement of the armature of the first magnet x, to be moved ahead one step and record an answered call. When the connection is no longer required, the subscriber hangs his receiver upon the gravity hook-switch S, thereby opening his circuit. This causes the clearing-out signal-lamp K' to light, and the operator seeing the signal withdraws her cord-plug from the substation's line-jack. This act opens the circuit of the battery b at the contact-point 4 of the subscriber's jack, thereby deënergizing the line relay-magnet E and the magnet y. The magnet y releases its armature, the detent-catch of which engages in the ratchet-wheel of the recording mechanism and locks it. The magnet E releases its armatures, which close the subscriber's switchboard-circuit through the electromagnet E' and battery b', but since the subscriber's line is open at the substation the magnet E' remains deënergized.

In Fig. 3, x and y are the two electromagnets which have been referred to above as associated with the call-register mechanism and also as the first and second magnet, respectively. y' is the armature of the magnet y, and x' the armature of the magnet x. The armatures are shown in their normal positions, but when the magnets are energized the armature x' is drawn into contact with the pole P^x of the magnet x against the retractile force of the spiral spring s^3 and the armature y' is drawn into contact with the pole P^y of the magnet y against the retractile force of the spring s^4. The armature x' carries a leg l, attached to its extremity, which leg l terminates in a foot d^x. The spiral spring s^3 is clamped at one extremity in the usual manner at M, while the other extremity is attached to the disk D. (Shown in dotted lines.) This disk is mounted and is free to rotate on the shaft S^2, it not being rigidly attached to the shaft. It carries a click c, restored by the bent spring s^2. The foot d^x of the leg l, attached to the armature x', engages in a triangular slot cut in the periphery of the disk D. On the same shaft S^2 is rigidly mounted a ratchet-wheel W, so that it can only revolve with the shaft. Into the teeth of this wheel the detent-catch d^y and the click c engage. The shaft S^2 connects with the registering mechanism, the revolution of th

shaft S^2 corresponding to a circumferential displacement of the ratchet-wheel equal to the width of one tooth being necessary and sufficient to record an answered call.

The operation of the mechanism is as follows: The magnet x is energized when the subscriber sends in his call. This draws up the armature x' to the pole P^x of the magnet, moving the leg l to the right. This motion of the leg l causes the heel h of the foot d^x, attached to the leg, to push against the surface of the triangular slot in the disk D, against which it normally rests. In response to this pressure the disk revolves, carrying back with it the click c the distance of one tooth in the ratchet-wheel W, as shown by the dotted lines. This distance is limited to that of one tooth by the toe t' of the foot d^x coming in contact with the second surface of the triangular slot in the disk D. The motion of the disk D puts in tension the spiral spring s^3, to which it is attached, and this tension is maintained even after the armature x' is released by the magnet x, owing to the click c being engaged in the ratchet-wheel W, which is held fast by the detent-catch d^y. When the operator plugs into answer the call, the magnet x is deënergized while the magnet y is energized. The result of this is that the armature x' is released, whereas y' is drawn up to the pole-piece P^y. The armature y' carries with it the detent-catch d^y, and thereby releases the ratchet-wheel W and shaft S^2. The spring s^3 being under tension restores the disk D and its associated click c to its normal position, (shown by the full lines), and in doing so revolves the ratchet-wheel and shaft, which are now free to move a distance corresponding to the width of one tooth of the wheel, thus registering an answered call. This forward movement of the click is limited to that of one tooth of the ratchet-wheel by the motion of the foot d^x, which in turn is limited by the leg l coming in contact with the back-stop P.

It is to be observed that for the operation of the mechanism—*i. e.*, in order to cause it to record an answered call—the concerted action of the subscriber and the operator at the central office is required, since in no way can the energizing of either one of the magnets x or y alone cause the shaft S^2 to rotate and register an answered call.

In Figs. 4 and 5, S^2 is the shaft, already mentioned in connection with Fig. 3, which connects the ratchet-wheel W with the index-pointers P', P^2, P^3, and P^4, that indicate the registered calls upon the dials D', D^2, D^3, and D^4, respectively, each dial having ten divisions upon its face. The motions of the shaft S^2 are communicated to the spindles, upon which the pointers P', P^2, P^3, and P^4 are rigidly mounted, by means of the train of gear-wheels w^2, w^3, and w^4, respectively, which in turn are rigidly mounted upon the spindles u^2, u^3, and u^4, respectively. Upon the shaft S^2 and the spindles u^2 and u^3 are rigidly mounted the pinions v', v^2, and v^3, respectively, which engage with the toothed wheels w^2, w^3, and w^4, respectively. The ratio of the number of teeth on each pinion v', v^2, and v^3 to those on the corresponding wheels w^2, w^3, and w^4 is one to ten.

In the operation of the mechanism a motion of the shaft S^2, due to a circumferential displacement of the ratchet-wheel W to a distance corresponding to one of its ten teeth, will move the pointer P' ahead one of the ten divisions on the face of the dial D', thereby recording an answered call. This motion of the shaft S^2, acting through the train of wheels described above, will move ahead the pointer P^2 one-tenth of one of the divisions on the face of the dial D^2, the pointer P^3 one-hundredth of the division on the dial D^3, and the pointer P^4 one-thousandth of one division on the dial D^4.

I claim—

In a telephone-switchboard, the combination with a subscriber's line centering thereat, including the subscriber's line-signal mechanism, of first a registering mechanism of two movements; second an electrical mechanism the operation of which causes or permits the first movement of said registering mechanism to be taken, while its own operation for such purpose is caused by the operation of the subscriber's line-signal mechanism; and third an electrical mechanism the operation of which causes or permits the second movement of said registering mechanism to be taken, while its own operation for such purpose is caused by the completion of the operator's answering-circuit; the two said electrical mechanisms being also so associated, that not only the effective operation of the second cannot take place without the previous operation of the first but the operation of the second prevents further operation of the first, substantially as described.

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Witnesses:
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