(No Model.) 2 Sheets—Sheet 1.

H. V. HAYES & T. C. WALES, Jr.

TELEPHONIC MEASURED SERVICE SYSTEM.

No. 589,431. Patented Sept. 7, 1897.

Fig. 3.

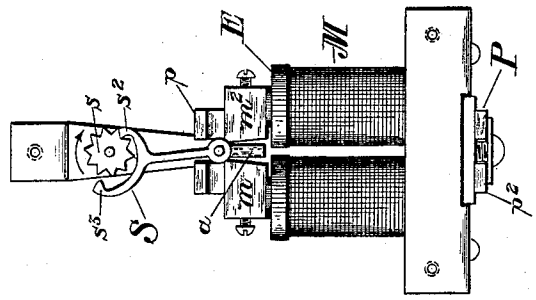


Fig. 1.

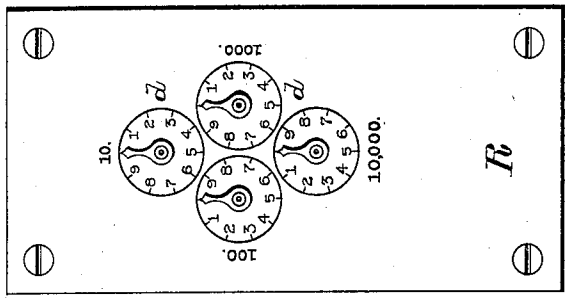
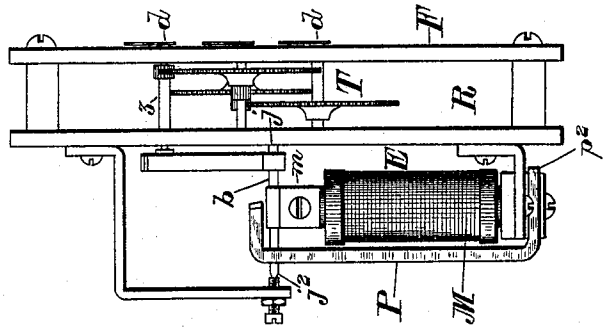


Fig. 2.



Attest,

Joseph A. Gately

Granville Pierce

Inventors

Hammond V. Hayes.

Thomas C. Wales Jr.

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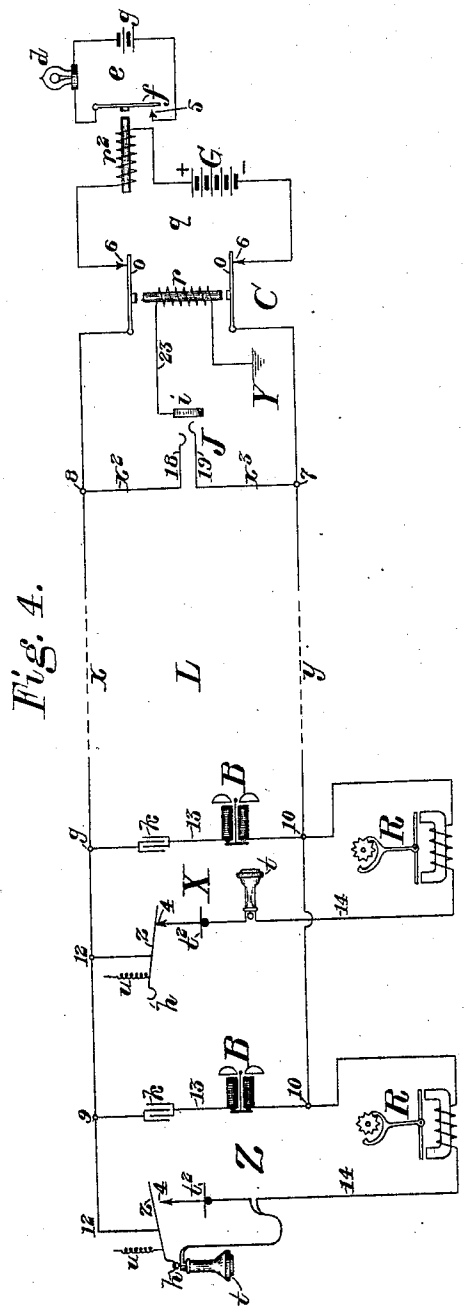

Fig. 4.

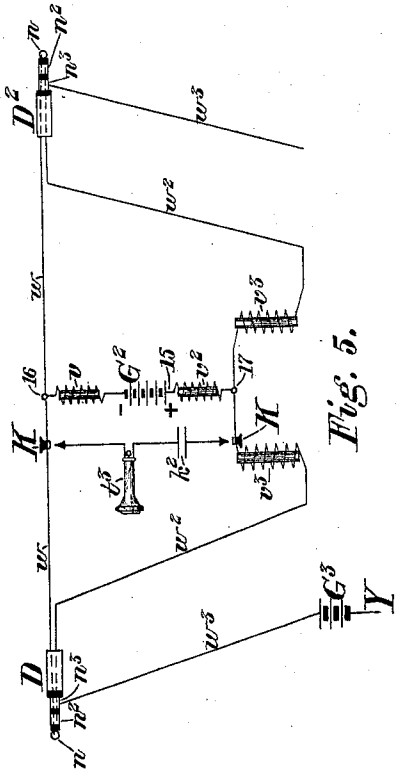

Fig. 5.

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UNITED STATES PATENT OFFICE.

HAMMOND V. HAYES, OF CAMBRIDGE, AND THOMAS C. WALES, JR., OF NEWTON, MASSACHUSETTS, ASSIGNORS TO THE AMERICAN BELL TELEPHONE COMPANY, OF BOSTON, MASSACHUSETTS.

TELEPHONIC MEASURED-SERVICE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 589,431, dated September 7, 1897.

Application filed June 23, 1897. Serial No. 641,918. (No model.)

To all whom it may concern:

Be it known that we, HAMMOND V. HAYES, residing at Cambridge, and THOMAS C. WALES, Jr., residing at Newton, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Telephonic Measured-Service Systems, of which the following is a specification.

This invention relates to the measurement of telephone service and is applicable to telephone-exchanges which have adopted the measured-service system of charging, and especially to those circuits of such exchanges which being arranged to serve a number of subscribers' stations are termed "party lines." Its object is the provision of effective and suitable means whereby all calls for connections sent in by any one of the several substations of a party-line circuit and answered by the operator at the central station may be automatically registered, it being, however, provided that calls transmitted from the substation, which for any reason are not responded to by the central-station operator, shall not be registered, counted, or charged for; that the registers of the other substations of the party line to which the call-initiating substation belongs shall not be affected by the action of the central-station operator in answering the call of the said substation, and likewise that the use by the wanted or called-for substation which is required to form the second or responsive party, in a communication initiated by others, of its circuits and apparatus, and in fact the use thereof consequent on the reception of any incoming message, shall not establish the conditions necessary to the operation of its register.

In an application for patent filed in the Patent Office by Hammond Vinton Hayes, a joint inventor herein, January 29, 1897, and serially numbered 621,163, is disclosed a measured-service system comprising a call-registering mechanism placed at the central station in association with the circuit of the subscriber whose business is to be registered, and such an arrangement of the substation and central station signaling and answering apparatus and circuit connections that the said measuring mechanism can be made operative and register service to be charged for only by the performance of the complete cycle of operations resulting when two successive current-impulses are caused to traverse the main circuit, the first due to the action of the subscriber in sending the call and the second due to the action of the central-station operator in answering it. Thus to register an appropriate charge the conjoint action of the customer and the operator is requisite, and no unaided act of either is capable of affecting the record. Therefore such calls as may be justly charged to the account of the customer are registered, and neither customer nor operator have any opportunity afforded them to produce an erroneous or falsified record by the improper manipulation of their apparatus.

While the registering mechanism placed at the central station in the manner provided by the invention of the before-mentioned application for patent is clearly well adapted for single-station lines, it is evident that were it similarly placed in association with party-lines a practical difficulty would at once be introduced, because the calls of all of the stations of the circuit would be alike registered by the sole central-station counting mechanism, a single non-discriminative record of service being thereby produced, and because the system affords no means for dividing the calls composing such a single record between the several stations, so that each may be charged only for such proportion of the entire registration as corresponds to the number of calls as it individually has sent in and which have been answered—neither more nor less. It is evident, therefore, that for party-line circuits registering mechanism requires to be placed at each substation and that each such registering apparatus must count and record the answered calls initiated by its own substation only, and it is desirable for efficiency, as well as for uniformity in practice, that the operation of each such registering mechanism shall depend upon the same general principles as underlie the operation of the central-station registering mechanism which counts and records the calls of single-station lines—viz., upon the transmission

through the circuit of two independent and successive current impulses, one resulting from the act of the subscriber in sending the call and the other from the act of the operator in answering the same. Our present invention is based upon and meets these conditions.

At each of the several substations of a party-line telephone-circuit we place a toll or call register, whose counting or multiplying train, by means of a ratchet-wheel and pawls, a star-wheel and pallets, or similar mechanism, is actuated by a polarized electromagnet and armature responsive to changes in the direction of main-line currents and associated with the main circuit.

The subscriber's main-line circuit is normally open and may be closed through the telephones at any substation by the operation of an automatic switch, brought into action by removing the telephone from its resting-place or support. A current-generator, such as a battery, is included in the main circuit, and when the latter is closed by the operation of the said switch the current from the battery traverses the circuit, acting upon the central-station signal appliances to give the call and also acting upon the polar device at the substation (which for this purpose has its electromagnet connected in the normally open telephone branch conductor) and causing the armature thereof to make a movement in a particular direction. This current-impulse is the first of the two which are requisite for the operation of the register, and its effect on the mechanism is to bring it into position, where a second single movement of the armature in the opposite direction will register a call. We may say that the result of the passage of this first impulse through the electromagnet is the production of a half-beat of the registering apparatus, a full beat or two half-beats in opposing directions being necessary to the counting or charging of the call, or generally the operation so far may be described by saying that the first current-impulse so brought about acts merely to set or wind up the counting mechanism, bringing it thereby into a condition where it is capable of responding to a second and reversely-directed current-impulse, which effectuates the desired registration of the call.

A second current-generator is associated with the connecting cords and plugs at the central station to furnish current for the substation-transmitters, and the circuit and switch connections are so arranged that when an answering-plug is inserted into the switch-socket of any line to answer a call the original battery is disconnected and the second is substituted therefor; but the said second battery is so connected with the cord-conductors that the relation of its poles to the main-line circuit shall be opposite to that normally sustained by the poles of the original battery. Hence the current of the said second battery traverses the line-circuit in a direction opposite to that of the current of the first, or, in other words, the line-current is reversed. The current-impulse of this second battery is the final one of the two which conjointly are necessary for the operation of the register or meter at the subscriber's station, and its effect on the said meter is to move the armature back into the original position from whence it was moved by the first current-impulse, and in doing so to release the previously set or wound-up mechanism, or to produce the final half-beat motion of the pointer and its axis, which is requisite in order that the call may be registered. Since the register-magnet at the substations is connected in the telephone branch, the action of the automatic switch is to bring it into the circuit, where it of course stays until the switch is reversely operated by the replacement of the telephone. Moreover, as a movement or half-beat of the register-armature in the setting or winding direction is always the essential preliminary to a registering operation, and as in the case of a called station or the station responding to a call-signal no such preliminary movement of the armature has occurred, it is evident that when the current of the second or substitute battery traverses the line the actuating-armature of the registering appliance will simply remain unmoved, it being already in the position to which such current would tend to move it, and that the call-counting mechanism cannot and will not register or make a charge-record at any substation for communications initiated elsewhere, for incoming business, or at other stations connected together with the calling-station on the same party-line circuit.

In the drawings illustrating our invention, Figure 1 is a front view of a call-registering device embodying our invention. Fig. 2 is a side view of the meter movement and its actuating polarized electromagnetic device. Fig. 3 is a detail showing the electromagnet, armature, pallets, and star-wheel of the said registering device. Fig. 4 is a diagram of a subscriber's telephone-circuit, and Fig. 5 a diagram of one set of plug-and-cord switch connections.

In Figs. 1, 2, and 3, R is the toll-register, having dials *d* to indicate the number of transmitter call-signals, the first or uppermost dial being arranged to register, say, ten calls, the next one hundred, the third one thousand, and the fourth or lowermost one ten thousand calls in single revolutions of their respective pointers. The counting or multiplying motor-train T is of course arranged to revolve these pointers in a well-understood manner, so that the pointers of each of the three lower denominations of dial revolves ten times while that of the dial next higher in succession makes one complete revolution. The total number of calls which have been transmitted and answered can therefore at any time be correctly ascertained by a reading of the several dials taken together.

The multiplying-train may be supported in a framework F, the front and rear plates whereof are perforated to provide bearings for the several arbors of the said train. The arbor 3 of the first or unit pointer has secured to it behind the rear plate a star-wheel *s*, having ten teeth, which are engaged by the pallets s^2 s^3 of an actuating-lever S, secured to and operated by the armature *a* of the electromagnet M. The said electromagnet is shown as being provided with adjustable pole-pieces *m* and m^2, and the armature, which is preferably of soft iron, is by means of an axis *b* hung in journals or terminals *j* j^2. The electromagnet and armature are both polarized by the permanent magnet P, which is so mounted that one of its poles *p* overhangs or bestrides the center of the pivoted armature and inductively imparts a definite fixed polarity thereto and that its other pole p^2 is bolted or otherwise secured to the center of the heel-piece of the electromagnet, so that the two poles of the said electromagnet both receive a like normal initial polarity opposite to that of the armature. The whole constitutes what may be called the "polarized electromagnetic device" E, and while the form shown is efficient and highly convenient it is obvious that the parts and relative magnetic arrangement of such a polarized electromagnetic mechanism can in the present condition of the art be varied within wide limits and that many well-known forms could be associated with our invention without practically affecting its operative merits.

The form and relative arrangement of the armature *a*, pallets s^2 and s^3, and star-wheel *s* is such that to move the said wheel round one-tenth of a revolution, and consequently the pointer attached to the shaft thereof one space on the dial, one complete excursion of the armature from one pole-piece to the other and back again is necessary, one-half beat of such excursion being responsive to the passage through the electromagnet winding of an electric current or current-impulse of definite direction and the other to a second current or impulse of opposed direction—that is to say, the electromagnetic device being polarized is for the movements of its armature dependent on reversals of current.

The star-wheel *s* moves when actuated by the armature and pallets in the direction of the arrow, Fig. 3, and the first half-beat of the armature moves the wheel and the pointer only one-half the distance to the next figure of the dial, the remaining portion of the distance being passed over only when the current is reversed and when the armature in consequence makes its second half-beat.

The second current or current-impulse uniformly should be of such direction that its passage through the coils will restore the armature to its resting position, and the pointer must of course be so adjusted that while the armature occupies this resting position the said pointer rests over or opposite some one of the figures of the dial. It follows that the direction of the current producing the first half-beat must be such as to so excite the cores and pole-pieces that the armature shall be attracted away from its resting position and shall act to move the pointer into the middle of a space between two figures. Thus supposing the first current to be brought into action by the operation of the subscriber in taking his telephone from the switch-hook the pointer advances but half a space, and so far makes no charge; but when the first current is discontinued and the second current of opposite direction is brought into action by the operation of the central-station operator, who in answering the call inserts a switch-plug into the appropriate switch-socket, the pointer advances the remaining half-space and registers one more call to be added to the number answered since the last reading. It is clear that if for some reason the operator fails to answer the pointer necessarily remains on the half-space, so that no charge is made, and it is likewise plain since the pointer does so stay on the half-space and the armature controlling it remains attracted by the pole-piece to which it was drawn by the first current that if the subscriber hangs up his telephone and later again removes it from his hook, thus sending another call, no farther advance of the pointer and consequently no extra charge is or can be made, because the said armature being already attracted as far as it can go in the direction in which it is moved by the calling-current can make no farther advance until the current having been reversed it has been first retracted to its initial or resting position. Furthermore, it is evident that unless the armature has first been moved away from its resting side and the pointer moved through half a space by the calling-current, brought into action by the removal of the substation-telephone from its support, they cannot be moved at all by the operation of plugging in at the central station, for in that case the reversely-directed current thrown on the circuit merely tends to more firmly hold the armatures in their resting position. This consideration is of the highest importance, as it shows that no substation-register will be actuated by the second current, though there may be several stations on the same line, save only that one from whence a call has been transmitted, and also that the register of a substation, which merely answers or responds to a call or which has been called for, will not be operated when the line of such station is switched to that of the station which has called for it.

In Figs. 4 and 5, L represents a party-line metallic telephone-circuit extending from substations X and Z to a central station C, the intervening portion of such circuit being indicated by dotted lines. Each subscriber is shown as being provided with a call-bell B in a bridge 13 between a point 9 on one main conductor *x* to a point 10 on the other main

conductor y of the line-circuit, a condenser k being included in the said bridge, so that while the bell-circuit is conductively open it shall be inductively closed. There is also at each substation a normally open branch or bridge 14, between the points 10 and 12 of the two main conductors y x, respectively, which bridge contains the receiving and transmitting telephones t t^2 and has its continuity controlled by the automatic telephone-switch z, which is operated by hanging the receiver t on the hook h and by removing it therefrom.

When the telephone hangs upon the hook h, the telephone branch 14 is held open between the substance of the switch-lever z and the contact 4, and no current can pass through it from one main conductor to the other; but when the telephone is removed from the hook h the counter-spring u pulls the said lever into contact with the point 4, and a current may flow from one main conductor to the other through the telephones.

At each station the electromagnet of the call-register R is connected in the normally open telephone branch 14, and thus when the telephone is taken up for conversation the said register is brought into the main circuit.

At the central station each circuit L is fitted with one or more plug socket-switches J, into which switch-plugs may be thrust through the frame or test-ring i. The spring-jack or socket-switch J has three electrical contact-surfaces—to wit, a spring 18, connecting by wire x^2 with main conductor x at the point 8, a spring 19, connecting by wire x^3 with main conductor y at the point 7, and the test-ring or socket-frame surface i, connected by wire 23 through the winding of the cut-off relay r with ground or return Y. Normally the line-circuit continues at the central station through an extension-loop q, containing a call-signal relay r^2 and the main call-signal current-generator G, and the said loop connects with the main conductor at the contacts 6 of the armatures o of the cut-off relay r. There is also ordinarily for each subscriber's circuit a local circuit e, containing the signal-receiving appliance d and local battery g and controlled to give or withhold the signal by the signal-relay r^2 through its armature f and front contact-stop 5. These connections and appliances we are aware are of themselves not new; but we employ the generator G for an additional purpose—viz., to excite the electromagnet of the call-registering device at the substation and thereby to set or wind the mechanism thereof ready for action, or to cause the necessary initial half-beat or half-space motion of the armature of said electromagnet.

D D^2 are the switch-plugs of one set of plug-and-cord connections, the conductors only of the associated cord connectors being shown. Each plug has three conducting-surfaces n, n^2, and n^3, these being adapted to make contact, when the plug is thrust into any socket-switch J, with the three conducting-surfaces 18, 19, and i thereof, respectively. The tips n of the two plugs are united by conductor w, the surfaces n^2 by conductor w^2, and the surfaces n^3 are furnished with conductors w^3, leading to supervisory apparatus (not shown and not germane to our present invention) and to a test-battery G^3 and a ground or return connection Y.

A bridge-conductor 15 unites points 16 and 17 on the conductors w and w^2, respectively, and contains a current-generator G^2 and impedance-coils v v^2.

The operator's telephone t^3 can be brought into the circuit to answer a call by well-known means, such as the keys K, which when depressed connect the said telephone between the conductors w w^2 in a bridge, which likewise may contain the condenser k^2.

When the plugs D D^2, or either of them, are placed in the switch-sockets J of any line, the battery G^2 furnishes current for the supply of the substation-transmitter of such line. In our invention it also furnishes the current-impulse required for the second half-beat or half-step of the registering mechanism R of a station which has sent in a call-signal. For this purpose, as has been explained, the second required current-impulse is to be opposite in direction to this first. The drawings indicate that the two generators G and G^2 have their poles so connected with their circuit-conductors that the required reversal of current is certainly brought about when the answering-plug is inserted. The normally-connected battery G has its plus pole united through the relay r^2 and contact 6 with the main conductor x at 8 and its minus pole united to main conductor y. When, therefore, the telephone-bridge 14 at any substation is closed, the current from the said battery proceeds through the magnet-coils of the register R from conductor x at point 12 to conductor y at point 10. When, however, the plug D is placed in the socket J of any subscriber's circuit, the battery G is disconnected and the battery G^2 is substituted therefor; but its plus pole connects by way of conductor w^2, the second conducting-surface n^2 of the plug, and socket-spring 19 with the main conductor y, and its minus pole by way of conductor w, plug-surface n, and socket-spring 18 with the main conductor x. Hence the current from the battery G^2 passes through the magnet-coils of the register R reversely, or from conductor y at point 10 to conductor x at point 12, operating the polarized armature of the said register accordingly.

The apparatus and circuit arrangement of all of the substations X or Z are similar. When either or any one of the several substations of a circuit sends a call and closes the main circuit there, the telephone branches of all of the other stations of course remain open, and as the register-magnet is placed in this branch it results from this arrangement that the reversed current thrown on the line by the answering of a call is prevented from

affecting the registers of non-calling stations in two ways, first, because their mechanisms have not been already set by the operation of the initial current, and, second, because their circuits being open no portion of the answering-current can pass that way.

In the general operation of our invention a subscriber desiring communication with another lifts his telephone from its resting-place on the hook-switch, and thereby closes the main circuit through the telephones at his station and through the electromagnet of his register. The armature of this magnet normally rests near to that one of the magnet-poles which brings it into a position where the pointer operated thereby points directly to one of the figures of the dial. A battery G to furnish current for the operation of the call-signals being connected with the line, the closure of the circuit at the substation permits an electric current to flow through the said circuit and through the register-magnet, and the direction of such current is such as to move the armature to the other magnet-pole, and thus to set the register by moving its pointer a half-step into a position between the figure indicating the total of calls previously answered and the total next to be reached. The same current operates the relay r^2, enabling it to close the local circuit e and display the call-signal d. The central-station operator, observing the call-signal, places the answering-plug D in the switch-socket J, and, closing thereby the circuit of the test-battery G^3 through the cut-off relay r, causes the same to attract its armatures o from their contacts 6, and thus to cut off the extension-circuit q and disconnect the original battery G from the main circuit. The same operation also causes the contact-surfaces n n^2 of the plug to engage with the corresponding socket-springs 18 and 19 in socket J, and the battery G^2 is thus enabled to take the place of G, which has been disconnected, and to supply current for the substation-transmitter; but the poles of the battery G^2 are connected with the circuit in a manner opposite to that in which the poles of the battery G were arranged, and the new current thus thrown on the line is therefore also reversed in direction. The register R responds to this reversal of current direction, its armature swinging back to the original position and imparting the second half-step required to count or register the call. Thus the call being answered is recorded, one of the two current-impulses necessary to such registration having been thrown on the circuit by the action of the calling subscriber and the other by the answering operator. The call-registering devices of the other stations are still in open circuit, and hence remain unaffected. The name or number of the substation with which communication is desired having been made known in the usual way, the operator establishes connection with the line thereof by placing the remaining plug D^2 of the pair in the switch-socket of said line, and though it is true that such action connects the generator G^2 with the line also and that a current therefrom traverses the said line as soon as it is closed by the subscriber, who lifts his telephone from its support, no call is registered at the said desired substation, for, though the answering-current passes through the exciting-helix of the register-magnet there, the armature of the said magnet is not moved under its influence, which merely tends to more strongly hold the said armature in its normal position, the said armature not having previously been moved to its setting position by a current from the normal battery permitted to flow through the line consequent on an initial removal of the receiver from its support, for when a subscriber removes his telephone for use in response to a received call, though the two acts of such removal and of placing a plug in the switch-socket at the central station are both performed, they are performed in inverse order, and therefore cannot exercise any influence upon the call-register of the substation in question.

It is of course obvious that it is not essential to the operation of our invention that there shall be physically separate and distinct generators G and G^2, and that conditions may in some cases prevail in which the same generator may be employed and may by the insertion of the switch-plug to answer the call merely have its poles, and consequently its current, reversed.

Having thus fully described our invention and its mode of operation, we claim—

1. In a telephone system, the combination with a main telephone-circuit extending between a substation and a central station; of a call-register at the substation responsive for the registration of a call, to two successive oppositely-directed electrical current-impulses traversing the said circuit in a definite order; telephone call apparatus at the said substation organized to establish in the circuit the required initial current-impulse of appropriate direction, when operated to transmit the call; and switch apparatus at the central station adapted when operated for the answer of said call to establish in the circuit the required final current-impulse, of direction opposite to that of the first; substantially as set forth.

2. In a telephone-exchange system the combination of a party-line telephone-circuit extending between two or more substations and a switchboard at the central station; with a call-register at each substation adapted to count and register the answered calls of said station only when two successive current-impulses of opposite direction, in a given order, traverse the said circuit; means at each substation controlled by the call-sending apparatus thereof, for establishing the initial current of required direction in the main circuit when the said apparatus is operated to send the call-signal; and other means at the cen-

tral station controlled by the call-answering switchboard apparatus, whereby the second required current-impulse of opposed or reversed direction may be established in the said circuit, when the said switch apparatus is operated to answer such call-signal; substantially as described.

3. The combination in a telephone-exchange system, substantially as hereinbefore described, of a party-line telephone subscriber's circuit; the substation signal mechanism; and the central-station switch apparatus thereof; with a service-registering mechanism at each substation requiring for the registration of a call two independent armature movements, in response to two successive independent main-line current-impulses, following one another in prescribed order; circuit-controlling devices at each substation operated by the said call-signal-sending mechanism, and acting to establish the initial current-impulse required; and current-controlling switch apparatus at the central station for answering the substation-call, and simultaneously establishing the final required current-impulse; whereby a call can be registered only at the station transmitting the same, and only when the operation of transmission and answering have both been performed.

4. In a telephone-exchange, the combination of a main telephone-circuit uniting a number of subscribers' stations, at each of which it is normally open, to a central station where it is normally closed through a current-generator, and signal-receiving devices; with a normally discontinuous portion or branch of the said circuit at each substation; an electromagnetic telephone-call register or meter, contained in the said discontinuous branch, requiring for its operation two successive current-impulses of opposed direction; a circuit-controlling switch adapted to close the said main circuit through the said branch, thereby furnishing the first required current-impulse, and simultaneously transmitting the call-signal; and switching and answering apparatus at the central station controlling the direction of the line-current, and adapted in answering the call to withdraw the original current from the circuit, and to substitute therefor the second and oppositely-directed current required, to complete the registration of the said call.

5. The combination in a telephone-exchange, of a main telephone-circuit extending between a number of subscribers' stations at each of which it is normally open, to a central station where it is normally closed through a call-current generator, and signal-receiving appliances; with a normally discontinuous branch of the said circuit at each substation including the station-telephones; a telephone-call register or meter requiring for its operation two successive current-impulses of opposite polarity, having its electromagnet included also in said telephone branch; an automatic telephone-switch adapted to close the main circuit through the said telephone branch and register-magnet, and thereby establish the current of said call-generator in the said completed circuit; a second current-generator at the central station; switching and call-answering apparatus controlling the poles of both generators, and adapted by the act of answering the call-signal, to withdraw the original generator, and connect the second one but with its poles reversed, substantially as specified herein.

6. In a telephone-exchange system the combination of a normally open party-line telephone-circuit extending between several substations and a central station, and provided at the latter with call-signal apparatus; a source of current normally associated therewith and arranged to establish therein when the circuit is closed a call-current of definite direction; a switch or key at each substation adapted to close the said circuit, for the establishment of such current, and thereby to operate the said call-signal apparatus; call-answering and current-reversing switchboard mechanism at the central station, controlling the connections of the same or a separate source of current, and adapted by the act of answering a substation-call to withdraw the original current and establish in the circuit another of opposed direction; and a register or meter at each substation for counting and recording answered calls, having a polarized electromagnet-actuating mechanism organized to operate by two successive movements, corresponding to the two relatively-reversed successive current-impulses accompanying respectively the independent acts of sending and answering the call-signals; whereby the call-signals transmitted by the several substations may be registered only when they have been answered; substantially as described herein.

In testimony whereof we have signed our names to this specification, in the presence of two subscribing witnesses, this 19th day of June, 1897.

HAMMOND V. HAYES.
THOMAS C. WALES, JR.

Witnesses:
GEO. WILLIS PIERCE,
JOSEPH A. GATELY.