(No Model.) 3 Sheets—Sheet 1.

J. H. BICKFORD.

AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

No. 349,975. Patented Sept. 28, 1886.

Fig. 1.

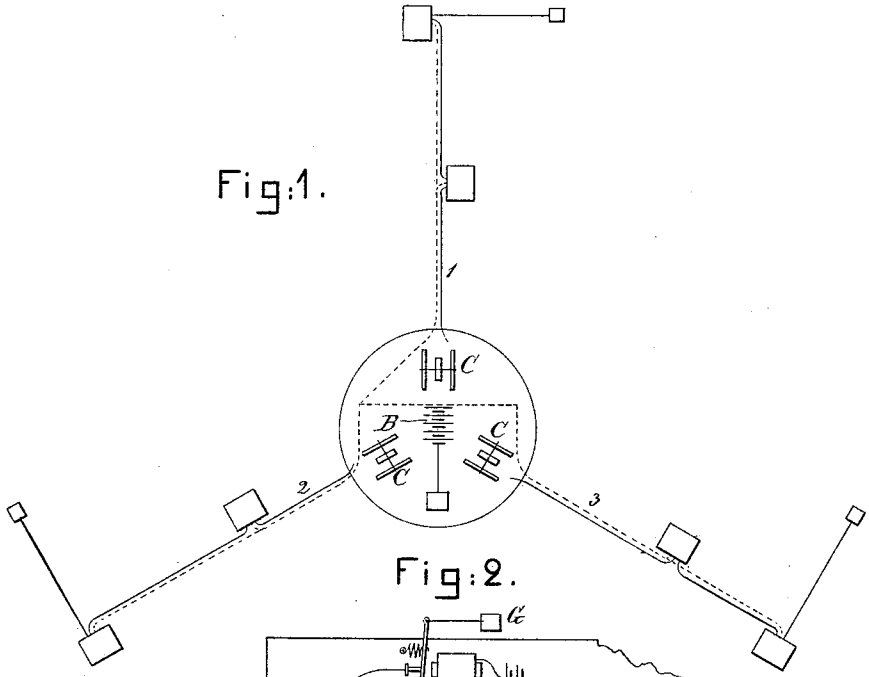


Fig. 2.

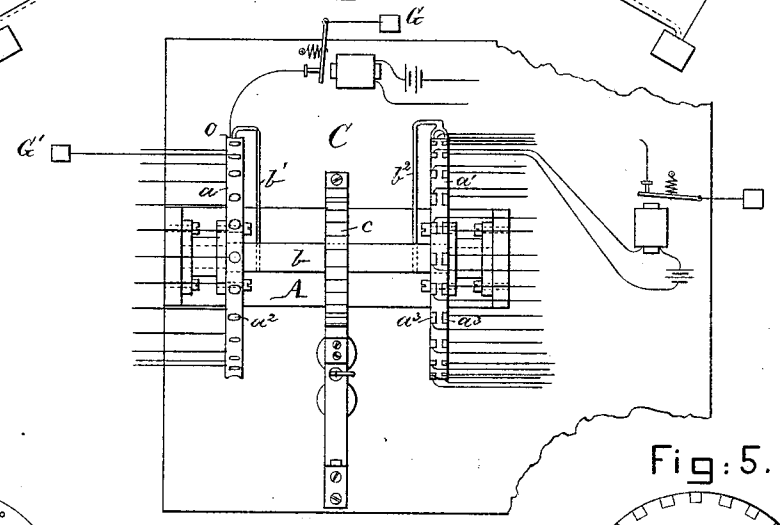


Fig. 4.

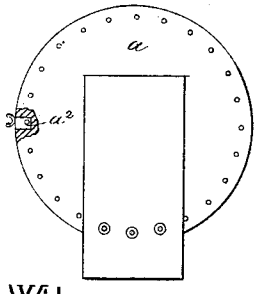


Fig. 3.

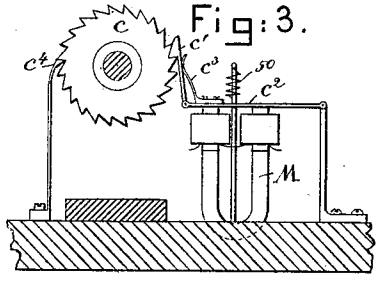
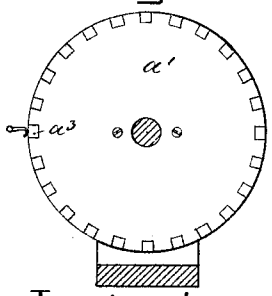


Fig. 5.



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(No Model.) 3 Sheets—Sheet 2.

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AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

No. 349,975. Patented Sept. 28, 1886.

Fig: 6.

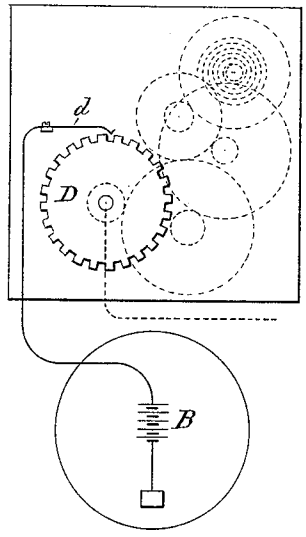
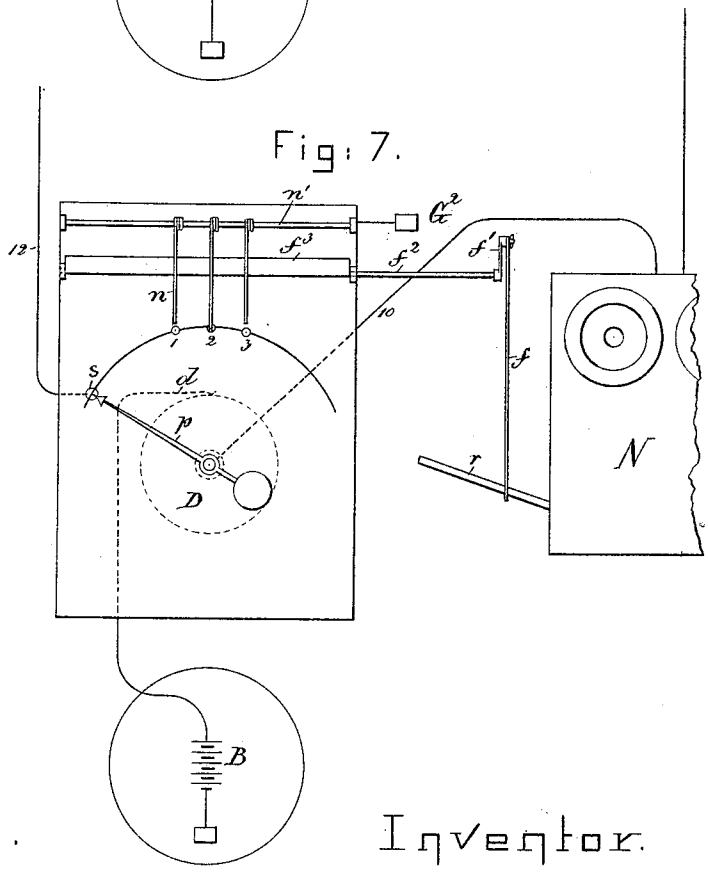


Fig: 7.



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(No Model.) 3 Sheets—Sheet 3.

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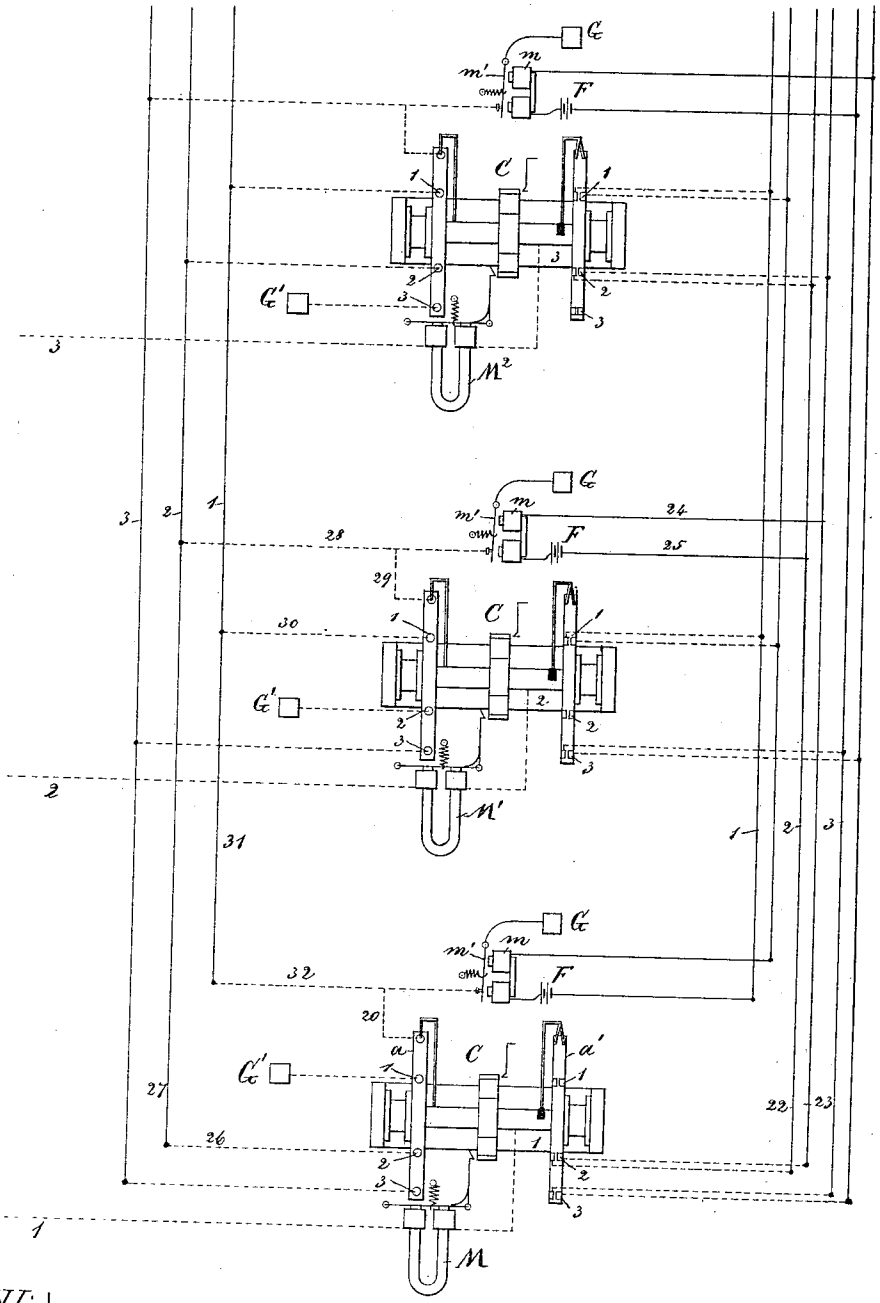
AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

No. 349,975. Patented Sept. 28, 1886.

Fig: 8.



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UNITED STATES PATENT OFFICE.

JOHN H. BICKFORD, OF SALEM, MASSACHUSETTS, ASSIGNOR OF ONE-THIRD TO S. FRED SMITH, OF SAME PLACE.

AUTOMATIC TELEPHONE-EXCHANGE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 349,975, dated September 28, 1886.

Application filed November 25, 1885. Serial No. 183,970. (No model.)

To all whom it may concern:

Be it known that I, JOHN H. BICKFORD, of Salem, county of Essex, and State of Massachusetts, have invented an Improvement in Automatic Telephone-Exchange Systems, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

In telephone-exchange systems as now commonly constructed an operator is employed to make connections and disconnections; but in small cities and villages, where the number of subscribers is comparatively small, a central office employing an operator cannot be maintained, and it has been found desirable and commercially economical to construct a central office which shall be automatically operated to connect and disconnect the several subscribers' lines one with another by the subscribers individually. Various appliances and systems have been organized in furtherance of this plan, and by my invention I seek to improve and extend such plan, so as to render it more useful. With this object in view I have provided a central office containing a series of normally-grounded instruments—one instrument for each subscriber's line leading from the said central office--said instruments comprising suitable means, which, when brought into co-operation, removes the ground-terminals of the said instruments one by one at the will of the subscriber, and also establishes a connection with such other instrument as the subscriber may desire, the ground-terminal of the latter instrument being the final one removed. The instruments at the central office are each constructed substantially alike, are normally grounded and supplied with electro-magnets in local circuits, said electro-magnets, when energized, removing the normal ground-terminals from the instruments. The instruments are interchangeably connected by main-line circuits, while the electro-magnets are also interchangeably connected with the said instruments by the local circuits. The instruments located at the central office—one for each subscriber's line--each consist of two fixed disks, each disk being composed of insulating material, and provided with a series of conducting stops or surfaces, preferably about its periphery, while between the said disks a shaft rotates in suitable bearings, said shaft supporting two pens or contact-pieces at opposite ends, which latter co-operate, respectively, with the disks. The shaft also has mounted upon it a ratchet-wheel, which is moved step by step to rotate the shaft by a pawl fixed to a spring-controlled armature of a polarized magnet. One of the disks of each instrument having the series of conducting stops or surfaces, preferably upon its periphery, while co-operating with the traveling pen or contact-piece, closes the local circuits, thereby operating suitable electro-magnets therein, removing the normal ground-terminals from the remaining instruments, one at a time, while the other disk, also having a series of conducting stops or surfaces, preferably upon its periphery, simultaneously co-operating with its traveling pen or contact-piece, connects the said instrument in circuit with the remaining instruments, one at a time, the subscriber controlling the movement of the ratchet-wheel, thereby determining how many steps shall be taken. The instruments at the central office are each numbered to correspond with the line with which it is intimately connected, and the disks of each instrument are provided preferably with one normal or zero conducting stop or surface, and as many other conducting stops or surfaces as there are instruments or subscribers' lines leading from the central office, the said conducting stops or surfaces of each disk being numbered alike and in rotation, commencing at the zero-stop, and the numbers or stops of each disk bearing corresponding numbers are interchangeably connected by electric circuits. The conducting stops or surfaces of each instrument bearing its own number, counting from the normal or zero conducting stop, are also normally grounded. At the central office a main battery is also located, one pole of which is normally grounded, while from the other pole a battery-line leads beside a subscriber's line to the subscriber's stations. Each subscriber's station is supplied with a suitable call or signal box, and such other appliances as may be necessary. The call-box consists of a break-wheel having a pen or contact-piece connected with the battery-line, and arranged to co-operate therewith, but normally discon-

nected therefrom. The break-wheel is set in motion by a motor, and its shaft is supplied with a pointer, the end of which normally rests upon a contact-piece, both the pointer and contact-piece being connected with the subscriber's line. The break-wheel is preferably provided with as many notches or breaks as there are subscribers' lines, and its pointer swings over a dial having the respective numbers marked thereon. The box is also provided with fingers or stops, which when brought into position over or at a desired number upon the dial limit the further rotation of the pointer, and consequently the break-wheel will only rotate until the pointer strikes the finger, remaining at rest until the finger or stop has been removed or returned to its normal position, when the break-wheel will continue and complete its rotation. When one of the stops or fingers is brought into position at a certain number and the motor started, the pointer leaves it contact-point, thereby opening the line behind it and rotates until it strikes the said finger, there stopping while connection is made with the subscriber's instrument at the central office, and another instrument bearing the number corresponding with the number marked upon the dial, at which point the finger is depressed. The fingers or stops are pivoted at the call-box to a shaft, which latter is normally grounded, and as each subscriber's line is also normally grounded a ground-circuit is offered over which conversation is carried on. As the break-wheel rotates the battery-line is connected at intervals with the main line, and impulses are sent to the central office, which operate the polarized magnet belonging to the subscriber's line over which impulses are transmitted, thereby moving the ratchet-wheel of that instrument as many stops as there are impulses sent. Suitable automatic devices are supplied, whereby the fingers or stops at the call-box are returned to their normal position after a subscriber has finished his conversation, which removal permits the pointer and break-wheel to complete their rotation, thereby, through the intervention of the polarized magnet, completing the rotation of the shaft of the instrument.

I have thus stated in a general way the salient features of this system, and I will now proceed to set forth and finally claim the essential features of my invention. I may, however, remark that, so far as I am aware, the polarized magnet, which is a very essential element of my system, has not heretofore been utilized in effecting the putting of subscribers automatically into connection in such systems of telephony.

Figure 1 shows a diagram of subscribers' lines leading to a central office, a main battery in said central office, and battery-line; Fig. 2, a front elevation of one of the instruments located at the central office with which the subscribers' lines are connected; Figs. 3, 4, and 5, details to be referred to; Fig. 6, a portion of the call or signal box at the subscriber's station, the face-plate being removed and the battery-line connected with the main battery at the central office, which latter is shown in diagram adjacent to the subscriber's station; Fig. 7, a similar view to Fig. 6, the face-plate being added, also a portion of the magneto-bell and the subscriber's line; and Fig. 8, a diagram of the central office, showing three instruments, indicative of three subscribers' lines and the arrangement of the circuits.

It is designed by this invention that several subscribers' lines may lead from a central office and be interchangeably connected by automatically-operated instruments at said central office, whereby the subscriber upon one line may automatically make connection with any other subscriber's line leading from the central office. At the central office a main battery, B, one pole of which is normally grounded, is located, from which the battery-line leads to the several subscribers' stations connecting with said central office, while the several subscribers' lines converge at said central office, and by the intervention of suitable selecting-instruments are interchangeably connected. Each line leading to the central office is provided with a selecting-instrument (see Figs. 2, 3, 4, and 5) which is normally grounded. The said selecting-instruments consist of two fixed disks, a a', connected with uprights of a suitable frame-work, as A. The disks a a' are made of insulating material, and are provided about their peripheries with conducting stops or surfaces, the disk a having a single series, as at a^2, while the disk a' has a double series, as at a^3 a^3. The shaft b, mounted in suitable bearings in the uprights of the frame-work A, and between the disks a a', having rigidly connected therewith two pens or contact-pieces, b' b^2, is rotated intermittingly by means of a ratchet-wheel, c, fixed thereon, which is engaged by a pull-pawl, c', connected with the spring-controlled armature c^2 of a polarized magnet, M, consisting of a permanent magnet having soft-iron cores connected with the poles thereof and insulated wire wound upon the cores. The pawl c' is retained in engagement by a spring, c^3. The pen b^2 is insulated from the shaft b. A retaining-pawl, c^4, is also provided to prevent the ratchet-wheel from backward-movement. As the shaft b rotates the pen or contact-piece b' wipes over the periphery of the disk a, touching the conducting stops or surfaces thereon, while simultaneously the pen b^2, provided with a bifurcated end, wipes over the periphery of the disk a', and thereby touches both series of conducting stops or surfaces thereon.

The selecting-instruments just described, and for convenience lettered C, located at the central office, and one for each subscriber's line, are interchangeably connected by the subscribers' wires, which connect the disks a of each instrument, the said wires being connected with the conducting stops or surfaces thereon, consequently each disk a is provided

with as many conducting-stops a^2 as there are subscribers' lines, and also with one additional conducting-stop, upon which the pen b' normally rests, which may be called "zero." Each selecting-instrument is numbered to correspond with the number of the subscriber's line with which it is intimately connected, as, for instance, referring to Figs. 1 and 8, the subscribers' lines 1 2 3 connect intimately with the selecting-instruments 1 2 3, respectively, and the conducting-stops upon the disk a of the several instruments 1 2 3 will each be characterized by the numbers commencing at zero, as, for instance, the next conducting-stop after zero of each disk a will be numbered 1, which upon instrument No. 1 will be its own number, while upon instrument No. 2 will be the conducting-stop with which instrument No. 1 is connected with No. 2, and so on, while conducting-stop No. 2 upon instrument No. 1 will be connected with instrument No. 2, and conducting-stop No. 2 upon instrument No. 2 will be its own number, as clearly shown in Fig. 8. At each instrument the conducting-stop upon the disk a bearing the number of the instrument itself is grounded at G', for purposes hereinafter explained. The disk a' of each instrument is provided with a double series of conducting-stops, a^2 a^3, there being as many pairs as there are conducting-stops a^2 upon the disk a, and arranged at equal distances apart, so that the pens b' b^2, traveling by means of the shaft b, simultaneously touch their conducting-stops. The disk a' of each instrument is arranged similar to the disk a, in that it has a zero-point, and the pairs of conducting-stops are numbered, counting from zero, the same as the conducting-stops upon the disk a. Local circuits containing batteries F, and electro-magnets m, operating spring-controlled armatures m', which latter control the normal ground-terminals of each instrument, are connected interchangeably with the several pairs of conducting-stops upon the disks a' of each instrument, similar to the subscribers' line-connections upon the disk a, that pair of conducting-stops of each disk a' bearing its own number having no connection whatever, while the zero point or points over which the pens b^2 normally rest are insulated. As before stated, the several subscribers' lines lead from the central office, and the subcribers' stations are looped into the said lines, while a battery-line leads from the main battery B, also located at the central office beside the subscribers' lines, and each subscriber's station is also connected with said battery-line.

Referring to Figs. 6 and 7, the call or signal box by means of which the instruments at the central office are automatically operated are shown, together with a portion of a magneto-bell, and it is obvious that such other appliances as commonly found at a telephone subscribers' station may be located here also, and suitably connected in circuit, although not shown. Each call-box is provided with a break-wheel, D, set in motion, when desired, by any suitable motor and train of wheelwork. The pen d, connected with the battery-line, is arranged to co-operate with the break-wheel D, but is normally disengaged therefrom. A pointer, p, is placed upon the shaft of the break-wheel D, one end of which is connected with the wire 10, being a portion of the subscriber's line, while its opposite end normally rests upon the contact-stud s, which is connected with another portion, 12, of the subscriber's line, so that when the pointer is at rest the current will pass through the wire 12, pointer p, and wire 10, thereby permitting any other box located in the same subscriber's line behind it to transmit its signal.

Fig. 7 represents the box shown in Fig. 6, and the mechanism by which it is connected with the magneto-bell N, the main battery at the central station being shown adjacent to the box to more clearly illustrate the operation. The break-wheel D is supplied with as many notches as there are subscribers' lines, or as there are instruments at the central office, and rotation of the break-wheel D connects the battery line with the subscriber's line, and thereby sends an impulse to the central office for each notch or closure, which will depolarize the polarized magnet M, releasing its armature c^2, and thereby permitting the latter, aided by the force of the spring 50, to engage the next tooth of the ratchet-wheel c, the opening of the line by means of the break-wheel D permitting the magnet M to again attract its armature, and thereby pull the ratchet-wheel c one tooth, and, as the ratchet-wheel c is toothed to also correspond with the number of subscriber's lines, a complete step-by-step process is carried out. Stops or fingers n—one for each subscriber's line—are connected with a rod, n', at each call-box, and are capable of being turned down into the path of rotation of the pointer p, to thereby stop the pointer p at that point. These stops or fingers are arranged at suitable distances apart corresponding with the notches of the break-wheel D, so as to retain the pointer p, and consequently the break-wheel D, at any desired point after it has caused a determined number of impulses to be transmitted, the pen or contact-piece d at the time the pointer strikes the finger or stop n being disengaged. The rod n' is normally grounded at G^2, for purposes to be hereinafter explained, and when the pointer strikes a certain finger or stop, n, the subscriber's line is broken at the contact-stud s, while the circuit from the ground G^2 passes through the rod n', finger n, pointer p, over the subscriber's line 10. Each subscriber's line leading from the central office terminates in a ground-connection, as shown in Fig. 1. After the pointer p has been retained by one of the fingers or stops n a sufficient length of time to allow the subscriber to complete his conversation the subscriber hangs his telephone upon the lever r of the magneto-bell N, which draws the connecting-rod f downward, thereby rotating the crank f', turning the shaft f^2,

which latter is provided with a flat strip, f^3, which strikes the fingers or stops n and returns them to their normal position, thereby permitting the pointer and its break-wheel D to complete its rotation.

The operation is as follows: Normally the circuit is from the main or subscriber's line through the magnet M, shaft b, pen b', thence by wire 20 through the armature m' to the ground. Should the subscriber upon line No. 1 desire to make connection with a subscriber upon line 3, he first depresses the finger or stop n, pointing to Fig. 3, marked upon the face of the call-box, then starts his motor, and the pointer travels forward until it strikes the finger, when it comes to rest. In the meantime the break-wheel D is rotated sufficiently to cause the pin d to connect the battery-line with the subscriber's line three times, thereby sending three impulses. The impulses thus transmitted from the subscriber's station are of opposite polarity to the polarized magnet M, thereby depolarizing it, repelling the armature, while the signal-current coming from any subscriber passes through the polarized magnet in a reverse direction, and being of the same polarity merely acts to attract the armature still stronger. Upon transmitting the first impulse the polarized magnet M by its pawl draws the ratchet-wheel c one tooth, thereby rotating the shaft b sufficiently to cause the pens b' b^2 to come in contact with the conducting stops or surfaces No. 1, which being the number of the instrument, the current will pass from the subscriber's line through the magnet M, shaft b, pen b', and thence to the ground G', the pen b^2, as previously stated, being preferably insulated from the shaft b. The second impulse causes the polarized magnet M to move the ratchet-wheel c another tooth, and thereby the pens b' b^2 to come in contact with the conducting stops or surfaces No. 2, the current at this time passing from the subscriber's line through the shaft and pen b' of the said instrument, the pen b^2, closing the local circuit, thereby permitting the current to pass through the wires 22 23 24 25, causing the magnet m to attract its armature and thereby remove the ground-terminal from the instrument No. 2, while the current leaving the pen b' of the first instrument will pass through the wires 26 27 28 29, pen b' of instrument No. 2, its shaft, and thence reversely through the polarized magnet M to the subscriber's line No. 2, and the third impulse will cause a similar operation and connection of circuits at instrument No. 3 as the second impulse caused at instrument No. 2. Should the subscriber upon line No. 2 want to connect with subscriber's line No. 1, the operation will be similar to that just described, the break-wheel rotating one notch, at which time the pointer will strike the finger No. 1, when the current will pass over subscriber's line 2, through instrument No. 2, its pen b^2 bearing upon the conducting-stop No. 1, closing the local circuit, thereby removing the ground-terminal from instrument No. 1, and the current leaving the pen b' of instrument No. 2 will pass over the wire 30 31 32 20, through the pen b' of instrument No. 1, its shaft, and thence reversely through the polarized magnet M to the subscriber's line No. 1. After the subscriber has completed his conversation he hangs the telephone upon the lever r of the magneto-bell, which, as previously described, returns the fingers or stops n to their normal positions, thereby releasing the pointer, which then completes its rotation, and through the intervention of the polarized magnet M at the central office causes the selecting-instrument to return to its normal position step by step. As will be readily seen, the call-box at the station desiring to communicate being grounded, when the desired connection is made behind the magneto-bell and other appliances a ground-wire is completed over which conversation may be carried on.

I claim—

1. In a telephone-exchange system, the combination, substantially as herein set forth, of a series of subscribers' lines converging at a main or central station, a selecting-instrument, substantially as described, including a polarized magnet for each subscriber's line located at the central office, all of said selecting-instruments being interchangeably connected with each other, a movable contact piece or pen forming a co-operative part of the selecting-instrument, for establishing electrical connection with another instrument, mechanism, substantially as described, for moving the said contact piece or pen, and means, substantially as described, for operating said mechanism from a distance.

2. In a telephone-exchange system, the combination, substantially as hereinbefore set forth, of a series of subscribers' lines converging at a central or main office, a selecting-instrument, substantially as described, including a polarized magnet for each subscriber's line and located at the central office, said selecting-instrument containing a series of conducting stops or surfaces, a co-operating movable contact piece or pen and actuating-motor therefor for causing the contact piece or pen to make connection with the said conducting stops or surfaces consecutively, said contact-piece normally resting upon a grounded conducting-stop, while the remaining conducting-stops are interchangeably connected with corresponding conducting-stops of the several selecting-instruments, with the exception of that conducting-stop which is characterized by the number of the selecting-instrument of which it forms a component part, which latter is grounded.

3. In a telephone-exchange system, the combination, substantially as hereinbefore set forth, of a series of subscribers' lines converging at a central or main office, a selecting-instrument, substantially as described, for each subscriber's line, and located at the cen-

tral office, said selecting-instrument containing a series of conducting stops or surfaces, a co-operating movable contact piece or pen and actuating-motor therefor, for causing the contact piece or pen to make connection with the said conducting stops or surfaces consecutively, said contact-piece normally resting upon a grounded conducting stop, while the remaining conducting-stops are interchangeably connected with corresponding conducting-stops of the several selecting-instruments, with the exception of that conducting-stop which is characterized by the number of the selecting-instrument, of which it forms a component part, which latter is grounded; also a series of pairs of conducting stops or surfaces correspondingly located with the former series of conducting-stops, those two pairs corresponding with the two grounded conducting-stops being omitted, a local circuit connected with each remaining pair, and a contact piece or pen and actuating-motor therefor moved simultaneously with the contact-piece above mentioned, and arranged to make connection with the several pairs of conducting-stops consecutively, but normally disengaged therefrom, electro-magnets in said local circuits and operating to remove the normal ground-terminal from the first mentioned contact-piece.

4. In a telephone-exchange system, the combination, substantially as hereinbefore set forth, of a series of subscribers' lines converging at a central office, a normally-grounded selecting-instrument, substantially as described, for each subscriber's line, located at the central office, and interchangeably connected with each other, a movable contact piece or pen forming a co-operative part of the selecting-instrument, a shaft, to which said contact-piece is attached, a ratchet-wheel, and pawl for rotating the ratchet-wheel, and a polarized magnet controlling the operation of the said pawl and forming part of each selecting-instrument.

5. In a telephone-exchange system, the combination, substantially as hereinbefore set forth, of a series of subscribers' lines converging at a central or main office, a normally-grounded selecting-instrument, substantially as described, for each subscriber's line, located at the central office, and interchangeably connected with each other, a movable contact-piece for each selecting-instrument, and a rotary shaft carrying such contact-piece, a ratchet on said shaft, and a pawl co-operating therewith, and controlled by a polarized magnet, for intermittingly moving the said contact-piece to establish electrical connection between different pairs of the said selecting-instruments, and operating simultaneously with the said contact-piece for removing the ground-terminals from the several selecting-instruments consecutively.

6. In a telephone-exchange system, the combination, substantially as hereinbefore set forth, of a series of subscribers' lines converging at a central or main office, a normally-grounded selecting-instrument, substantially as described, for each subscriber's line, located at the central office, and interchangeably connected with each other, an intermittingly-moving contact-piece under the control of a polarized magnet for establishing electrical connection between different pairs of selecting-instruments, a call or signal box at the subscriber's station, containing a break-wheel and co-operating pen for controlling the movement of the polarized magnet, and means, substantially as described, for stopping the break-wheel at any predetermined point during its rotation for an interval of time.

7. In an electric circuit, a call or signal box containing a motor, break-wheel, and co-operating pen or contact-piece normally disengaged therefrom, and connected with the battery-line, a pointer mounted upon the break-wheel shaft, which latter is connected with the main line, a contact-stud, also connected with the main line, and upon which the pointer normally bears, a series of normally-grounded stops, *n*, arranged to be brought independently into the path of rotation of the said pointer, and against which the pointer strikes when rotated by the break-wheel, thereby determining at will the number of impulses transmitted by the break-wheel breaking the line behind the box and grounding the main line.

8. In an electric circuit, a call or signal box containing a motor, break-wheel, and co-operating pen or contact-piece normally disengaged therefrom and connected with the battery-line, a pointer mounted upon the break-wheel shaft, which latter is connected with the main line, a contact-stud, also connected with the main line, and upon which the pointer normally bears, a series of normally-grounded stops, *n*, arranged to be brought independently into the path of rotation of the said pointer, and against which the pointer strikes when rotated by the break-wheel, thereby determining at will the number of impulses transmitted by the break-wheel, breaking the line behind the box and grounding the main line, and means, substantially as described, for automatically restoring the stop *n* to its normal position, permitting the break-wheel to complete its rotation.

9. An instrument for governing the transmission of an electric current over several normally-grounded subscribers' lines consecutively, which consists of a disk, *a*, having a series of conducting stops or surfaces about its periphery, a pen, *b'*, and rotating shaft *b*, said pen normally resting upon that conducting-stop through which the main-line is grounded, while the remaining conducting-stops are independently connected with the lines having the ground-terminals, a disk, *a'*, having a series of pairs of conducting-stops about its periphery, a pen, b^2, having a bifurcated end and attached to but insulated from the said rotating shaft *b*, thereby moving simultaneously with the pen *b'*, the said pen b^2 normally resting upon an insulated portion of the disk *a'*,

while the several pairs of conducting-stops are connected with local circuits containing local batteries and electro-magnets, which, when operated, remove the normal ground-terminal at one end of the several subscribers' lines consecutively, a ratchet-wheel, *c*, and pawl *c'*, and means, substantially as described, for intermittingly moving the said pawl, all as set forth.

10. In a system for telephonic communication, a series of subscribers' lines leading to a central office, and having normal ground-terminals, a selecting-instrument, substantially as described, for each subscriber's line, located at the central office, and interchangeably connected with each other, means, substantially as described, intermittingly controlled by a polarized magnet, for establishing electrical connection with each of the several selecting-instruments consecutively and simultaneously removing the ground-terminals of each subscriber's line at the central office consecutively, commencing with instrument No. 1, and following in rotation until a desired number is reached, a call or signal box at each subscriber's station containing a break-wheel, and co-operating contact piece or pen normally disengaged therefrom, and connected in circuit with a main battery, the break-wheel having as many notches as there are subscribers' lines, a pointer mounted upon the break-wheel shaft, which latter is connected with the subscriber's line, while the pointer normally bears upon a contact-stud, also connected with the subscriber's line, and means, substantially as described, under control of the subscriber, for stopping the rotation of the break-wheel at any desired point for a period of time, and grounding the subscriber's line at the box in which the break-wheel is rotating, thereby controlling the intermittent operation of the polarized magnet and releasing mechanism for the break-wheel, that it may complete its rotation, all substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JOHN H. BICKFORD.

Witnesses:
D. W. GOOCH,
J. H. CHURCHILL.