No. 782,892. PATENTED FEB. 21, 1905.

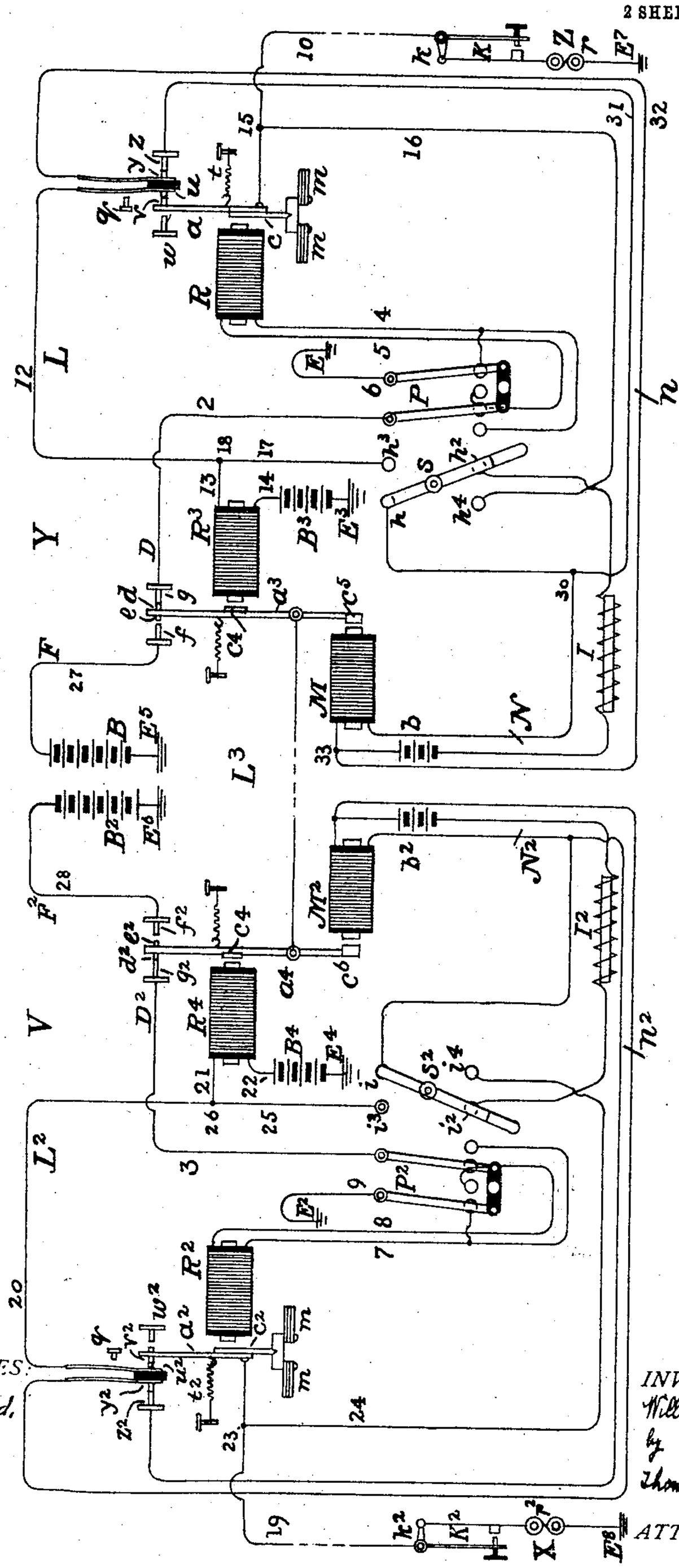
W. E. ATHEARN.

TELEGRAPHIC REPEATING APPARATUS.

APPLICATION FILED MAY 13, 1904.

2 SHEETS—SHEET 1.

Fig. 1.



No. 782,892. PATENTED FEB. 21, 1905.

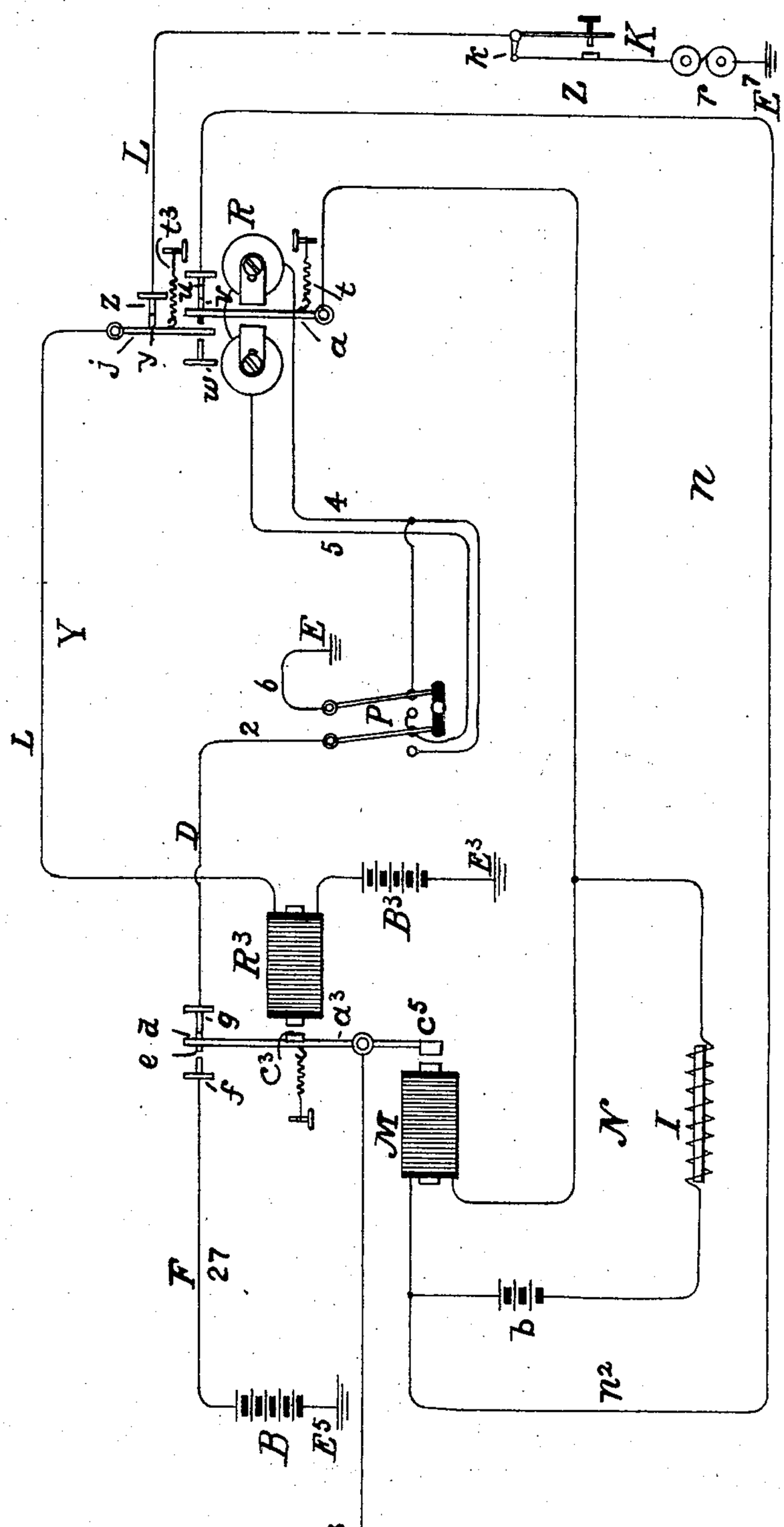
W. E. ATHEARN.

TELEGRAPHIC REPEATING APPARATUS.

APPLICATION FILED MAY 13, 1904.

2 SHEETS—SHEET 2.

Fig. 2.




WITNESSES:

Frank C. Lockwood.

Joseph A. Gately.

INVENTOR.

William E. Athearn

BY

Thomas D. Lockwood.

ATTORNEY.

No. 782,892. Patented February 21, 1905.

# UNITED STATES PATENT OFFICE.

WILLIAM E. ATHEARN, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

## TELEGRAPHIC REPEATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 782,892, dated February 21, 1905.

Application filed May 13, 1904. Serial No. 207,841.

*To all whom it may concern:*

Be it known that I, WILLIAM E. ATHEARN, residing at New York, in the county of New York and State of New York, have invented certain Improvements in Telegraphic Repeating Apparatus, of which the following is a specification.

There are two well-known ways of arranging and working simple telegraphic circuits—viz., the "closed-circuit" system, so called, wherein the source of current is normally connected in the circuit and the signals are transmitted by successive interruptions and completions of the circuit, and the "open-circuit" system, so called, in which the circuit, though composed of a continuous chain of conductors, has no normally connected source of electrical energy, but is supplied therewith in and by the act of transmitting the signals, which act, indeed, consists in successively establishing and disestablishing connection between the circuit and a suitable source of current-supply, such as a battery or dynamo-electric machine. Each of these systems has its own peculiar advantages and disadvantages, and the employment of either in any particular case is properly to be determined by the conditions of such case. In the employment, however, of either system it is often desirable and convenient to work a through line of communication in semi-independent sections or circuits acting upon one another by repeaters, in preference to arranging and operating the same as a single circuit wherein the same current traverses the entire line of communication, and the manipulation of a transmitting-key directly determines the presence or absence of such current in all parts of the circuit. Accordingly many forms of repeating apparatus for closed-circuit systems and some for open-circuit systems have heretofore been devised; but so far as I am aware no telegraphic repeater capable of repeating in either direction between two circuits of the open and closed types, respectively, has prior to my invention been operated or devised.

It frequently occurs that a considerable portion of the business of organizations operating telegraphic or telephonic lines is to lease main lines to private parties, such as bankers and brokers. Under these conditions long main lines uniting two distant cities usually terminate at said cities in central stations, and at such central stations are or may be associated with short extension-circuits leading to the offices of the customer or lessor. For these short extensions the closed-circuit system is generally preferable; but it is also frequently desirable that the long intermediate circuit shall be an open circuit and that they generally shall be operated upon the open-circuit plan.

The objects of this invention are to provide a simple and practical system of reciprocal telegraphic communication over an organized working circuit composed in part of closed circuits and in part of one or more associated open intermediate circuits, to provide means whereby such a compound and heterogeneous line may readily be operated as a single circuit, so that notwithstanding the dissimilar character of its component circuits signals can readily be transferred between them in either direction, and more generally to enable closed and open telegraphic circuits to be worked together, so that each when transmitting shall be capable of transferring its signals to the other without regard to the direction of transmission.

The system and apparatus described, illustrated, and claimed herein comprises a main-line open circuit and two terminal closed-circuit extensions therefor, associated and combined with a repeating device placed between the adjoining ends of the open and closed circuits, the same being responsive to the current changes and signals in each or either circuit and adapted to produce corresponding changes in and thus transfer or repeat such signals to the other circuit.

It also comprises the organization in a single line of telegraphic communication of a main-line circuit normally disunited from any source of electrical energy, two closed circuits extending from the ends of said main line, respectively, to out stations and repeating apparatus placed between the adjoining ends of

each two circuits and adapted to control the continuity of the associated closed circuit and the connection between said open circuit and its source of current.

It consists also in an open and closed circuit repeater to be placed at the junction of open and closed telegraphic circuits and to repeat the signals of either circuit into the other, as either for the time may be the transmitting or the receiving circuit.

In the drawings which accompany this specification, Figure 1 is a diagram conventionally representing the open and closed circuit repeater and its application to a compound telegraphic line composed of open and closed circuits in accordance with the terms of this invention; and Fig. 2 is a similar diagram of one end of such a compound circuit, comprising a single repeater with a modified form and contact arrangement of the open-circuit-receiving relay.

Referring to said drawings, L and $L^2$ are closed telegraphic circuits extending between outlying stations or substations Z and X to principal or central stations Y and V, and $L^3$ is an intermediate open circuit extending between the said principal stations, the whole forming a continuous line of telegraphic communication between the said two outlying terminal stations Z and X.

N $N^2$ are local repeater-circuits, $n$ $n^2$ shunt-circuits associated therewith, and E, $E^2$, $E^3$, $E^4$, $E^5$, $E^6$, $E^7$, and $E^8$ earth connections.

R $R^2$ are the relays (by preference of the polarized type) of the intermediate open-circuit main line $L^3$, included in normally attached branches 2 3 thereof at the two terminal stations Y and V, respectively. The armatures $c$ $c^2$ of these relays (shown in Fig. 1 as being polarized by the permanent magnets $m$) are attached to levers $a$ $a^2$, provided with retracting-springs $t$ $t^2$ and adapted to oscillate between the forward limit-stops $w$ $w^2$, which have no electrical connections and may in practice be tipped with some non-conducting material, and the yielding or resilient back contact-stops $u$ $u^2$. The said relays are also provided with a supplementary set of armature-contacts $y$ $z$ and $y^2$ $z^2$, the contacts $y$ $y^2$ being resiliently mounted and adapted to move with the previously-mentioned contacts $v$ $v^2$ of the first pair, albeit insulated therefrom, and the contact $z$ $z^2$ being fixed and arranged to serve as the ultimate back stops.

The form of polarized relay indicated in Fig. 1 is that described in United States Patent No. 324,799, granted to me August 25, 1885, and comprises an ordinary neutral electromagnet, the armature $c$ magnetized with a definite polarity by the bank of permanent magnets $m$ whereon it is mounted, and the spring $t$ strong enough to hold the said armature in its retracted position, notwithstanding its magnetized condition, as long as the magnet-cores remain unenergized. It is evident that when either of the terminal batteries becomes connected with the line $L^3$, if the direction of current be such as to develop in the magnet of the relay R or $R^2$ polarity of the same sign as that of the armature, the said armature will still remain in its retracted position, the repellent force of like polarities being then superadded to the pull of the spring; but when the direction of current in line $L^3$ is such as to develop a magnetic polarity in the magnet opposite to that of the armature the reciprocal attraction between the magnetic poles and the armature will attain its maximum and will be sufficient to move the latter sharply forward against the pull of the spring. Since the relays R $R^2$ are each to be operated by the current of the battery at the distant end of the line, it is obvious that batteries must be so poled as to determine the requisite operative polarities in said relays, or, what is the same thing, that the relays shall be so connected with the circuit that the current through them shall be properly directed. This is readily arranged for by means of the double switches P $P^2$, which by being moved from either of their positions to the other are adapted to transpose the relation of the relay-conductors 4 and 5 and 7 and 8 to the line branch and ground-wires 2 and 6 or 3 and 9, as the case may be. Since in the normal condition of the intermediate open circuit $L^3$ there is no current on the line, the armature-levers of the relays R $R^2$ rest normally on their back-stops, the members of the two sets of contact-points $v$ and $u$ and $y$ and $z$ controlled by said armatures being thus held together; but when the armatures are attracted to their magnet-poles the separation of the points $y$ and $z$ first occurs, being, however, instantly followed by that of the points $u$ and $v$. The springs carrying the two resiliently-supported points $u$ and $y$ are, as indicated, adjusted in such wise that when released they tend to move in the direction of the forward stop $w$. They therefore follow the armature-lever in its forward motion for a short distance, but come to rest on the stop $q$; but the armature continuing to move the dissolution of the contact between $u$ and $v$ is then effected.

B and $B^2$ are the terminal batteries of the intermediate open circuit at the principal stations Y and V, respectively, and it is expedient in order that the line shall promptly be cleared of electrostatic charges due to either that they shall be connected with poles of opposite sign to line.

$R^3$ and $R^4$ are the receiving and repeating relays of the closed extension-circuit lines L $L^2$, having ordinary actuating-armatures $c^3$ $c^4$ and supplementary armatures $c^5$ $c^6$, the two armatures of each being mounted on single armature-levers $a^3$ $a^4$, but on opposite sides of the fulcra thereof. The said relays $R^3$ $R^4$ are provided with associated holding or retaining magnets M $M^2$, mounted in operative relation

to the said supplementary armatures $c^5$ and $c^6$ and adapted to exercise attraction thereon, and the said magnets are connected in the local circuits N $N^2$ with the batteries $b$ $b^2$ and the electromagnetic resistances or reaction-coils I $I^2$. The armature-levers $a^3$ and $a^4$ of relays $R^3$ $R^4$ move between limit-stops $f$ $g$ and $f^2$ $g^2$, which are also contacts and are themselves provided with front and rear contacts $e$ and $d$, $e^2$ and $d^2$, coöperating with the fixed points $f$ $g$ and $f^2$ $g^2$, respectively.

Simple switches $s$ $s^2$ are provided to separate the two closed circuits L $L^2$ from the intermediate open circuit $L^3$ when it is desired to work them separately, and for this purpose the said switches may be turned from the buttons $h$ $h^2$ $i$ $i^2$ to the other pairs of buttons $h^3$ $h^4$ $i^3$ $i^4$.

$B^3$ and $B^4$ are the line-batteries of the closed-circuit lines L and $L^2$.

At the outlying terminal stations Z and X $r$ $r^2$ represent receiving instruments of any desired type, K $K^2$ transmitting or signaling keys, and $k$ $k^2$ the circuit-closing switches of said keys.

Referring now to the circuits of the system, the closed main circuit L, beginning at the substation-ground $E^7$, is traceable through the receiving instrument $r$, the key K or its circuit-closer $k$, and conductor 10 to the armature-lever $a$ of the open-circuit relay R, thence by the spring-contacts $v$ and $u$, conductors 12 and 13, the magnet-coils of its own relay $R^3$, conductor 14, and the current source $B^3$ to the earth connection $E^3$. The distant closed-circuit line $L^2$ extends between its substation X and its principal station V by a similar course, including its sending-key $K^2$ with circuit-closer $k^2$, its receiving instrument $r^2$, contacts $u^2$ $v^2$ of relay $R^2$, the magnet of relay $R^4$, and the battery $B^4$, and comprising the conductors 19, 20, 21, and 22 and the earth connection $E^4$. From points 15 and 23 on the conductors of circuits L $L^2$ branches 16 and 24 extend to the switch-buttons $h^4$ and $i^4$, respectively, and when the switches $s$ $s^2$ are turned to separate the circuits such branches are continued through the switch-levers to the corresponding buttons $h^3$ and $i^3$ and the extension branches 17 and 25 to points 18 and 26 and thence to the relays $R^3$ and $R^4$ of the two lines. The main portion of the intermediate open circuit $L^3$ extends from the armature-lever $a^3$ of the relay $R^3$ of closed circuit L at the principal station Y to the armature $a^4$ of relay $R^4$ of closed circuit $L^2$ at the principal station V. Since there is current normally flowing in the said circuits L $L^2$, the said relays are normally excited and their armatures are normally attracted to their forward contact-stops $g$ $g^2$. The circuit extensions D $D^2$, extending from contact-stop $g$ to earth connection E by way of conductor 2, switch P, and conductor 6 and from contact-stop $g^2$ to earth at $E^2$ through conductors 3 and 9 and switch $P^2$, are therefore normally attached terminal branches of the open circuit $L^3$ and contain, respectively, its relays R and $R^2$. Normally detached terminal branches F $F^2$ of the said open-line circuit $L^3$ extend from the back contact-stops $f$ $f^2$ of the relays $R^3$ $R^4$ of the two closed-circuit lines L $L^2$ to earth connections $E^5$ $E^6$ by way of conductors 27 and 28, the branch F containing the main current source B at principal station Y of said line $L^3$, and the branch $F^2$ containing the main current source $B^2$ of station V at the other end of said line. These batteries are thus adapted to be connected with the line and brought into action whenever the closed-circuit relay-armature levers are retracted and to be disconnected when the said armature-levers are attracted. When the open circuit is repeating into the closed circuit at either end of the line, it is necessary that the armature of the said closed-circuit relay shall be retained in its forward position, and thus prevented from making false breaks of the transmitting-circuit at the contact-points $d$ $g$ of said closed-circuit relay. For this purpose the electromagnets M $M^2$ are provided. They are connected in local circuits N $N^2$, which may be traced from their batteries $b$ $b^2$ through the coils of their respective magnets, thence to buttons $h$ and $i$, the switch-levers $s$ $s^2$, the switch-buttons $h^2$ and $i^2$, and the electromagnetic resistances or reaction-coils I and $I^2$ back to the batteries. The operation of the magnets M $M^2$ is controlled by short-circuiting shunt-circuits $n$ $n^2$, arranged round said magnets, said shunts being themselves controlled by the second set of contacts $y$ $z$ of the open-circuit relay. Taking, for example, the shunt $n$ of the local retaining-magnet circuit N, it is shown as comprising conductors 31 and 32, extending from any point 30 on the conductors of circuit N between the magnet M and the reaction-coil I through said contacts $y$ and $z$ to any other point 33 between the battery and the other terminal of said magnet. When the shunt is closed at said relay-contacts, the magnet M is short-circuited therethrough; but when by the separation of said contacts the said shunt is opened the entire current is permitted to flow through the magnet, which may then attract its armature. The reaction-coil is, however, always in the direct path of the current and operates to accelerate the magnetization of magnet M when the shunt is opened, for since the current through it is much stronger when the resistance of the magnet is shunted than when said magnet is in the circuit its self-inductive discharge, due to the weakening of the current when the shunt is opened, surges through said magnet and quickens its action in a marked degree. Since this quickening permits the use of a wider gap between the magnet-poles and the armature when the latter is retracted than would otherwise be permissible, it is evident that the armature tends to be quicker in its retraction also. In the open and

closed circuit repeater, which constitutes a cardinal feature of this invention, the open circuit leads through contacts of the closed-circuit relay $R^3$ and then (normally and while signals are coming in over it to be repeated into the associated closed circuit) through the coils of its own relay R to its earth terminal E, having also an alternative earth connection through other contacts of the closed-circuit relay, through which it may receive current for the transfer of signals into it from the closed circuit. The closed circuit leads through contacts of the open-circuit relay R and then passes on through the magnet-coils of its own relay $R^3$ to its current source and earth terminal $E^3$. The said repeater as an entity may therefore be regarded as consisting of the relays of the said open and closed line-circuits, the repeating-contacts of each circuit operated by the relay of the other, and the means actuated by the second set of contacts of the open-circuit relay for preventing the undesired action which tends to produce false breaks of the armature of the closed-circuit relay. The open circuit repeats into the closed circuit by controlling its continuity, while the closed circuit repeats into the open circuit by controlling its supply of current.

The arrangement of Fig. 2 does not differ in any essential respect from that of Fig. 1. It, however, shows but one such repeating apparatus as is defined above and also shows an arrangement modified in respect to the form of the open-circuit relay R and its repeating-contacts. In Fig. 2 the relay shown is of the more ordinary polar type, and the armature *a* thereof having a retracting-spring *t* acts directly upon the contacts *u v* of the shunt *n* of the retaining-magnet circuit only, there being a supplementary pivoted lever *j*, carrying one contact *y* of the closed-circuit line set and a fixed contact-stop constituting the other, *z*. The said lever *j* works between an insulated pin of the armature *a* and a simple front stop *w* and is held with the points *x* and *z* normally in contact by a suitable spring $t^3$. In either arrangement the adjustment of the contact-points of this relay should be such that the contacts *u* and *v* of the shunt controlling the operation of the retaining-magnet M shall separate an instant before the separation of the main closed-circuit contacts *y* and *z* in order that the said magnet M shall surely be able to attract the armature $c^5$ of the armature-lever $a^3$ of relay $R^3$ before the attraction of the main magnet of said relay upon the principal armature $c^3$ of said lever shall have relaxed.

In the operation of this system and repeating apparatus when signals are to be sent from a closed circuit to an open circuit—say from L to $L^3$—the closed circuit is opened and closed by the key K at any station, as Z. When the key opens the circuit, the main-line current of the battery $B^3$ can no longer excite the magnet of relay $R^3$ of said circuit, and the armature $a^3$ is drawn backward to its rear contact *f*, the open circuit $L^3$ being thereby disconnected from its normally attached terminal branch and relay R and connected with its normally detached terminal branch, which includes the current source B. Current is thus supplied to the open intermediate circuit $L^3$, flowing thereover for the operation of the distant polarized relay $R^2$ and the consequent operation of the distant closed circuit $L^2$ in correspondence with that of the home or transmitting closed circuit L. The operating-step of breaking circuit L has the effect of putting current on circuit $L^3$, and of course the step of closing-circuit L must also have the effect of withdrawing current from $L^3$. This, however, is rectified by the circumstance that at the distant station the relay $R^2$ of the open circuit operates to open the associated closed circuit at such station, and the effect, therefore, of opening and closing the closed circuit L is to similarly open and close the closed circuit $L^2$, and vice versa. Considering this, it may be assumed that signals have been impressed upon the open circuit by the operation of the closed circuit L at one end thereof and are being received at the other end and repeated into the receiving closed circuit $L^2$. The current from the open-circuit battery B coming over the line $L^3$ enters the repeater at station V at armature $a^4$ of the relay $R^4$ of the closed circuit $L^2$, passing on through forward contacts $d^2$ $g^2$ of said relay and then via the reversing-switch $P^2$ to the magnet of the open-circuit relay $R^2$, causing the armature of that relay to move to its forward stop $w^2$. This opens the closed-circuit line $L^2$ by the opening of the points $v^2$ and $u^2$. The armature $a^4$ of the closed-circuit-line relay $R^4$ does not, however, fall back as its circuit is thus opened, being held in its normal forward position by the retaining-magnet $M^2$, that magnet having been brought into action before the separation of contacts $u^2$ $v^2$ by the previous separation of contacts $y^2$ $z^2$ and the consequent opening of the short-circuiting shunt $n^2$. When battery B is again disconnected from the open-circuit line $L^3$ by the recurring closure of the transmitting closed circuit, the open-circuit relay $R^2$ permits its armature to be again retracted by the spring $t^2$ and again closes the closed-circuit line $L^2$ at contacts $u^2$ $v^2$, restoring also the shunt-circuit round the retaining-magnet $M^2$.

The dotted lines in the conductors of the closed and open main circuits L $L^2$ $L^3$ indicate any required length of circuit-conductor and that the instrumentalities of the circuit on the two sides of said dotted sections are in any event some considerable distance apart.

Having thus described the invention and its mode of operation, the following are the combinations claimed.

1. In a system of through telegraphic communication, the combination substantially as hereinbefore set forth, of two terminal closed telegraphic circuits; an intermediate open telegraphic circuit; and a repeater connected between each of the said closed circuits and the adjoining end of said open circuit, the said repeater being responsive to signals in either open or closed circuit, and adapted in either case to repeat such signals into the other circuit.

2. In a system of through telegraphic communication, the combination of two central stations at a distance from one another; an open-circuit telegraphic line extending between them; an out-station subsidiary to each central station; a closed-circuit extension-line extending between each central station and the out-station subsidiary thereto; and an open and closed circuit repeating apparatus located between each end of said open-circuit line and its associated closed-circuit extension, and adapted to repeat from each into the other; substantially as specified.

3. A telegraphic repeating apparatus to be placed between the adjoining ends of open and closed main telegraphic circuits, and to repeat from each into the other, consisting of a relay in the said open telegraphic circuit controlling the continuity of said closed circuit; a battery or current source terminal branch for said open circuit normally disunited therefrom; and a relay in said closed circuit controlling the connection between said open circuit and said source and adapted to establish or disestablish the same according as its armature is retracted or attracted; substantially as described.

4. In a telegraphic repeating apparatus, the combination with an open telegraphic line-circuit; and a closed telegraphic line-circuit; of alternative terminal branches for the former including respectively a receiving-relay, and a battery; and a second relay having its magnet in the closed-circuit line, and its armature-lever in the open-circuit line, the said armature-lever constituting a switch for transferring the said open-circuit line between the said alternative relay and battery terminal branches; substantially as set forth.

5. In an open and closed circuit telegraphic repeater, the combination of a closed telegraphic line-circuit; an open telegraphic line-circuit; a normally detached terminal branch for the latter circuit including a suitable source of current; a normally attached terminal branch therefor; a relay for the said open circuit connected in the said normally attached terminal branch thereof, and having armature-contacts controlling the continuity of the said closed circuit; and a relay connected in the said closed circuit and having armature-contacts controlling the connection of said open circuit with its current-supply and relay terminal branches alternatively; substantially as set forth.

6. In a telegraphic repeating apparatus, the combination of an open telegraphic line-circuit; a closed telegraphic line-circuit; two alternative terminal branches for the said open circuit; a relay having its magnet in said closed circuit, and its armature-lever in the said open circuit forming a switch adapted to transfer the main conductor of said open circuit between said terminal branches; a source of current for said open circuit in one of said terminal branches; a local circuit and a retaining-magnet for the armature of said closed-circuit relay included therein; a controlling-shunt for said retaining-magnet; and a relay for the said open-circuit telegraph-line having its magnet connected in the other of said terminal branches thereof, and having two sets of armature-contacts, one set arranged to establish and disestablish the continuity of said closed circuit, and thereby to repeat thereinto, and the other to open and close said controlling-shunt; substantially as and for the purposes set forth.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 9th day of May, 1904.

WILLIAM E. ATHEARN.

Witnesses:

H. S. TENNEY,

WALTER J. FISHER.