(No Model.)

D. H. KEELEY.

TELEGRAPH CIRCUIT.

No. 440,164. Patented Nov. 11, 1890.

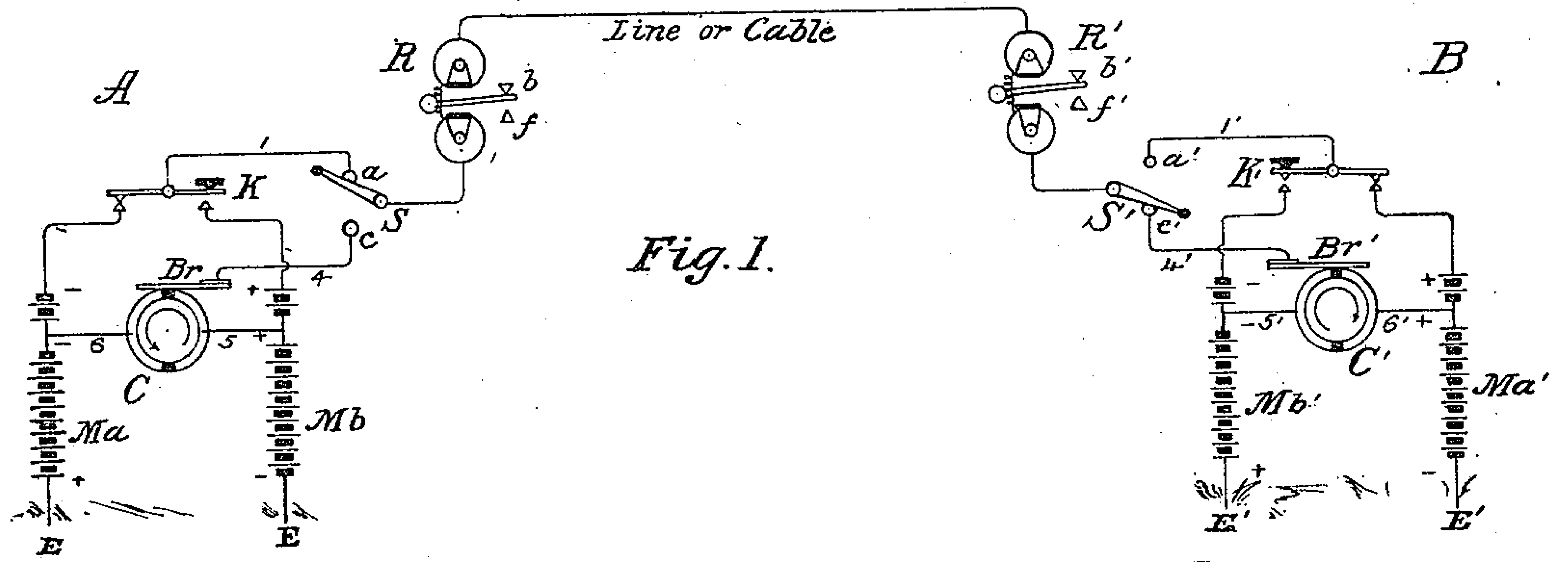

Fig. 1.

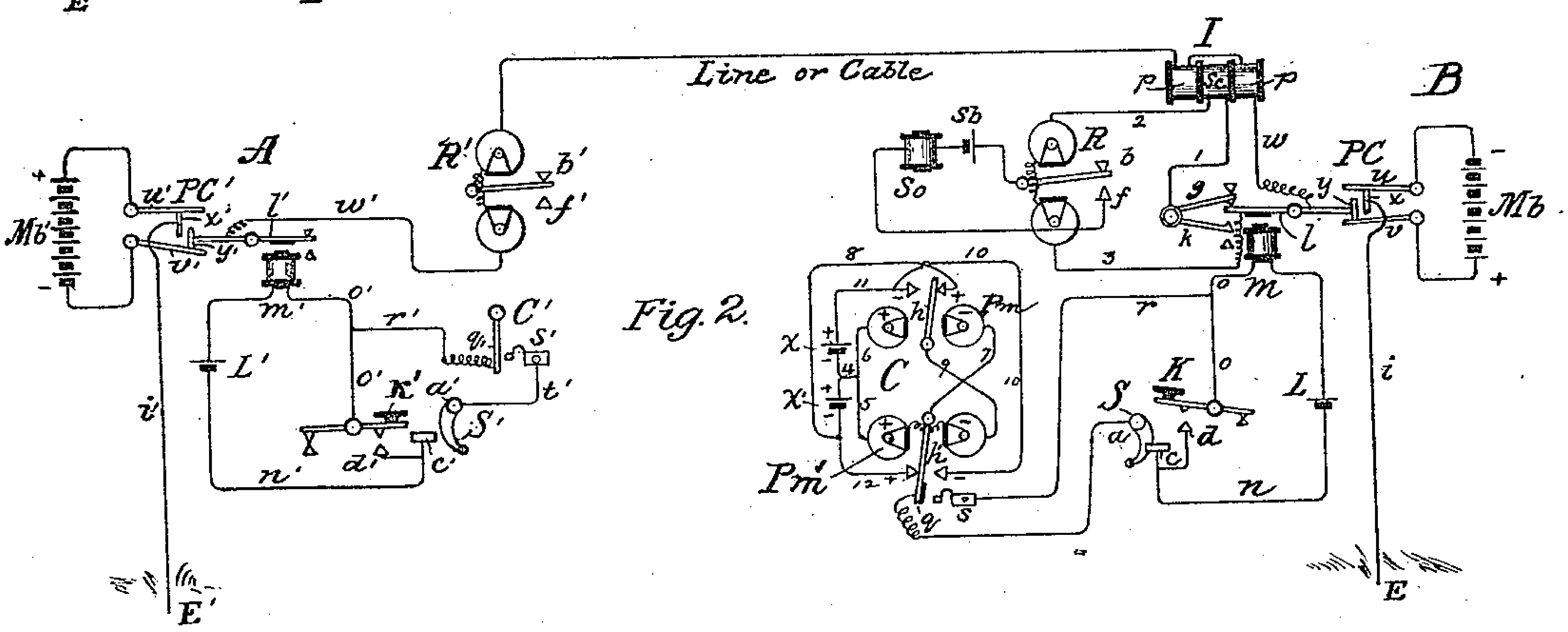

Fig. 2.

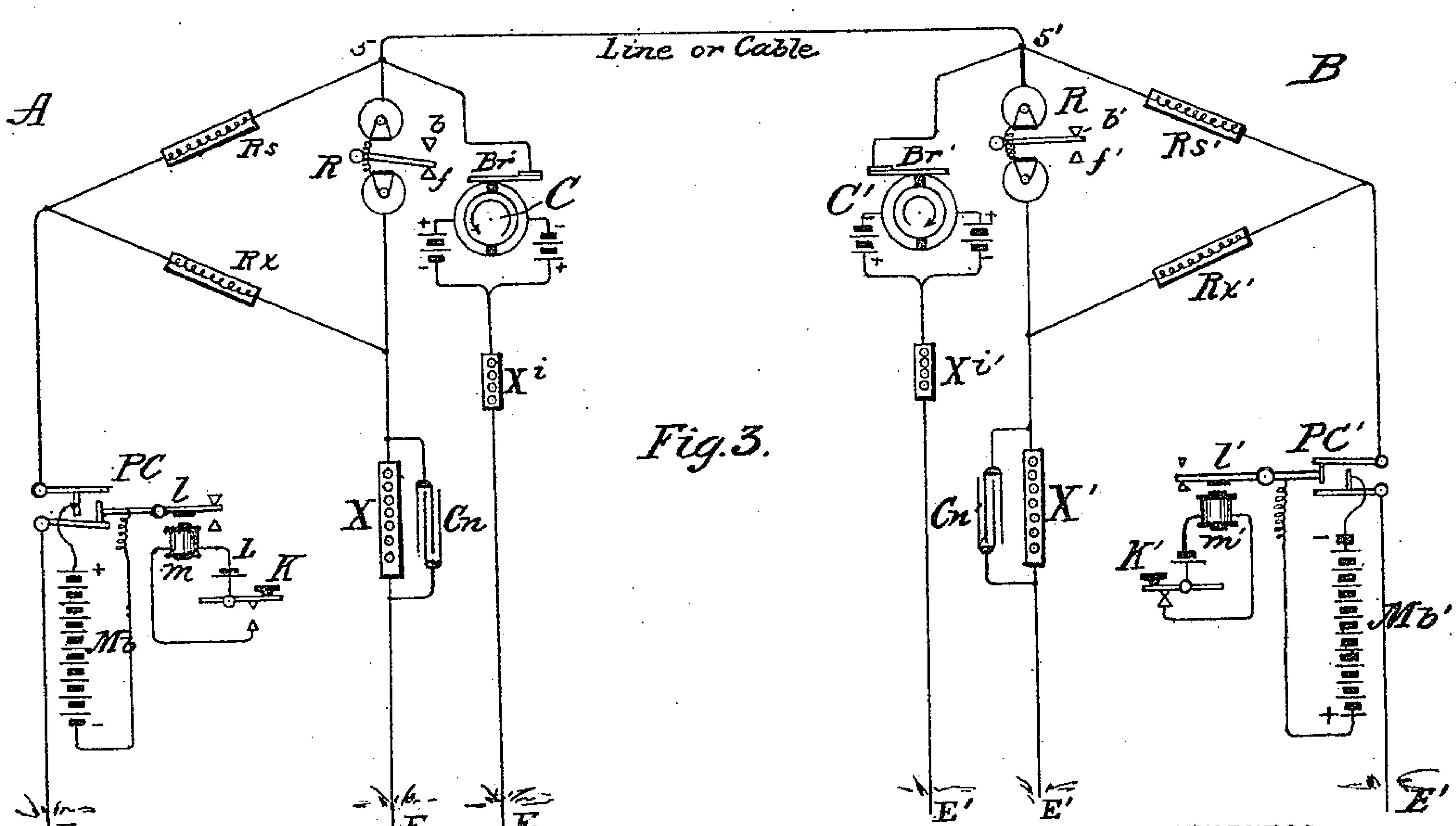

Fig. 3.

WITNESSES:

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TELEGRAPH-CIRCUIT.

SPECIFICATION forming part of Letters Patent No. 440,164, dated November 11, 1890.

Application filed November 4, 1889. Serial No. 329,197. (No model.)

To all whom it may concern:

Be it known that I, DAVID HERBERT KEELEY, a subject of the Queen of Great Britain, residing in Ottawa, in the Province of Ontario, Canada, have invented certain new and useful Improvements in the Operation of Telegraph-Circuits, of which the following is a specification.

My invention consists in a new arrangement of signaling apparatus whereby the interference from statical electricity in a circuit is entirely eliminated.

It has long been recognized that the transmission of signals in a telegraph-circuit is greatly interfered with by the phenomenon of static charge and discharge due to the electrification of the conductor, and so well have the conditions occasioning this phenomenon been studied that well-defined laws are laid down in the text-books, whereby the signaling capacity of any given conductor can be mathematically determined, and it has become an accepted fact that the economical operation of a simple Morse telegraph-line is limited to a certain mileage of the circuit-wire. In duplex and other multiplex systems of telegraphy the practicable length of line for efficient operation has been limited to a very marked degree, and in the operation of long submarine cables the speed of signaling is far below the practicable rate of an ordinary operator's manipulation, despite the use of specially-designed and delicate apparatus.

The object of my invention is to remove the impediment above described, and to render the transmission of signals both in single and duplex circuits on aerial or submarine wires of the greatest length easily practicable at the highest rates of speed. I accomplish this by the simple expedient of providing a rapidly-reversing current at the receiving end of the line, and at the sending end a double current-transmitter. The receiving-instruments are polarized. If the sending-key is depressed, a current of one polarity (say +) goes to line and charges the conductor. If the current-reverser at the distant end presents a — current to line, that current combines with the + current transmitted and effects the polarized receiver in one direction, say closes it. When the current-reverser presents a + current to line, it is opposed by the + current transmitted. Hence no effect is produced in the receiver, which remains closed. If the key at the sending-station is upraised, a — current goes to line. When the current-reverser at the receiving end presents + to line, it combines with the — transmitted and effects the polarized receiver in the direction opposite to that imparted before and opens it, and when the current-reverser presents — to line it is opposed by the — transmitted. Therefore no effect is produced and the receiver remains open. Hence the distant receiver is actuated by the distant battery under the operation of the sending-key.

The phrase "rapidly-reversing current" above used does not mean and is not calculated to imply that the reversals occur more quickly than it would be possible for the armature of the receiving-instrument to follow. They are, however, sufficiently rapid to produce + and — phases twice as fast as could be produced by a Morse operator in manipulation—that is to say, in the formation of a dot on the sending-key a + and a — current will be presented to line at the receiving end. On investigation I have found that the formation of a dot by the operator in Morse transmissions at the rate of forty words per minute occupies one twenty-fourth of a second. I require, therefore, for the operation of my invention forty-eight reversals of current per second to accommodate the fastest operators, while for ordinary rates of transmission lower rates of reversals will suffice. Since, however, the rate is variable, it would be inexpedient to set down any number invariably. Hence the phrase "rapidly-reversing current" is employed.

Single Morse circuits of great length have not heretofore been practicable, for the reason that in makes and breaks affected by movements of the key at the sending end the duration of the breaks does not allow sufficient time for the charge emanating from the battery at the distant end to withdraw from the circuit. The receiving-instrument consequently remains closed where makes and breaks rapidly occur.

In duplex and other multiplex circuits and in submarine cables the difficulty is that in many such circuits heretofore the receiving-instrument is actuated by currents emanating from the sending end alone. When the line is charged and the battery then withdrawn, the charge flows out at both ends to earth at the sending end, and through the receiver to earth at the distant end. The discharge-current renders the receivers sluggish in action, and the sending-currents must be heavy in order to be effectual in the circuits of land-lines operated in this way. In long cable-circuits heavy currents are inadmissible, a weak current is employed, and it is so attenuated after coursing through the great resistance of the conductor that receiving-instruments of great sensitiveness are necessarily employed. These are therefore rendered correspondingly sluggish by the action of the discharge-currents despite the application of special devices to accelerate their movements, and the speed attainable in signaling is consequently very low.

From what has heretofore been set forth it will be seen that all of the above-explained defects are obviated by the device constituting the principal element of my invention.

The principle and function of my invention having now been clearly set forth, the method of its application will be readily perceived by reference to the accompanying drawings, in which—

Figure 1 shows the plan of equipment of a single circuit. Fig. 2 shows the same with details of the current-reverser and receiving-instruments. Fig. 3 shows how my invention is applied to duplex circuits in land lines or cables.

In Fig. 1, at station A, R is a polarized relay of any suitable description. *Ma Mb* are main-line batteries connected to the back and front stops, respectively, of a sending-key K. The batteries *Ma Mb* are also connected to the opposite halves of a two-part commutator C, which is rotated under the brush B*r*, and consequently presents to it the currents from *Ma* − and *Mb* + alternately. The + pole of *Ma* and the − pole of *Mb* are connected to earth.

S is a three-point switch, to the arm of which the main-line wire, through the relay R, is connected. When the switch S is closed on the point *a*, the main line is connected with the key K, and when S is closed on the point *c* the main line is connected with the brush B*r*. The parts at station B are identical and correspondingly lettered. Station A is represented as sending to station B. The switch S at A is closed on the point *a*, and the switch S′ at B is closed on the point *c*′. At station B the rotating commutator C′ alternately presents + and − currents from the batteries *Ma*′ *Mb*′ to the main line. These alternations are made at the rate of about twenty-four per second, or twice as fast as the rate of practicable manipulation of a key in Morse transmission. At station A the key *k* is open and resting on its back stop, and its position presents the − current of the battery *Ma* to the main line. The circuit is traced from E at A through battery *Ma*, key K, point *a*, switch S, through relay R to line, thence through relay R′ at B, switch S′, point *c*′, wire 4′ to brush B*r*′ on the commutator C′, thence by wires 5′ and − *Mb*′ to earth at E′ or by wire 6′ and + *Ma*′ to E′. There is therefore a − current traversing the line from station A. When the commutator C′ at B presents a − current to line, the one neutralizes the other, and no effect is produced in the relays R R′; but when the commutator C′ at station B presents a + current to line the one current combines with the other, and the combined current operates to actuate the relays R R′. With the − current from A therefore the + current at B operates to actuate the relays, and − at B has no effect. As the relays are polarized, the + current at B operates to actuate them and move the lever in a certain direction—say to their back stops *b b*′, as shown in the drawings. Now, when the key K at station A is closed and rests on its front stop the + current from the battery *Mb* goes to line. This obviously has the reverse effect of the former current, and + current at station B is now neutralized, and the − current at B operates to actuate the relays R R′ in the opposite direction and moves their levers to the front stops *f f*′. The opening and closing of the key K at station A therefore causes the relays to be actuated in one direction and the other. Consequently the movements of the key are reproduced by the relays, and signals are transmitted in the usual way.

In very long lines, or where the discharge or return current due to the emissions of the batteries at the receiving-stations are very considerable, the connections of the commutator with the batteries are made at a certain point in each battery, so as not to include the whole, whereas the whole of the battery in each case is included in the connections with the key. This is shown in the drawings, where the whole of the battery *Ma* is connected with the back stop of the key K, and the commutator C is connected at a certain point in *Ma*, not including the entire series. The same with respect to the connections of the battery *Mb*. The object of this arrangement is to make the current transmitted from the sending-station paramount in the circuit. When this condition exists, a given inclination imparted to the relay at the distant station is maintained despite the contrariwise discharge-current there occurring.

In the practical application of the idea involved in the arrangement of apparatus described in Fig. 1 any suitable means for producing the requisite alterations of current at the receiving end of the circuit may be applied. Preferably the special device shown in Fig. 2 at station B is employed. It consists of a pole-changing transmitter—such as is used in duplex and quadruplex systems PC—which is operated by the electro-magnet M, local battery L, and Morse key K in the usual way when the switch S is open, and by the automatic circuit-breaker C with its contacts q s when the switch S is closed.

The composition and operation of the automatic circuit-breaker C is as follows: PM PM′ are polarized electro-magnets so connected with the batteries X X′ that when the lever h of PM is against the stop − it closes a circuit, (X + wire 11 h 9 PM′ 5 4 − X,) whereby the lever h' of PM′ is moved to its top −. The latter contact closes a circuit, (X + 11 10 h' 7 PM 6 4 − X,) whereby the lever h of PM is moved to its stop +, and this latter contact in turn closes a circuit, (X′ + 4 5 PM′ 9 h 8 − X′,) whereby the lever h' of PM′ is moved to its stop +. This latter contact (by the circuit X′ + 4 6 PM 7 h' 12 − X′) causes the lever h of PM to again return to its stop −. The action is then again repeated and goes on continually. The levers of PM PM′ are therefore continually oscillated, the rapidity of oscillation being determined by the strength of the batteries X X′ and the distance apart of the rest-points of the respective levers. An extension q, with a spring-contact s, can therefore be provided on one of them PM′, whereby the circuit of the pole-changer magnet M may be opened and closed regularly at any desired rate of operation. At station B in Fig. 2 an arrangement of the receiving-instruments is also shown, in which the relay R is associated with an induction-coil I. The primary wire pp of the induction-coil is included in the main-line circuit. The relay R is included in the circuit of the secondary wire sc, and the friction-jaws gk, moved by the lever l of the pole-changer PC, operate to close the circuit of the relay to receive the induced current due to the introduction of a current into the primary pp, and to open the circuit of the relay before the withdrawal of a current from the primary. The circuit of the relay is traced from the secondary sc by wire 1, jaw g or k, lever l, wire 3, relay R, wire 2 to the secondary sc. The action of the lever l and jaws gk is that by friction the jaws remain in whichever position moved by the lever l. When l is drawn down, it leaves g, thereby opening the circuit of the relay before the contact y of the pole-changer leaves the spring v, which is connected to the + pole of the battery MB, and l closes on the jaw k after the contact y has left v and before it touches the spring u, connected with the − pole of the battery MB. When the lever l is upraised, the reverse action takes place. The relay R is in consequence of this device only influenced by the polarity of the currents introduced into the primary wire pp of the induction-coil. The object of this is to accelerate the movements of the relay on circuits where extraordinarily rapid transmission of signals is to be effected, in which case a single + or − phase of the correspondingly-rapid reversals of current required at the receiving end of the circuit would be too brief to affect the relay directly.

With the explanation given it will be seen that the arrangements in Fig. 2 are substantially the same as in Fig. 1. In Fig. 2 station A is represented as sending to B. The switch S′ at A is open. The pole-changer PC′ is operated by the key k'. The latter is open and a − current is sent to line. The circuit is from E′ at A by wire i', contact x', spring u', + MB′ −, spring v', contact y', wire w', through relay R′ to line; thence through primary pp of the induction-coil I at station B by wire w, contact y, spring v, + MB −, spring u, contact x, wire i to earth at E. The switch S at station B is closed; but the contacts qs of the automatic circuit-breaker C are open. Consequently the lever of the pole-changer PC is unattracted and upraised, and the + of the battery MB is presented to line. A + current at station B therefore combines with the − current from station A, and operates to put the levers of the relays on their back stops b' b. A − current at station B would neutralize the − from A, and the relays would remain undisturbed, while, as before explained, if the key K′ at station A were closed and a + current transmitted therefrom the − current at B, when presented to line, would combine with it and operate to put the relays on their front stops $f f'$. The position of the key at the sending-station therefore determines the position of the levers of the relays, whose actuation, however, is referable to the allied or opposing forces alternately presented to line at the receiving end of the circuits.

Fig. 3 shows the arrangement of a duplex on the bridge system adaptable with my improvement to a long land-line or submarine cable-circuit. The current-alternator, which may be arranged in any suitable way or according to that specified in connection with Fig. 2, is represented at C, station A, and is included in a derived circuit from the main-line wire.

The arrangement and operation of the duplex system being well known and understood, it will only be sufficient to point out that the existence of the derived circuit affords two paths for the current sent out to line. One part goes to earth by the derived circuit and the other part through the line-wire to earth at the distant station.

According to my arrangement of the apparatus the resistance of the derived circuit is made (by an adjustable resistance X′) comparatively low with reference to that of the line-circuit. Consequently only a small portion of the current emanating from the sending-battery goes to line. This small current, however, of whatever polarity, is supplemented by a current emanating from a similar derived circuit at the distant end, embracing a current-reverser C′, and the combined currents operate to actuate the receiving-instruments. There is no synchronism of the commutators. They are wholly independent. The condition of the circuit (as a whole) is such that very little current from either of the commutators passes to line. Their batteries are small compared with the signaling-batteries. The current from either one of the commutators operates to actuate the receiving-instrument at the same end of the line where it is located, and the signaling-current, transmitted from a distant end, augments or neutralizes its effect and controls the movement of the armature of the receiving-instrument. The signaling-battery at the same end of the line as the commutator now being considered has no effect whatever on the receiving-instrument at that end, because in the duplex outgoing currents have no effect in the receiver. When the transmitted current is withdrawn from the line, the latter concurrently discharges by way of the low-resistance circuits in derivation at either end. Consequently there is no lagging effect in the receiving-instruments, and speedy signaling is accomplished with the greatest facility.

The operation of the apparatus and circuits is as follows: At station A, R is the polarized receiving instrument or relay included in the neutral wire of the bridge. R*s* R*x* are the short-arm resistances. X is the balancing-resistance made equal to the joint resistances beyond the point 5 of the bridge-connections. C*n* is a condenser of small capacity to compensate for whatever small amount of return-current escapes past the derived circuit (5 C X′ E) and passes through the relay. As arranged, it is well understood, the outgoing currents emanating from the battery MB have no effect on the receiver R, while incoming currents actuate it. The currents emanating from the current-reverser C in the derived circuit therefore flow in, as it were, from the line and affect the relay + in one direction and − in the other. The joint resistance of the circuits from the point 5 to earth being very low compared to the resistance of the main-line circuit, very little current from C will pass over the line. To produce the proper effect on the relay R, therefore, the currents emanating from C are not necessarily very strong. Supposing no current is to line at the distant end, and − from C operates to open the relay R, while + from C operates to close it. If the key at the distant end is closed and + sent to line, part of it will pass by way of 5 C X′ to earth at E, and part through the relay R in the same direction as the + from C. The relay will therefore close, and so long as + continues to flow from station B the relay R will remain closed, since its presence in R will neutralize the effect of the − current from C, which would otherwise operate to open it. The reverse effect takes place when − is sent from station B. The relay R at A is therefore actuated by the current from C at A under the control of the key at the distant end of the circuit. The arrangements being identical at both ends of the line, the relay R′ at B is in like manner operated by the key at A, the line being thus duplexed.

It is obvious that my improvement may be applied to any other system of duplex telegraphy in substantially the same way—viz., by placing a current-reverser in derivation to the main line at either end of the circuit.

Having thus described my invention, I claim—

1. In a telegraphic system, a pole-changing transmitter, in combination with a rapidly and constantly acting current-reverser at the receiving-station for either neutralizing or augmenting the impulses transmitted.

2. In a telegraphic system, a pole-changing transmitter, in combination with a receiving apparatus consisting of a polarized relay and a rapidly and constantly acting current-reverser, whereby the transmitted impulses are either neutralized or augmented.

3. In a telegraphic system, a main line, including the primary of an induction-coil, a relay, and a make and break switch included in the secondary of said coil, in combination with a pole-changer operating said switch to open and close said secondary circuit, and to effect its closure before the introduction of a current into and its opening before the withdrawal of a current from the said primary, whereby the movements of the relay on long circuits are accelerated.

4. An automatic circuit-breaker comprising two polarized electro-magnets and two batteries with circuits and contacts and a separate circuit, all arranged so that the movement of an armature of one magnet effects a reversal of current in the other magnet, and one of the armatures being arranged to make and break the said separate circuit.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

DAVID HERBERT KEELEY.

Witnesses:

F. N. GISBORNE,

J. S. DAURENT, Jr.