4 Sheets--Sheet 1.

M. G. FARMER.

Duplex Telegraph Apparatus.

No. 160,581 Patented March 9, 1875.

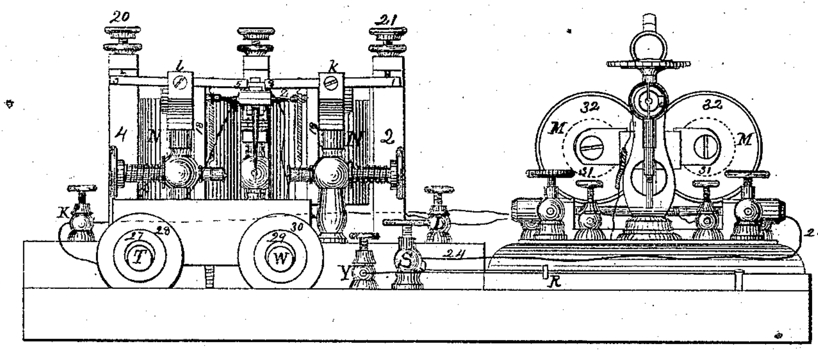

Fig. 2.

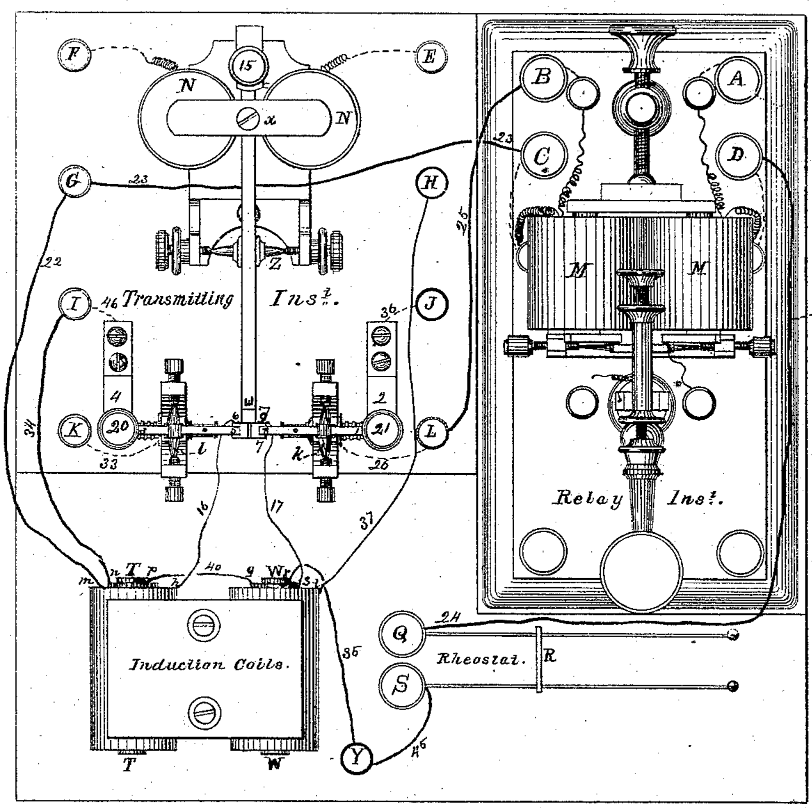

Fig. 1.

Witnesses.

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No. 160,581. Patented March 9, 1875.

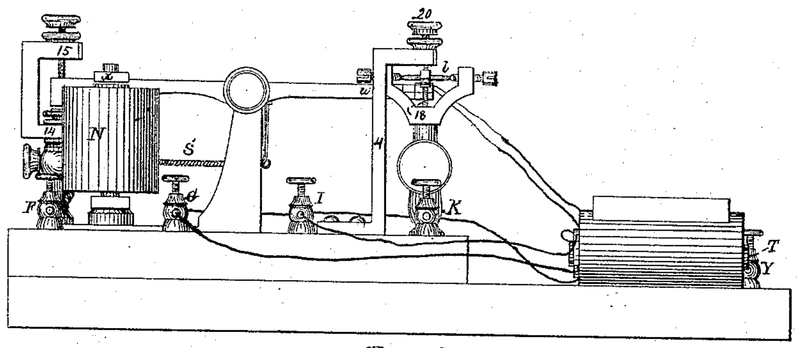
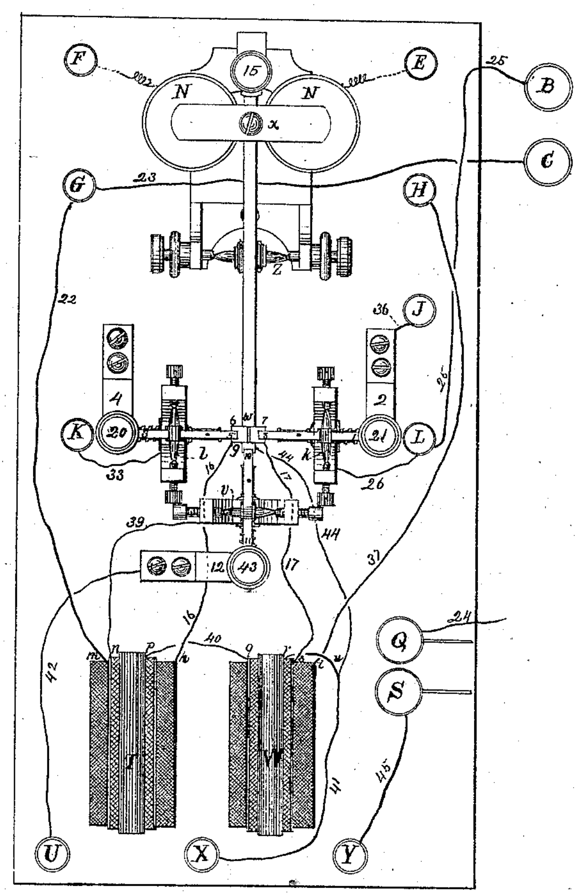


Fig. 3.



Witnesses.

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Fig. 4.

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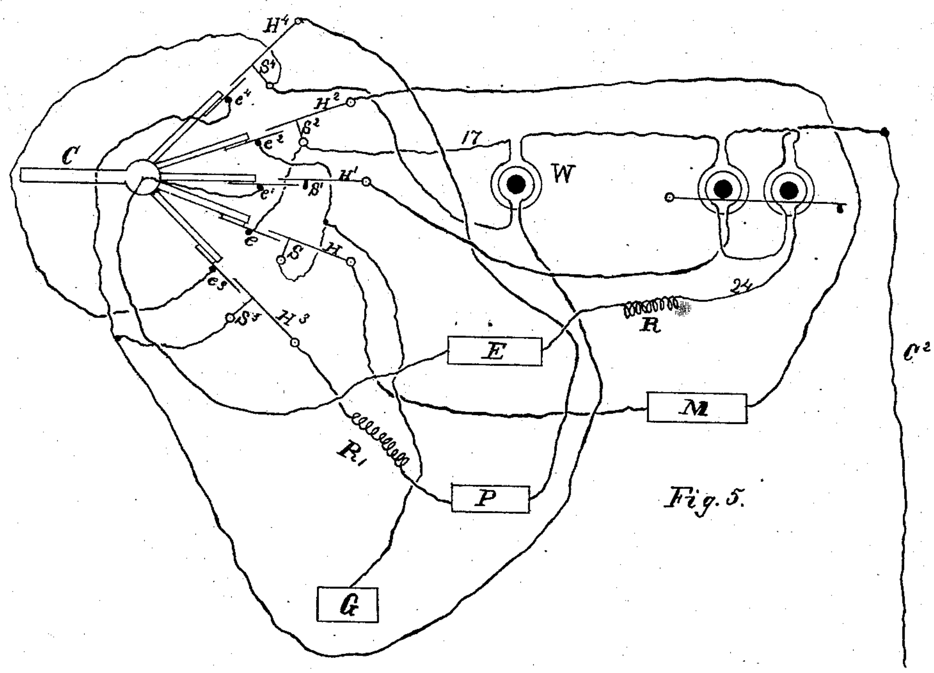

Fig. 5.

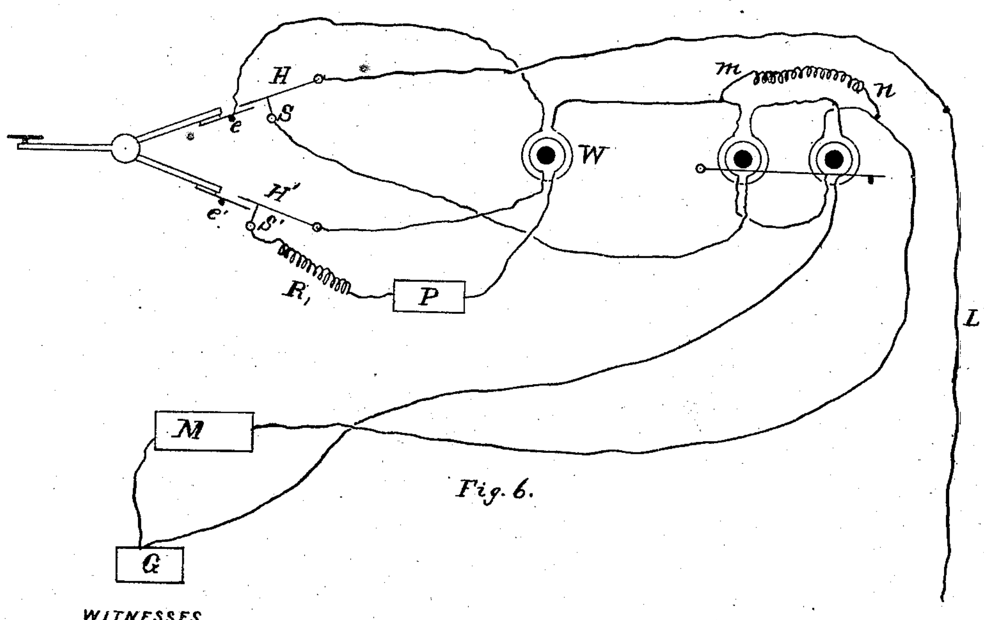

Fig. 6.

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Duplex Telegraph-Apparatus.

No. 160,581. *Boston.* Patented March 9, 1875.

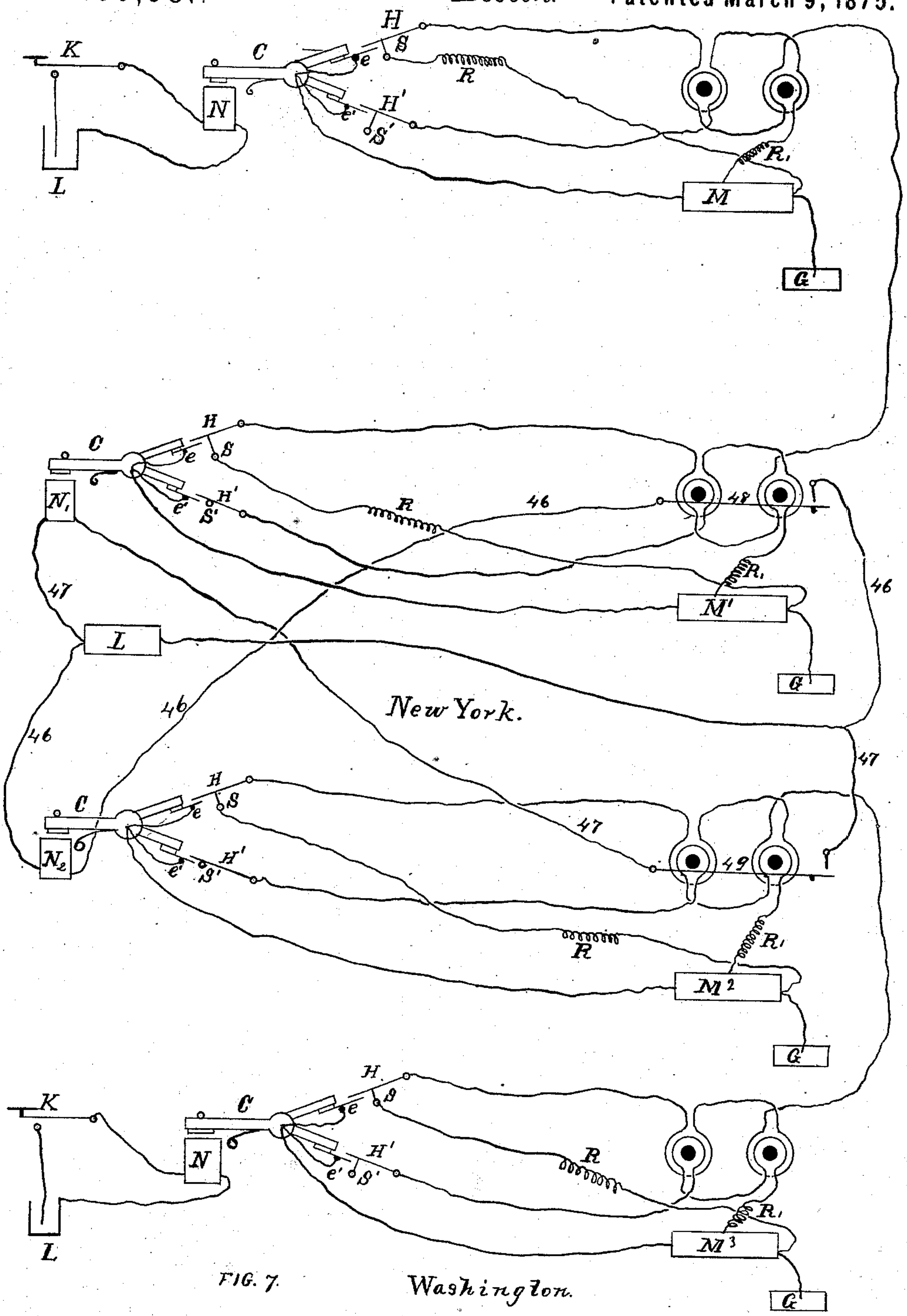

FIG. 7.

WITNESSES.
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UNITED STATES PATENT OFFICE.

MOSES G. FARMER, OF SALEM, MASSACHUSETTS.

IMPROVEMENT IN DUPLEX-TELEGRAPH APPARATUS.

Specification forming part of Letters Patent No. **160,581**, dated March 9, 1875; application filed September 30, 1872.

To all whom it may concern:

Be it known that I, MOSES G. FARMER, of Salem, in the county of Essex and Commonwealth of Massachusetts, have invented certain Improvements in Telegraphic Instruments for Double Transmission, of which the following is a specification:

In attempting to send two messages simultaneously over the same long telegraphic wire in opposite directions, by means of a divided current—one part passing through a coil in the main circuit and the other part passing through an accessory or equating coil or circuit—the phenomenon of charge makes its appearance, and the two coils upon the relay, which would completely neutralize each other's influence upon the armature in a short line, do not seem to do so on a long line, for the first rush of current through that coil or portion of the relay which is in the main circuit for an instant overpowers the action of that portion which flows through the equating-coil and rheostat, and causes a sudden and momentary jump of the armature. The reason of this action is this: A long line of telegraph is as a Leyden jar, the wire being the inner coating and the earth beneath the wire acting like the outer coating. Such a line has a definite static or charge capacity, depending upon its diameter, its length, and its height from the ground. If it be insulated and buried in the ground or sea, its charge-capacity is still greater, and this momentary rush so much the greater. After this first rush is over the two currents or branches of the current neutralize each other's action upon the armature, if the rheostat has been properly adjusted. This sudden motion of the armature may be hindered in two principal ways: First, by attaching a condenser, or Leyden jar, to the equating coil or circuit, which condenser shall have a charge-capacity approximately equal to that of the main line. This has been already accomplished on land-lines. Second, by inserting the secondary wire of a common induction-coil into the main circuit, and so adjusting the time and mode of interrupting the primary circuit that, at the instant when the main-battery current is applied to the line, a sudden stroke shall be induced in this secondary coil by the opening of its primary, and the direction of this secondary stroke shall be opposed to the direction of the battery-current in the main line, and shall be equally powerful, and simultaneous with the sudden rush due to the charge-capacity of the line, and shall subside at the same time. Another way is to put this induction-coil into the equating-circuit and cause the direction of the instantaneous stroke to be coincident with the direction of the current in the equating wire or coil, thus momentarily adding to the strength of the equating-current. It is evident that induction-coils may be inserted both into the main and into the equating circuits, and both induction-strokes be caused by the interruption of a single primary circuit, which embraces both of the primary coils; only this must be attended to—that the induction-stroke in the main circuit must tend to hinder the development of the battery-current in the coil which is in the main line, and the induction-stroke in the accessory or equating circuit or coil must tend to help the development of current in that branch. Since an induction-stroke is developed in the secondary wire of a double helix, upon closing as well as upon opening the primary circuit, it is best to insert these secondary coils into such portions of the main or equating circuits as are open when the primary wire of the induction-coils is closed. For this purpose it is well to make use of either the three-point key described and figured at Fig. 1 of my Patent No. 21,329, of August 31, 1858, or else of the two-point key figured in my Patent No. 81,485, of August 25, 1868.

To work this my invention I make use of a relay, a rheostat, one or more induction-coils, and a transmitter.

Fig. 4 shows the complete three-point transmitting-key with three secondary levers, the induction-coils, a portion of the rheostat, and a portion of the relay.

Fig. 3 shows a side elevation of the transmitter and the induction-coils.

Fig. 2 shows an end view of the transmitting-key, the induction-coils, and the relay.

Fig. 1 shows a ground plan of the transmitting-key with one of the secondary levers omitted. It shows also the induction-coils, the relay, and the rheostat.

The relay is like those in common use, except that there are two independent wires coiled on each of the cores of the electro-magnet. One of these wires is to be included in the circuit of the main line. The other wire is to be included in the accessory or equating circuit. These two wires may be coiled simultaneously into one coil, or one wire may be coiled onto the core first, and then the other outside of it; or, thirdly, one wire may be made into a coil by itself, not occupying the whole length of the core, while the other wire is made into another coil, occupying the remainder of the core. This latter method I do not consider as good as either of the two others. Each leg of the magnet is provided with a similar double coil.

I make use of a transmitting key or device which differs from those in common use for single transmission in this particular respect—that it provides for preserving the continuity of the main circuit. It is also provided with means for opening and closing the accessory or equating circuit, and likewise opens and closes the primary circuit of the induction-coils T W.

Two methods of operating the primary circuit of the induction-coils are shown, one of them in Fig. 1, the other in Fig. 4. In Figs. 1 and 4, the transmitting key or lever *w x* is represented as operated by an electro-magnet, N, and its armature *x*. This is for the purpose of repeating from one circuit to another. The lever *w x* might be operated directly by the finger when situated at a terminal station; but it is more convenient, and less wearisome to operate it by the intervention of an independent circuit, into which it is included by the screw-cups E and F.

I use, also, a rheostat, to adjust the strength of the equating current, so that its magnetizing effect on the cores of M shall be equal to and neutralize the magnetizing effect of the main-line current through the other coil or wire 32 32 of the relay M. Also, a rheostat may be used to modify the action of the primary circuit of the induction-coils.

The key *w x* operates the main-line circuit through the intervention of an auxiliary lever, 1 8, pivoted at *k*, as seen in Figs. 1 and 2. The outer end 1 of this lever is limited in its upward motion by the adjustable screw 21 in the post 2. Its inner end 8 receives a downward tendency by the spring 19, as seen in Fig. 2. The end *w* of the lever *w x* is situated underneath the inner ends of the levers 1 8, 5 3, and 10 11, seen in Fig. 4, and also underneath the inner ends of the short levers 1 8 and 3 5. (Seen in Fig. 1.) This end *w* of the lever *w x* is provided with three insulated pieces of platinum, 6, 7, and 9, in Fig. 4, and with two pieces, 6 and 7, in Fig. 1. These pieces of platinum on the upper side of the end of the lever *w x* serve to make contact with similar pieces on the under side of the inner ends of the levers 1 8, 3 5, and 10 11. The lever 3 5, pivoted at *l*, is used to open and close the accessory circuit at 5 6 in Figs. 1 and 4. By proper adjustment of the screws 20 and 21 the closing of the accessory or equating circuit at 5 6 can be made simultaneous with the closing of the battery onto the main circuit at 7 8, and this act is simultaneous with, or precedes, the removing of the main circuit from its ground-connection at 1 21.

I will now proceed to describe the mode of connecting up the induction-coils T and W, and inserting them into their proper circuits. They are constructed substantially as induction-coils ordinarily are, having a bundle of soft-iron wires, which can be thrust into them to a greater or less distance, according to the strength of the induction-stroke required. The secondary wire of W is inserted into the main circuit; the secondary wire of T into the equating circuit, as follows: The outer end of the secondary wire of W at *t* is connected by wire 37 to screw-cup H, which cup receives one pole (say, the positive or copper pole) of the main battery, the other or zinc pole being to earth. The inner end of this secondary wire *s* is connected by wire 17 to the platinum piece 7 on the end *w* of the lever *w x*.

The outer end *h* of the secondary wire of the coil T is connected by wire 16 to the platinum piece 6 on the lever *w x*, while the inner end *m* of this secondary wire is connected by wire 22 to the screw-cup G, and this, by wire 23, to screw cup C on the relay. This cup C is one terminal of the equating coil or circuit of the relay, the cup D being the other terminal.

The primary circuits of the coils T and W are connected in Fig. 4 as follows: The axis *b* of the secondary lever 10 11 is connected by wire 39 to the outer end *n* of the primary or coarse wire of the helix T. The inner end *p* of this primary wire is connected by wire 40 to the outer end *q* of the primary of W, and the inner end *r* of this primary is connected by wire 41 to the screw-cup X. This wire 41, at *u*, makes a junction by the wire 44 to the platinum piece 9 on the end of the lever *w x*. The post or cock 12 is connected by wire 42 to the screw-cup U. The cups U and X receive the poles of the primary battery, which operates the induction-coils T and W simultaneously. The circuit is broken and closed by the motion of the auxiliary lever 10 11, between the point 11 and the screw 43.

The use of the wire 44 is to prolong the duration of the secondary currents in T and W, as more fully shown in my patent of May 14, 1872. It is not always necessary to make use of this device, nor always needful to have the auxiliary lever 10 11, and the primary battery at U and X, so another method of operating these primary circuits is shown in Fig. 1, where the whole or a portion of the equating-battery is used to operate these primaries, when not used in the equating-circuit. Its connection and mode of action are more fully shown in Fig. 1. Thus: the cup I is connected by wire 34 to the outer end *n* of the primary wire of T, the inner end *p* is connected by wire 40 to *q* as before, while *r* is connected by 35 to screw-cup Y, which receives one pole of the equating-battery. The cup I is connected by wire 46 to post 4, so that the primary circuit of T W is broken at 3 20 by the motion of the auxiliary lever 3 5. The axis *l* of the lever 3 5 is connected by wire 33 to screw-cup K, which receives the other pole of the equating-battery. The axis K of the lever 1 8 is connected by wire 26 to cup L, and this by wire 25 to cup B, one of the terminals of the main circuit of the relay. A is the other terminal of this main circuit, and receives the line-wire. The post 2, carrying the screw 21, is connected by wire 36 to cup J, which receives the ground wire.

Supposing the equating-battery to be properly connected—say, its positive pole to Y and its negative to K, while the positive of the main battery is at H—there will be two different paths open for the main circuit, according as the armature *x* be up or down. The course of the currents and the action of the apparatus will be as follows in Fig. 1: The circuit of the main battery will be interrupted at 8 9, (if the armature *x* be up,) the equating-circuit will be interrupted at 5 6, but the primary circuit of T W will be closed at 3 20. If, now, the armature *x* be depressed, the end *w* of the lever *w x* will lift the auxiliary levers 3 5 and 1 8, closing the main circuit at 8 7, the equating-circuit at 5 6, and breaking the primary circuit at 3 20. The main-battery current, starting from H, will flow by wire 37 into the secondary coil of W at *t*, pass out at *s*, and by wire 17 to platinum-piece 7, thence to the end 8 of lever 1 8, thence from *k* by wire 36 to L, and by 25 to B, where it enters the main-circuit wire of the relay M. It emerges at A, and enters the main line and proceeds to the other station, where it enters a similar instrument, as at A. The course of the equating-current in Fig. 1 will be as follows: The equating-circuit being closed at 5 6, from the cup Y it proceeds by 46 to cup S of the rheostat R. Leaving it at Q, it passes by wire 24 to cup D on the relay, and flows through the equating-wire in such contrary direction as to neutralize the effect of the main current on the cores of M. It emerges at C, passes by 23 to G, and by 22 to *m*, where it enters the secondary coil of T. Leaving this at *h*, it goes to 6, and thence to 5, with which it is in contact; passes thence by *l* and 33 to K, where it re-enters the equating-battery.

The primary circuit in Fig. 1 of T and W is broken at 3 20 at the same time that the equating-circuit is closed at 5 6. So the equating-battery at K Y is constantly employed either in charging the equating or the primary circuit, and care should be taken to properly proportion the resistance of the two circuits so as properly to accomplish the results desired, the manner of doing which is familiar to skilled electricians.

From the above it will be seen that at the instant of depressing the armature *x*, a sudden stroke is generated in the two secondaries of T and W, and if they are properly connected the stroke in T will help the equating-circuit, and the stroke in W will hinder the main-battery current at the instant of closing. A rheostat for modifying the action of the primary circuit may be inserted into it, say, in place of the wire 34 in Fig. 1, or 42, Fig. 4. The coils of these rheostats may have iron cores within them, so as to contribute to the strength of the induction-stroke.

The scheme shown in Fig. 4 possesses some advantage over that in Fig. 1, since, by varying the adjustment of the screw 43, the induction-strokes of the coils T and W can at pleasure be made to precede or follow the closing of the main and equating circuits, while, by the plan in Fig. 1, the induction-strokes cannot be made to precede the closing of the equating-circuit.

I will trace out the course of the primary current in Fig. 4. Commencing at U, passing by wire 42 to the post 12, it goes by screw 43 to the end 11 of the lever 10 11; thence from axis *v*, by wire 39, it enters the primary coil of T at *n*. Emerging at *p*, it passes by wire 40 to *q*, where it enters the primary of W. It emerges at *r*; passing by the junction *u* and wire 41, it arrives at the other pole *x* of the primary battery.

The use and action of the wire 44, in Fig. 4, is as follows: The armature *x* being up, this primary circuit is closed at 11 43. If the armature *x* be depressed the contact 9 10 is made before that at 11 43 is broken.

The energy which is stored in the primaries *n p* and *q r*, instead of appearing in the form of a spark at 11 43, will be expended in prolonging the time of the subsidence of the magnetism in the cores of T and W, and, of course, will prolong the duration and modify the intensity of the induction-strokes of the secondary coils of T and W. This will be of especial use in lines that have large static capacity, as, for instance, short cables or long land-lines.

Having thus fully described the construction of my invention and its mode of operation, I will show briefly, by Figs. 5 and 6, how it may be applied to or combined with my inventions patented August 31, 1858, and November 15, 1859. The lettering in these two figures will correspond, so far as convenient, with the lettering in those specifications.

In Fig. 5, the springs or levers H^3 and H^4 are similar to H, H^1, and H^2 in Letters Patent No. 21,329. These two levers serve to connect the primary battery P with the key or transmitter C, and to afford the means of reversing the direction of the current in the primary circuit of the induction-coil W. There is a rheostat, R_1, in this primary circuit for the purpose of increasing or diminishing the strength of the primary current. There is also a rheostat, R, in the equating-circuit, for the purpose of modifying the strength of the equating-current. No induction-coil is shown in connection with the equating-circuit. E is the equating-battery; M, the main battery; G, the ground-plate, and C^2 the line-wire.

Fig. 6 shows the adaption of the induction-coil W of this present invention to my patent No. 26,097. H is the contact-spring of the main circuit, and H^1 of the primary circuit. P is the primary battery; R_1, a rheostat in this primary circuit. M is the main battery; *m n*, the rheostat which shunts the outer coil of the relay. L is the main line.

Fig. 7 shows how these double-transmitting instruments may be so connected as to enable messages to be repeated simultaneously from one main line to another. In this diagram the induction-coils and their adjuncts are omitted for clearness' sake.

Three stations are represented, viz, Boston, New York, and Washington. M M^1 M^2 M^3 represent the main batteries. There are two represented at the repeating-station, (New York,) although one will suffice, provided the batteries at the terminal stations are properly connected. H is the contact-lever of the main circuit, and H^1 of the equating-circuit. The keys or circuit-closers C C, at the repeating-station, are operated by the electro-magnets N_1 N_2 and the single local battery L, which serves for the two local circuits 46 and 47. They are opened and closed by the armatures 48 and 49 of the relay-magnets M^1 M^2. From what has been said above their mode of operation will be readily understood by skilled electricians.

Having thus described my invention, I claim as new—

1. The combination of a main telegraphic circuit and its batteries with an induction-coil so arranged as to hinder the effects of static charge, substantially as set forth.

2. The combination of an induction-coil with an equating-circuit to help the equating-circuit to neutralize the effect of static charge on the relay in the main circuit, substantially as set forth.

3. The combination of a continuity-preserving key and an induction-coil with an equating-coil and an independent equating-battery, substantially as set forth.

4. The combination, in the main or equating circuit of an induction coil or coils, in such parts of the main or equating circuits as are open when the main and equating batteries are disconnected, substantially as set forth.

5. The combination of the circuit-preserving key above alluded to with a relay or its equivalent, and with one or more induction-coils, substantially as set forth.

6. The combination of the continuity-preserving key with a relay, an induction coil or coils, and with a means of regulating both the strength of the induction stroke or strokes and the strength of the equating-current, substantially as set forth.

7. The combination of primary and secondary helices with the means above described of preventing the appearance of a spark upon rupturing the primary circuit, substantially as above described.

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