G. SMITH.

MULTIPLEX TELEGRAPH.

No. 185,589. Patented Dec. 19, 1876.

FIG. 1.

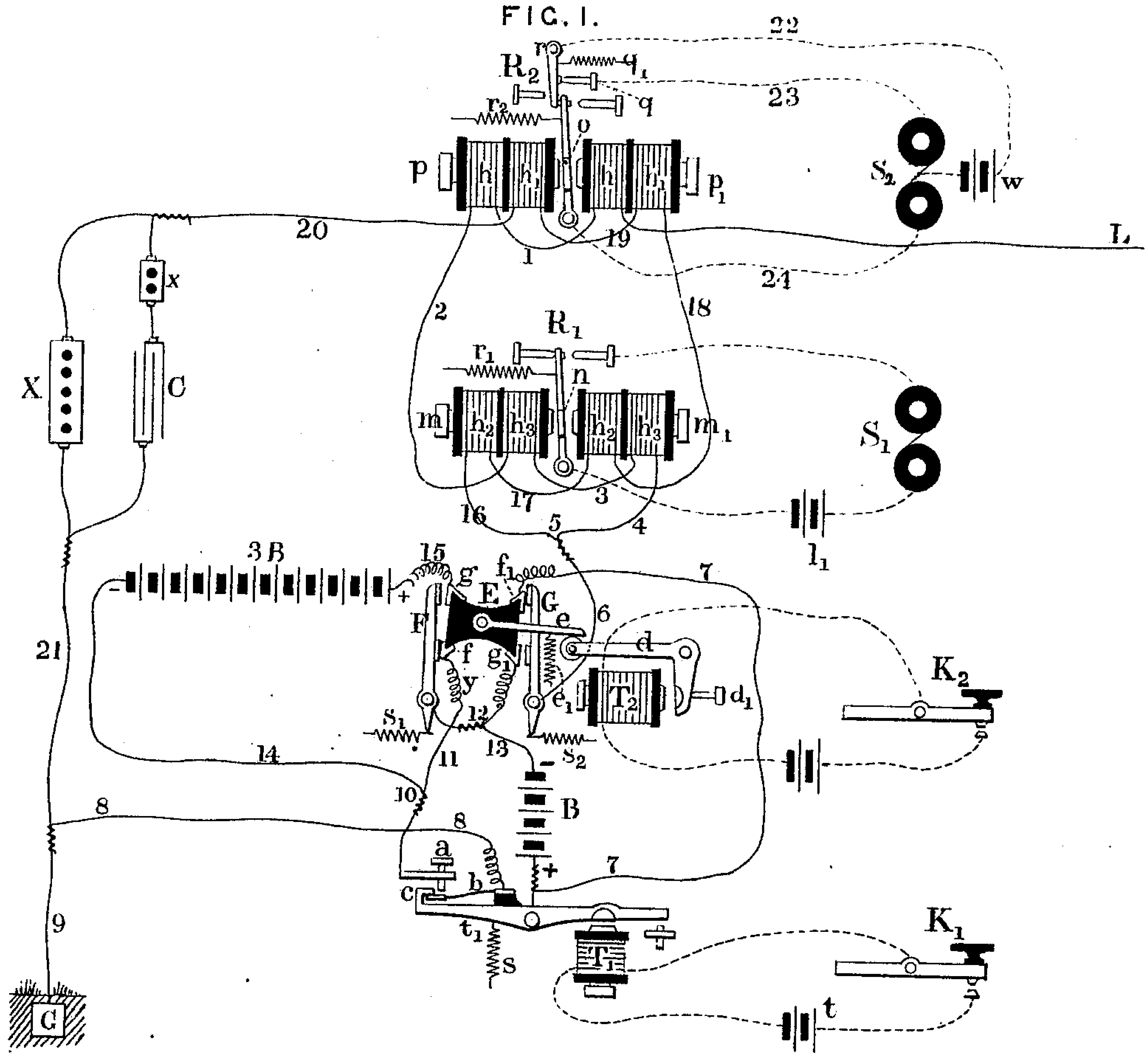


FIG. 2B

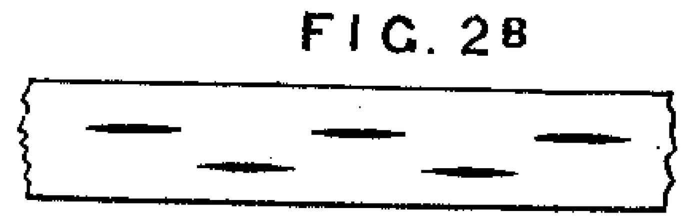


FIG. 2A

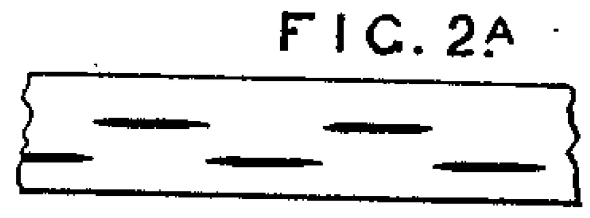


FIG. 2.

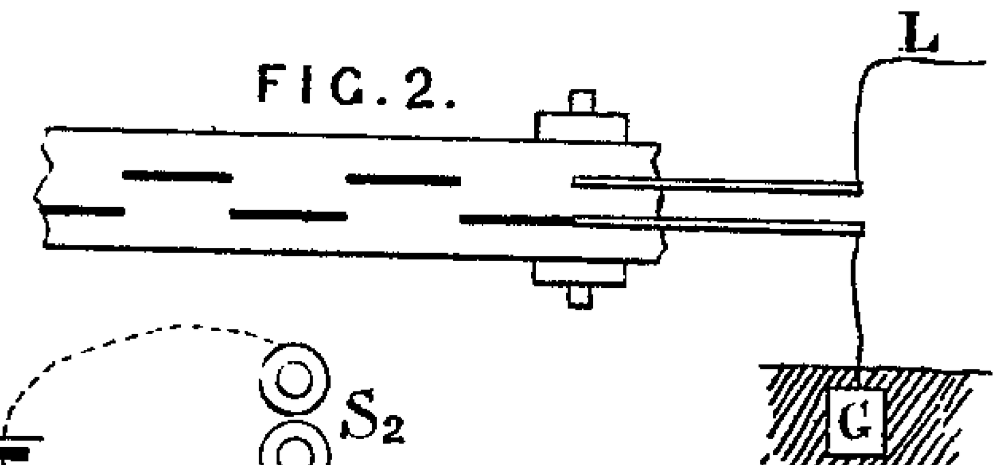


FIG. 3.

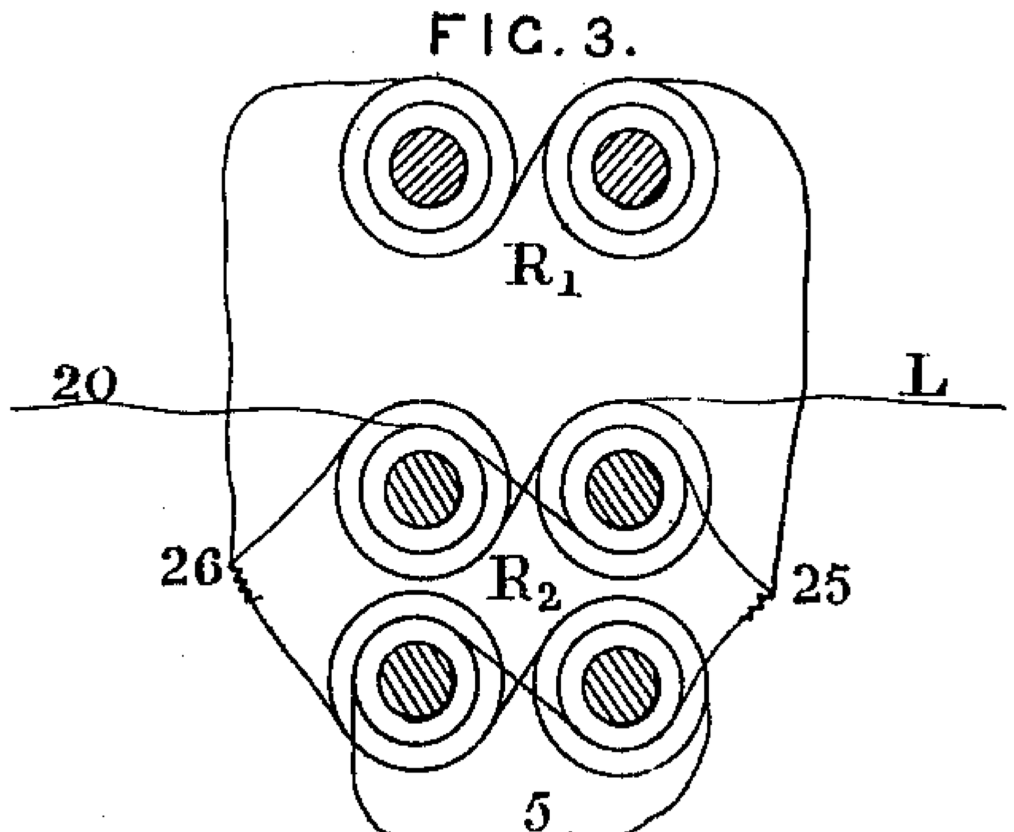


FIG. 4.

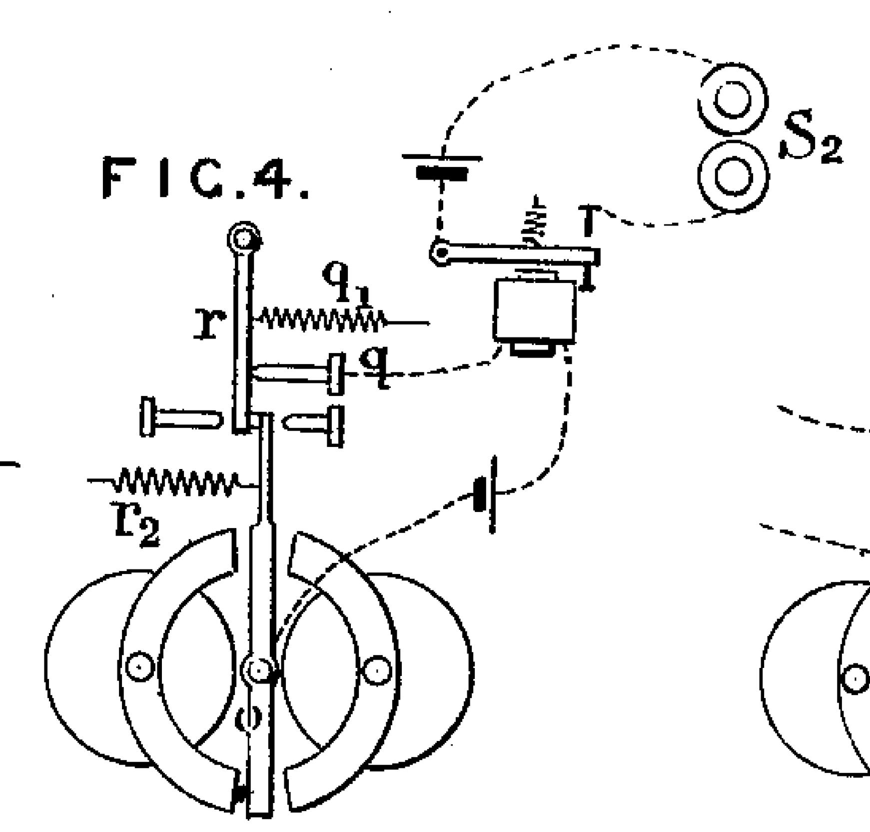
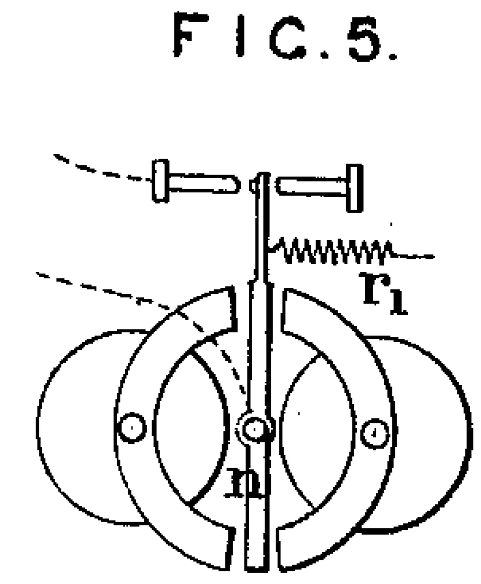


FIG. 5.



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UNITED STATES PATENT OFFICE.

GERRITT SMITH, OF ASTORIA, ASSIGNOR OF ONE-HALF HIS RIGHT TO GEORGE B. PRESCOTT, OF NEW YORK, N. Y.

IMPROVEMENT IN MULTIPLEX TELEGRAPHS.

Specification forming part of Letters Patent No. **185,589**, dated December 19, 1876; application filed December 7, 1875.

To all whom it may concern:

Be it known that I, GERRITT SMITH, of Astoria, in the county of Queens and State of New York, have invented a new and useful Improvement in Multiple Telegraphs, which improvement is fully set forth in the following specification, reference being had to the accompanying drawings.

The object of my invention is to provide an improved means whereby two distinct communications may be simultaneously transmitted over one telegraphic conductor in the same direction, and which may at the same time be combined with any suitable method of simultaneous transmission in opposite directions, commonly known as "duplex methods," by which combination four distinct communications, two in each direction, may be made to pass simultaneously over a single conductor without interference.

My invention consists in an improved arrangement of the transmitting apparatus in reference to the batteries, whereby the required combinations of currents are transmitted without at any time interrupting the main circuit. It further consists in the employment of two separate and independent polarized armatures, each of which operates its own receiving-instrument by means of an independent local circuit, and in the arrangement of a receiving-instrument in combination with a relay-armature, whose movements are capable of being controlled by changes of polarity in the line-current, and a supplementary contact-lever, by means of which the difficulties which have heretofore been encountered in working apparatus of this kind upon long circuits are entirely overcome.

In the accompanying drawing, Figure 1 is a general plan of my invention, showing both the transmitting and receiving instruments with their various connections. Fig. 2 is a diagram intended to illustrate the manner in which electric currents are modified by transmission through long lines, while Figs. 3, 4, and 5 represent certain modifications in the details of my apparatus.

In order that two communications may be simultaneously transmitted in the same direction over the same conductor, it is necessary to make use of two independent transmitting instruments or devices at the sending-station, and also of two independent receiving-instruments at the receiving-station.

For the purposes of this description it will be assumed that the method of telegraphic transmission known as the "Morse system" is used, although any other electro-magnetic system may be substituted therefor.

The transmitting devices are preferably operated by connecting them, either mechanically or electrically, with the levers of common Morse keys.

The operation of two independent transmitters or keys, when arranged in this manner, gives rise to four distinct electrical conditions of the line, as follows: first, first and second keys both open; second, first key closed, and second key open; third, second key closed, and first key open; fourth, first and second keys both closed.

The manner in which these four different electrical conditions of the line are brought about, by the operation of two transmitters, will now be explained.

In Fig. 1, t is a lever capable of a slight vertical movement upon its axis in one direction by the attraction of the electro-magnet T^1, and in the other by the retractile force of the spring s.

The lever t^1, with its appendages, constitutes the first or single point transmitter, and is operated by means of a key, K^1, and a local battery, t, in a manner well understood.

One end of a flat metallic contact-spring, b, is fixed to an insulating support, which is mounted upon the extremity of the lever t^1, while its free end, by its own elasticity, presses upward against the projection c formed upon the extremity of the lever t^1, and is therefore in electrical contact therewith. When, however, the key K^1 is depressed, the attraction of the electro-magnet T^1 for its armature elevates the opposite end of the lever t^1, which carries with it the contact-spring b, and presses the latter against the fixed stop a. The further movement of the lever t^1 in the same direction causes the spring b to yield, and the projection c is separated from it. Thus the effect of closing the key K^1 is to first form an electrical contact between the spring b and stop c, and then to break, almost at the same instant, the previously-existing contact between the spring b and lever t^1. As the electric circuit passing through the spring b is by this arrangement never interrupted, being at all times continuous, either through a or c, or both, it may be termed a continuity-preserving transmitter.

The second or double-point transmitter is preferably constructed substantially in the form shown in Fig. 1, and consists of a quadrangular plate, E, composed of some suitable insulating material, which is mounted upon an axis passing through its center in such a manner as to be capable of receiving an oscillating motion from the arm e, which is rigidly attached to its axis. By means of a spring, e^1, the arm e is caused to press upon a roller fixed upon one end of the lever d, which pressure forces the other end of this lever against the stop d^1. The lever d carries the armature of the electro-magnet T^2, which, like the single-point transmitter, is connected with and operated by a local battery and key, K^2. The oscillating plate E is provided with four metallic contact-pieces, f g f^1 g^1, fixed upon its four angles, as shown in the figure.

Two contact-levers, F and G, are situated one at each end of the plate E. These are mounted upon axes, and tend to press against the respective ends of the oscillating plate E by the action of springs s^1 s^2. In the normal position of the transmitter, as shown in the figure, the contact-lever F rests against the contact-piece f, and the contact-lever G against the contact-piece g^1, and the parts are retained in this position by the action of the spring e^1. If, now, the electro-magnet T^2 becomes active, in consequence of the closing of the key K^2, its armature is attracted, the tension of the spring e^1 is overcome, and the arm e is raised, causing the plate E to turn upon its axis, so as to cause the contact-piece g to press against the lever F, and g^1 against G.

It will be observed that during the movement of the plate E upon its axis, the lever F must necessarily be constantly in contact either with f or with g, and the lever G with f^1 or g^1, and thus precisely the same action takes place in this arrangement as in the single-point transmitter first described, except that it is duplicated, there being two sets of contact-points instead of one.

I will next proceed to describe the effect produced upon the electrical condition of the line by the different position of the keys at the transmitting-station.

1. *When the first and second keys are both open.*—This is the position of the apparatus represented in Fig. 1. Disregarding for the present the receiving-instruments, and their connection with the line, the circuit may be traced as follows: From the earth-plate G through wires 9 and 8, contact-spring b, lever t^1, wire 7, contact-piece f^1, contact-lever G, wires 6 and 5, through the receiving-instrument to the line-wire L. The line-wire is connected to the earth without passing through either battery. In this position of the keys there is no current upon the line.

2. *When the first key is closed and the second key open.*—The route is the same as before, from the earth, at G, to the contact-springs b. From this point it now diverges, through the contact-point a and wires 10 and 11, to f; thence through contact-lever F, wires 12 and 13, and battery B to wire 7, and thence to the line L, as before. In this position the battery B is placed in circuit with its positive or + pole to the line.

3. *When the second key is closed and the first key open.*—The route of the circuit is as follows: From the earth at G, through wires 9 and 8, contact-spring b, and lever t^1, as in the first instance; thence through battery B and wires 13 and 12 to g^1; thence through contact-lever G and wire 6 to 5, and through the receiving-instrument to the line L. In this case the same battery B is placed in circuit with its negative, or − pole to the line.

4. *When both the first and second keys are closed.*—The route of the circuit is as follows: From the earth, at G, by wires 9 and 8 to contact-spring b; thence by contact-point a and wire 14 to battery 3B; thence by wire 15, through g to contact-lever F, wire 12, and g^1, to contact-lever G, and finally through wires 6 and 5 to the line L. In this case the battery 3B, which should be much more powerful than battery B, (consisting of, say, three times as many cells,) is placed in circuit with its positive or + pole to the line.

The receiving apparatus consists of two sounders, or other suitable receiving-instruments, S^1 and S^2, which are controlled by two relays, R^1 and R^2. (See Fig. 1.)

It is obviously necessary that the sounder S^1 should respond to the movements of the key K^1, and the sounder S^2 to the movement of key K^2, while both sounders should, in like manner, respond when both keys are depressed. The manner in which this is accomplished will now be explained. The line-wire L, on entering the receiving-station, passes through the helices of the respective relays R^2 and R^1, and thence to the earth. The relay R^1 is preferably constructed with two electro-magnets, m m^1, arranged with their poles facing each other, and provided with a polarized—that is to say, a permanently magnetized—armature, n, mounted between the opposite poles of the electro-magnets, as shown in the figure.

The circuit of the line L, entering the relay R^2, passes through the wire 2, and helix or coil h^3 of electro-magnet m, and thence through the helix h^3 of electro-magnet m^1, and these helices are arranged in a manner well understood, so that a negative current (for example) passing through both helices will cause the polarized armature n to be attracted by the magnet m^1 and repelled by m, while with a positive current precisely the opposite effect will take place. I will here remark that there are many different methods of constructing relays with polarized armatures by which this effect may be produced, and although I prefer to make use of the arrangement herein described, I do not desire to confine myself to it.

The armature of the relay R^1 is provided with a retracting-spring, r^1, and operates the sounder S^1 by means of a local battery, l^1, in the ordinary manner. The relay R^2, like the relay R^1, consists of two electro-magnets, p and p^1, placed opposite each other, and is provided in like manner with a polarized armature, O, having a retracting-spring, r^2. These armatures may be composed of hardened steel, and permanently magnetized, which is the arrangement shown in the drawing, or they may be steel or soft iron, polarized either by contact with a permanent magnet or by a helix through which the current of a constant local battery is made to circulate. The relay R^2 differs materially, however, from relay R^1 in the arrangement of its local-circuit connections, by means of which the sounder S^2 is operated. The polarized armature O, instead of being held against a fixed stop by the tension of the spring r^2, rests against the free end of a movable contact-lever, r, the opposite end of which moves upon a pivot. The contact-lever r is in turn held against the fixed stop q, by the tension of a spring, q^1, which tension should be considerably greater than that of the spring r^2. This is the normal position when no current is traversing the helices of the relay. The local battery w is placed in the wire 22, leading from the contact-lever r to the sounder S^2. The sounder S^2 is preferably constructed with differential helices, so that an equal portion of the current of the local battery w flows through each of the two coils, (when the circuits of wires 22 and 24 are both closed,) but in opposite directions, and thus the sounder will only act when one of the two latter circuits is interrupted. The local circuit of the relay R^2 may also be arranged in the manner shown in Fig. 4, and as more fully set forth in a certain application for Letters Patent, filed August 19, 1874, by Thomas A. Edison, designated as case 99.

The manner in which the receiving-instruments operate in each of the four conditions of the line hereinbefore mentioned is as follows:

1. *No current.*—The local circuit of the sounder S^1 is kept open by the action of the spring r^2 on the armature n, and it remains inactive. The opposing branch circuits 23 and 24 of the sounder S^2 are both closed by the relay R^2, as shown in the figure, which renders this sounder also inactive.

2. *Positive current from battery B.*—The relay R^1, which is operated by positive currents of any strength, closes the local circuit of sounder S^1. The relay R^2 attracts its armature in such a manner as to cause it to press more strongly against the contact-lever r, but this pressure is not sufficient to overcome the considerable tension of spring q^1, and sounder S^2 is therefore not affected.

3. *Negative current from battery B.*—The armature of relay R^1 is attracted in the same direction as the tension of its spring r^1, and, therefore, sounder S^1 is not affected. The polarized armature of relay R^2 overcomes the tension of its spring r^2, breaking the local circuit of wire 24 between the armature O and contact-lever r, and permitting the opposing local circuit in wires 22 and 23 to operate the sounder S^2.

4. *Positive current from battery* 3B.—The armature of R^1 operates as in 2. The more powerful positive current of 3B overcomes the tension of spring q^1 in relay R^2, and breaks the local circuit of wire 23, permitting the current in wires 22 and 24 to operate the sounder S^2. Thus the positive current of 3B operates both sounders.

In the hereinbefore-described arrangement it will be observed that in case the key K^2 at the sending-station is depressed a negative current will be transmitted, and the sounder S^2 will be actuated. Now, if the key K^1 at the sending-station be also depressed, the line-current is instantly changed from negative to positive, in order to operate the sounder S^1, as before explained; but it is also necessary that the reversal of the current (which passes through the relay R^2) should not cause a break in the signal which is being given at the same moment upon the sounder S^2.

The occurrence of this break is a difficulty which has always been experienced in the use of previous inventions for simultaneous double transmission in the same direction, and it increases in proportion to the length of line which separates the transmitting from the receiving apparatus. This is owing to the fact that when a reversal of the polarity of the line-current takes place at the sending-station the negative current succeeds the positive, or vice versa, without an appreciable interval between them. In traversing a long conductor the successive waves of alternately-opposite polarity tend to neutralize and destroy each other, and when they arrive at the distant station the interval between them is increased by the shortening of the waves themselves. This is shown by the action of the current upon chemically-prepared paper in the following experiment:

It is well known that when an iron pen is used the decomposition necessary to form marks upon the paper can only be produced by the positive current. Therefore, if two of these pens be arranged at the receiving-station, resting upon a moving strip of prepared paper, and one pen be connected to the line and the other to the earth, as shown in Fig. 2; that when a positive current is sent over the line the pen connected with the line will mark, while with a negative current the pen connected with the earth will mark. Now, if the positive and negative current succeed each other without appreciable interval, and are of uniform strength, the paper will be marked with two sets of lines, as shown in Fig. 2, the commencement of one line coinciding exactly with the termination of the preceding one. This is the case on a circuit of moderate length, say, of fifty to one hundred miles. If this distance is increased to, say, three hundred miles, the lines upon the paper are modified, as shown in Fig. 2A. Each line begins and ends in a blunt point, indicating that each electric wave does not instantly attain its full strength, but that a portion of the electricity of each wave combines with and neutralizes a portion of the adjacent wave of opposite polarity.

This effect is still more apparent at a distance of, say, five hundred miles, the points of the marks becoming more and more acute in proportion as the circuit is lengthened. The breadth of the mark indicates the strength of the current. When this falls below a certain minimum it becomes insufficient to operate an electro-magnet. Thus at a distance of five hundred miles there exists an appreciable interval, after the positive wave, for example, has become too weak to actuate an electro-magnet before the succeeding negative wave becomes strong enough to influence it. The effect of this is to increase the length of the period during which the action of the current upon the electro-magnet becomes null at each reversal of polarity.

By the arrangement of the contact-lever V in connection with the armature-lever *o* of relay R^2 and the local circuits, as hereinbefore described and shown in Fig. 1, the reversal of the polarity of the line-current in the relay R^2 takes place without interrupting the signal upon the sounder S^2, for the reason that when the armature *o* moves it passes directly over from one extreme position to the other, without stopping at the intermediate position long enough to affect the sounder S^2, notwithstanding that there may be a considerable interval between the successive currents.

In order to adapt the hereinbefore-described apparatus to the simultaneous transmission of four communications upon the same wire—two in each direction—it is only necessary to use it in connection with some suitable method of duplex telegraphy. I prefer to make use for this purpose of the method set forth in Letters Patent of the United States No. 136,874, which were granted to Joseph B. Stearns on the 18th of March, 1873, and which I have illustrated in Fig. 1 of the accompanying drawings. To this end I place an additional helix or coil upon both the electro-magnets of each of the relays R^1 and R^2, as shown at h^1 h^1 and h^2 h^2, which contain the same length of wire and the same number of convolutions as the helices *h h* and h^3 h^3, but exert an opposing or neutralizing effect upon the cores of the electro-magnets. The helices h^1 h^1 and h^2 h^2 are included in the circuit of an artificial or branch line, diverging at the point 5, and leading, by way of 16, 17, 18, 19, 20, and 21, to the earth at G. This circuit is made to pass through a resistance, X, which is capable of adjustment so that the strength of the current in the artificial line may be made equal to that in the main line. When this has been done the outgoing currents are divided between the main and artificial line, and do not affect the action of the relays R^1 and R^2. I also make use of a condenser, C, for the purpose of compensating the return or static charge of the line, in the manner fully set forth in Letters Patent of the United States No. 126,847, issued to Joseph B. Stearns on the 14th day of May, 1872, to which reference is had. I furthermore insert a rheostat, *x*, between the said condenser C and the relays R^1 and R^2, in order to somewhat retard the discharge of the former, so that it will reach the relays at precisely the same instant as the discharge from the line.

The duplex method set forth in Letters Patent of the United States No. 132,932, granted to Joseph B. Stearns on the 12th of November, 1872, and known as the "bridge method," may be used instead of the differential plan shown in Fig. 1, if preferred, or, instead of either of these methods, I sometimes prefer to employ a combination of the two, as illustrated in Fig. 3, in which the relay R^1 is placed in the bridge-wire 25 26, and the relay R^2 is composed of a double set of electro-magnets, provided with differential helices, acting in conjunction with each other upon a single armature-lever common to all, the different sets of differential helices being arranged in the sides of the bridge, as shown in the figure.

The relays R^1 and R^2 may be interchanged, R^2 being constructed like R^1 in Fig. 3, and placed in the same position, if preferable. Instead of making use of two separate relays, as shown in Fig. 1, a relay having a single pair of cores may be employed, arranged with curved pole-pieces at each end, between which the polarized armatures *n* and *o* are mounted. Fig. 4 represents one end of such a relay, and Fig. 5 the opposite end of the same relay.

I am aware that the simultaneous transmission of two communications in the same direction, by the use of positive and negative currents, combined with currents of one or the other polarity but of a different strength, is not new, it having been shown and described in Letters Patent of Great Britain, No. 2,575, of 1855, and in other printed publications. Neither do I claim the combination of two separate and independent polarized armatures, operated in the manner described, except when they are connected with their respective receiving instruments by independent local circuits; nor a compound relay-magnet, having a polarized armature, except when constructed with differential helices, and used in the manner and for the purpose herein specified; nor a relay having an armature provided with a supplementary contact-lever, in combination with a local circuit, and receiving-instrument, except when the receiving-instrument is so connected therewith as to be caused to operate substantially in the manner and for the purpose specified.

What I claim as my invention, and desire to secure by Letters Patent, is—

1. In a duplex or multiple telegraph, two transmitters, connected with the same line-wire, one having a device so constructed and arranged as to close one branch of the circuit before opening another, and the other provided with two separate and simultaneously-acting devices of like construction and arrangement, in combination with two independent batteries, so that one battery may be made to send to line either a positive or a negative current, and the other a current of one determinate and invariable polarity, without in any case interrupting the main circuit, substantially as and for the purpose specified.

2. The oscillating double circuit-changer E F G, in combination with an electro-magnet, local battery, and key, substantially as specified.

3. A compound differential relay, consisting of a permanently-polarized armature, so arranged as to be impelled in one direction or the other, according to the polarity of the magnetizing-current, by the attraction and repulsion of two or more separate electro-magnets, and provided with differential helices, simultaneously brought into action by the said current, substantially as herein specified.

4. A receiving-instrument or sounder and a local battery, in combination with a relay, consisting of one or more electro-magnets, provided with an armature or armatures, capable of being moved from one extreme position to the other by a change of polarity in the line-current, and one supplementary contact-lever, so arranged in reference to the said armature that the receiving-instrument will be actuated when the armature is at rest in either of its extreme positions, but not when at rest in an intermediate position, substantially as specified.

5. A receiving-instrument having a differential electro-magnet, the opposing coils of which are included in separate local circuits, or in separate branches of a common local circuit, in combination with a relay so arranged that when its polarized armature is moved in one direction by the action of a positive current traversing the main line, it will open one, and when moved in the opposite direction by a negative current it will open the other, of the two opposing local circuits, and in either case the receiving-instrument will be actuated.

Signed by me this 3d day of December, 1875.

GERRITT SMITH.

Witnesses:
GEO. A. HAMILTON,
JAMES H. ELLIS.