S. D. FIELD.

MULTIPLEX TELEGRAPH.

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942,814.

Patented Dec. 7, 1909.

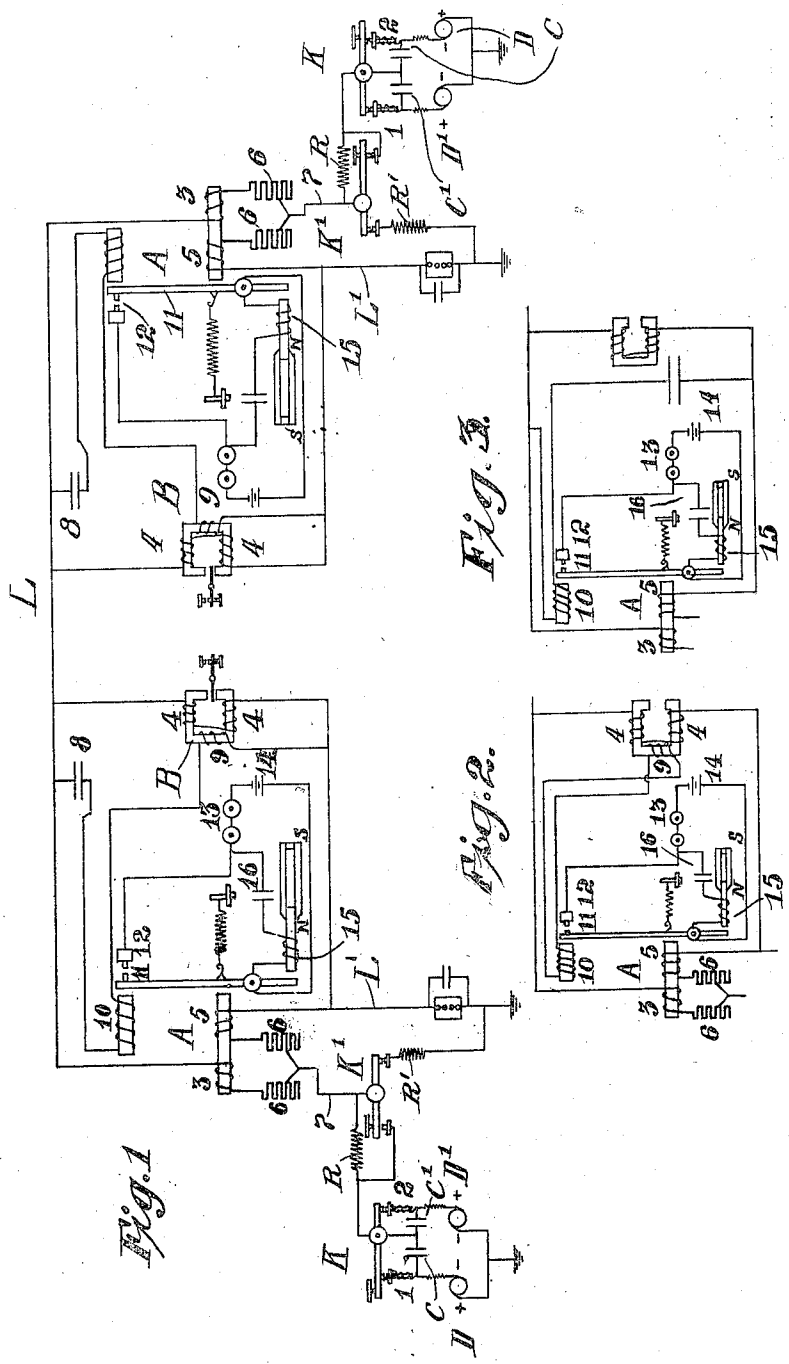

Fig. 1.

Fig. 2.

Fig. 3.

Attest:

Mary S. Trumbull

Paul H. Frank

by

Inventor

Stephen D. Field

H. On. Marble

Atty

UNITED STATES PATENT OFFICE.

STEPHEN D. FIELD, OF STOCKBRIDGE, MASSACHUSETTS, ASSIGNOR TO THE WESTERN UNION TELEGRAPH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

MULTIPLEX TELEGRAPH.

942,814. Specification of Letters Patent. Patented Dec. 7, 1909.

Application filed June 17, 1909. Serial No. 502,687.

To all whom it may concern:

Be it known that I, STEPHEN D. FIELD, a citizen of the United States, residing at Stockbridge, in the county of Berkshire and State of Massachusetts, have invented certain new and useful Improvements in Multiplex Telegraphs, of which the following is a specification.

My invention relates to improvements in multiplex telegraphs, and particularly in quadruplex telegraphs, and consists in means whereby a quadruplex system may be operated successfully and at high speeds on lines of high resistance and static capacity; all four "sides" of the quadruplex working satisfactorily.

It is well known that the quadruplex telegraph systems heretofore used have proved unsatisfactory in practice, particularly when used on lines having high resistance and static capacity; and that on such lines they rarely give the equivalent of more than about two and a half "Morse" or simple lines. A "KR" (capacity and resistance) factor of 20000 has been supposed to be the theoretical limit of successful quadruplex operation. I have found that this is by no means the limit, provided suitable means be employed for overcoming disturbances due to static discharge through the coils of the instruments; provided the instruments have proper relative inductance, and provided suitable means be employed for insuring full movement of the armatures of the neutral relays, once such armatures are started in motion, and for counteracting as to the armatures of these neutral relays, the effects of static discharge. The improved system herein described has been operated successfully and at high speed, as a quadruplex, upon lines having a KR factor in excess of 50000, without the limitation of the system being approached.

The objects of my invention are to permit successful and rapid operation of quadruplex systems, on lines having high resistance and static capacity, to obtain in such lines the full equivalent of four Morse or simple lines, to obviate disturbances due to static and inductive discharge from the main line, artificial line, and the instruments themselves, to avoid false signals or failure of signal at the neutral relays, and to make the system simple, easy to understand and easy to operate.

According to my invention I employ, at each end of the line, a neutral relay and a polar relay; together with transmitting means adapted to vary the strength of the line current, for the operation of the neutral relay at the distant end, and with means for reversing the polarity of the line current, for operating the polar relay at the distant end. One relay at each end of the line is differentially wound, according to common practice, but in addition is provided with a holding magnet, acting upon its armature; through the coils of which holding magnet a static or inductive discharge, or both, passes. Said discharge current energizes the holding magnet and thus provides a means whereby the neutral relay armature is held in place during the "no-line-current" period incident to current reversals. Said neutral relay is also provided with another magnet which insures full travel of the armature of such relay in case of reversal of the line current just following the initiation of a forward movement of such armature. The polar relay at each end of the line is connected in bridge relation to the line and artificial line, and is, or may be, provided with an extra winding in the circuit of the holding magnet of the neutral relay, before referred to; the discharge in this circuit, due to inductance in the said extra winding of the polar relay, serving to energize the said holding magnet at proper times. The inductance of such polar relay exceeds that of the corresponding neutral relay. This I have found to be a very important point, as if the contrary is the case, the system is incapable of working satisfactorily upon lines having a high KR factor.

Heretofore quadruplex and sextuplex systems have been proposed comprising, at each end of the line, a receiving relay in bridge relation to the line and artificial line, and a plurality of other receiving relays connected in series in the line and artificial lines, the total inductive capacity of the relays so connected in series in the line and artificial line of necessity greatly exceeding the inductive capacity of the relay in bridge relation. Patents Nos. 242,411, and 353,128 granted to me on May 31, 1881, and on Nov. 23, 1886, respectively, illustrate such systems: and Patent 242,41 also illustrates a similar "triplex" system, *i. e.*, a system arranged for simultaneous transmission of three mes-

sages in one direction only. Such a "triplex" system is operative; but when "duplexed" for transmission in both directions it becomes practically inoperative, because at instants of sudden decrease in current strength, there is a discharge of current, in the main and artificial lines, due to self-induction in the coils of the relays connected in series in the main and artificial lines, such discharges in the main and artificial lines being cumulative and passing through the closed local loop formed by the main and artificial lines and the bridge connection in which the third relay is located, and being opposed, in such bridge connection, only by a lesser discharge in the opposite direction due to self-induction in the coils of such third or bridged relay. The effect of such discharge is, not only to prolong the period of energization of the relays connected in series in the line, but also, in many cases, to overpower the third relay, located in the bridge connection, so causing such relay to give a false signal. A similar effect is experienced on sudden increases in current strength, the currents induced being, of course, of opposite sign. And similar effects would be experienced if there were but one differentially wound relay located in the main and artificial lines, and but one relay in the bridge connection, provided the inductive capacity of the differentially wound relay were greater than that of the relay connected in bridge. Since the trouble referred to varies as the square of the ampere turns producing it, and since, when there are differentially wound relays connected in series in the main and artificial lines, the line current must for that very reason be greater than if there were but one such relay, it is clear that systems such as illustrated in my said prior patents, in which the relays in the main and artificial lines have a higher total inductive capacity than the relay in the bridge connection, are not practicable. In my present system, however, I employ a single relay only, at each end of the line, in the main and artificial lines, and make this relay of considerably less inductive capacity than that in the bridge connections; which being so, not only is the discharge, due to self-induction in the coils of the line relay, unable to overcome the similar but opposite discharge due to self-induction in the coils of the bridged relay, but the discharge from the latter relay overcomes the discharge from the line relay, in the coils of that line relay, making the responses by that relay more prompt, and so improving its working.

In the accompanying drawings I illustrate diagrammatically a quadruplex system embodying my invention.

In said drawings: Figure 1 shows diagrammatically a quadruplex telegraph system embodying my invention. Figs. 2 and 3 are fragmentary diagrams illustrating alternative modifications.

Referring first to Fig. 1, A, A, designate line neutral relays, one at each end of the line, L designates the line conductor, L′ the artificial line conductor, and B, B designate polar relays connected in bridge between the line and artificial line, and each connected to the line and artificial line, with respect to the corresponding neutral relay A, on the line side thereof.

K K′ designate transmitters, at each end of the line, transmitters K being pole-changing transmitters and transmitters K′ being current varying transmitters. I have indicated a modification of the well-known Field key system, comprising current generators D and D′, connected to opposite contacts of key K and to ground, but oppositely connected, intense impedances 1 and 2 being interposed between the generators and their key contacts; and comprising also, resistances R and R′, with respect to key K′, which resistances are cut out when key K′ is depressed, so increasing the strength of the line current. The modification in the ordinary Field key system, illustrated in the drawing, consists in the provision of condensers C and C′ bridged between generators D and D′, respectively, and the line, the purpose of which condensers is to bridge over the "no current" period while the key is passing from one contact to the other; the effect of which is to connect the line to earth through the condensers when the key is passing from one contact to the other, which is equivalent to a momentary dead earth at such times, as the condensers terminate in equal potentials of opposite sign. The impedances 1 and 2 are, in practice, of but about one ohm, in ohmic resistance, but are of magnetic value sufficient to obviate during their momentary charging, any tendency to welding of the key contacts. The result of this arrangement is, that when the key K is operated, the line is put, momentarily, to what might be termed a "phantom earth" between the changes of current, instead of passing abruptly from one potential to the other. I have found that by so doing it is possible, in a measure, to diminish the disruptive discharge between adjacent circuits, and so to make the transmission of signals much more smooth.

The neutral relays, A, have the usual oppositely-connected or oppositely-wound line and artificial line coils, 3 and 5, respectively, connected through resistances 6, 6, to a wire 7 leading to the keys. These resistances 6, 6 are equalizing non-inductive resistances, of equal value, and arranged when the apparatus is installed to determine a fixed inductive value of highest amount between coils 3 and 5 and the coils 4, 4 of polar relay

B, after which they remain unaltered under all current conditions. In practice, they are resistance coils of somewhat greater value than are actually required. The correct points of connection of wires 7 to them are found by test and then the wire is soldered at such points.

The neutral relays, A, are each provided, in addition to the main magnet on which are coils 3 and 5, with a holding magnet 10, in a bridge circuit extending from the line conductor through an extra coil 9 of the polar relay B to the artificial line; and this bridge circuit may contain a condenser 8. Said relays A are also provided with an additional magnet 15, having a permanently magnetized core, and a coil thereon bridged together with a condenser 16, across a local circuit including a local battery 14, a sounder 13 or other instrument to be controlled by relay A, and the armature 11, and rear contact 12, of the relay.

The operation of the system is as follows: Arriving signals from the distant station find paths to earth via the coils 3 and 5 of neutral relay A and the coils 4—4 of the polar relay B. Assuming a current impulse of full strength to arrive from the line L, at one of the two stations, it will divide between the neutral and polar relays in proportion to their respective resistances, both relays being energized, the armature 11 of relay A being attracted and the armature of relay B being reversed in position only in case said current impulse is accompanied by a reversal of current. If now the current be reversed at the distant station, this reversal should affect only the polar relay, B, while the armature of the neutral relay, A, should remain stationary. It is well known, however, that in ordinary quadruplex systems the armature of the neutral relay usually falls back during the "no current" period accompanying current reversal. In the neutral relay herein illustrated, however, at the instant of reversal there is a discharge of current in the local circuit including the coils of magnet 10, such discharge due to the combined action of condenser 8 and of self-induction in coil 9 of relay B (though either of these discharges may be in itself sufficient, so that either coil 9 or condenser 8 may be omitted provided the other be retained). The effect of this discharge is to energize magnet 10 at the instant when energization of that magnet is required to hold the armature 11 in proximity to the magnet poles. By the time this discharge has passed the opposite current has been established in the coils of the main relay magnet, so holding the armature in its attracted position. In case of reduction of line current strength, as by release of transmitter K' at the distant station, there is a similar but lesser discharge through the coils of magnet 10, which, however, is not sufficient to prevent or appreciably retard retraction of the armature of the relay. When, while the armature 11 is in its retracted position, a current impulse of full strength arrives from the distant station, condenser 8 charges, producing a flow of current in the local circuit of magnet 10, and self-induction in coil 9 has the same effect; the result being to assist, slightly, forward movement of the armature 11.

In the operation of quadruplex systems there frequently comes a time when, just as the current strength in the line increases sufficiently to start the armature of the neutral relay moving forward, the line current is reversed. In former quadruplex systems, this generally causes the armature of the neutral relay to fall back to its rear contact stop, so making a false signal. To obviate this I have provided, in my neutral relay, the magnet 15, the core of which is permanently magnetized, as already stated, and the coil of which is bridged across a local circuit including sounder 13; condenser 16 being included in the bridge connection. The instant armature 11, in its forward movement, breaks the contact with rear contact stop 12, it deënergizes the magnet of sounder 13, and the resulting discharge through the coil of magnet 15, due to self-induction in the coil of the sounder, and to the charging of condenser 16, augments the strength of magnet 15 sufficiently to carry the armature 11 over toward its attracted position, giving time for the restoration of current in the line to occur and so cause the main magnet of the relay to catch and hold the armature, without any false back contact being made. Magnet 15 does not impede backward motion of the armature, upon decrease of line current strength, because the discharge from condenser 16 momentarily demagnetizes the cores of magnet 15, so contributing, momentarily, to firmness of contact between 11 and 12.

In this system the cores of the various magnets should be highly laminated as in this system the operation of the apparatus is greatly benefited by lamination of the cores, whereas the contrary is the case in most former quadruplex systems.

As indicated in Fig. 2, I may dispense with the condenser 8 in the local bridge circuit of holding magnet 10, the discharge from the coil 9 of the polar relay being relied upon to energize said magnet at suitable times, or as illustrated in Fig. 3, I may employ the condenser 8 in this local circuit, dispensing with the extra coil 9 of the relay 4. In general, however, I prefer to employ both the condenser 8 and the extra coil 9 in this circuit.

I do not in this application illustrate the mechanical structure of the relays A and B, as such structure will be readily apparent to

those skilled in the art, from the diagrammatic illustration. In a companion application filed June 17, 1909, Sr. No. 502,688, I have illustrated and described one mechanical structure of such a relay, and claimed the same.

What I claim is:—

1. A multiplex telegraph system comprising in combination main and artificial lines, a differentially wound relay, having its differential windings, one in such main line and the other in such artificial line, and another relay having its coils connected to the main and artificial lines in bridge relation with respect to said first relay and having an inductive capacity greater than that of the main line and artificial line coils of said first mentioned relay.

2. A multiplex telegraph system comprising in combination main and artificial lines, a differentially wound relay, having its differential windings, one in such main line and the other in such artificial line, and another relay having its coils connected to the main and artificial lines in bridge relation with respect to said first relay, and connected to the line on the line side of said first mentioned relay, and having an inductive capacity greater than that of the main line and artificial line coils of said first mentioned relay.

3. A multiplex telegraph system comprising in combination main and artificial lines, a differentially wound neutral relay having its differential windings, one in such main line and the other in such artificial line, and a polar relay having its coils connected to the main and artificial lines in bridge relation with respect to said neutral relay, and having an inductive capacity greater than that of the main line and artificial line coils of the neutral relay.

4. A multiplex telegraph system comprising in combination main and artificial lines, a differentially wound neutral relay having its differential coils, one in such main line and the other in such artificial line, and a polar relay having its coils connected to the main and artificial lines in bridge relation with respect to said neutral relay, and connected to the line on the line side of said neutral relay, and having an inductive capacity greater than that of the main line and artificial line coils of the neutral relay.

5. A multiplex telegraph system comprising in combination a main line, an artificial line, a differentially wound relay having its differential coils connected, the one in said main line and the other in said artificial line, said relay having also an armature and a holding magnet therefor, and connecting means bridging the coils of such holding magnet between the main and artificial lines, means in such bridge connection for creating a flow of current through such holding magnet coils, during times of current change in the line, and another relay connected to the main line and artificial line in bridge relation with respect to said first relay.

6. A multiplex telegraph system comprising in combination a main line, an artificial line, a differentially wound relay having its differential coils connected, the one in said main line and the other in said artificial line, said relay having also an armature and a holding magnet therefor, and connecting means bridging the coils of such holding magnet between the main and artificial lines, means in such bridge connection for creating a flow of current through such holding magnet coils, during times of current change in the line, and another relay connected to the main line and artificial line in bridge relation with respect to said first relay, and having inductive capacity greater than that of the main line and artificial line coils of the first mentioned relay.

7. A multiplex telegraph system comprising in combination a main line, an artificial line, a differentially wound neutral relay having its differential coils connected, one in said main line and the other in said artificial line, said relay having also an armature and a holding magnet therefor, and connecting means bridging the coils of such holding magnet between the main and artificial lines, means in such bridged connection for creating a flow of current through such holding magnet coils during times of current change in the line, and a polar relay connected to the main line and artificial line in bridge relation with respect to said first relay, and having inductive capacity greater than that of the main line and artificial line coils of the first mentioned relay.

8. A multiplex telegraph system comprising in combination a main line, an artificial line, a differentially wound relay having its differential coils connected, the one in said main line and the other in said artificial line, said relay having also an armature and a holding magnet therefor, and being connected to the line on the line side of said first mentioned relay, and connecting means bridging the coils of such holding magnet between the main and artificial lines, means in such bridge connection for creating a flow of current through such holding magnet coils, during times of current change in the line, and another relay connected to the main line and artificial line in bridge relation with respect to said first relay, and having inductive capacity greater than that of the main line and artificial line coils of the first mentioned relay.

9. A multiplex telegraph system comprising in combination a main line, an artificial line, a differentially wound relay having its differential coils connected, the one in said main line and the other in said artificial line,

said relay having also an armature and a holding magnet therefor, and connecting means bridging the coils of such holding magnet between the main and artificial lines, a condenser in such bridge connection for creating a flow of current through such holding magnet coils, during times of current change in the line, and another relay connected to the main line and artificial line in bridge relation with respect to said first relay, and having inductive capacity greater than that of the main line and artificial line coils of the first mentioned relay.

10. A multiplex telegraph system comprising in combination a main line, an artificial line, a differentially wound relay having its differential coils connected, the one in said main line and the other in said artificial line, said relay having also an armature and a holding magnet therefor, and connecting means bridging the coils of such holding magnet between the main and artificial lines, and another relay connected to the main line and artificial line in bridge relation with respect to said first relay, and having a coil inductively influenced by change of strength of the magnet of the relay and included in the circuit of such holding magnet of the other relay.

11. A multiplex telegraph system comprising in combination main and artificial lines, a differentially wound relay, having its differential windings, one in such main line and the other in such artificial line, another relay connected to the main and artificial lines in bridge relation to said differentially wound relay, said differentially wound relay having a holding magnet and a circuit including the coils of said holding magnet and connecting the main and artificial lines, and including a condenser.

12. A multiplex telegraph system comprising in combination main and artificial lines, a differentially wound relay, having its differential windings, one in such main line and the other in such artificial line, another relay connected to the main and artificial lines in bridge relation to said differentially wound relay, said differentially wound relay having a holding magnet and a circuit including the coils of said holding magnet and connecting the main and artificial lines, and including an extra coil of the bridged relay.

13. A telegraph system comprising in combination main and artificial lines, a differentially wound relay having its differential windings, one in such main line and the other in such artificial line, and having an armature and contacts operated thereby, a local circuit controlled by said contacts and including inductance, and a source of current and an auxiliary magnet for said armature, normally magnetized and having in addition coils, and a bridge connection across said local circuit, including said coils, and means for discharging current therethrough during change of current in such local circuit.

14. A telegraph system comprising in combination main and artificial lines, a differentially wound relay having its differential windings, one in such main line and the other in such artificial line, and having an armature and contacts operated thereby, a local circuit controlled by said contacts and including inductance and a source of current, and an auxiliary magnet for said armature, normally magnetized and having in addition coils, and a bridge connection across said local circuit, including said coils, and means for discharging current therethrough during change of current in such local circuit.

15. A telegraph system comprising in combination main and artificial lines, a differentially wound relay having its differential windings, one in such main line and the other in such artificial line, and having an armature, and a holding magnet for said armature and a bridge connection connecting the main and artificial lines and including such holding magnet, and means for discharging current therethrough upon current change in the lines.

16. A telegraph system comprising in combination main and artificial lines, a differentially wound relay having its differential windings, one in such main line and the other in such artificial line, and having an armature, and a holding magnet for said armature and a bridge connection connecting the main and artificial lines and including such holding magnet, and a condenser.

17. A telegraph system comprising in combination main and artificial lines, a differentially wound relay having its differential windings, one in such main line and the other in such artificial line, and having an armature, and a holding magnet for said armature, and a bridge connection connecting the main and artificial lines and including such holding magnet, and including a coil having a core provided with means for varying its magnetization upon change of current in the line.

18. A telegraph system comprising in combination main and artificial lines, a differentially wound relay having its differential windings, one in such main line and the other in such artificial line, and having also an armature and contact means operated thereby, a holding magnet for such armature, a bridge connection including the coils of such holding magnet and extending from the line to the artificial line and including means for discharging current through the coils of such holding magnet upon change of current in the line, a local circuit controlled by said contacts and in-

cluding a source of current and inductance, and an auxiliary magnet for said armature, having a normally magnetized core and coils, and means connecting same in bridge across such local circuit and including a condenser.

19. A telegraph system comprising two sources of current of different potentials, a current reversing device provided with a line connection and with separate contacts connected to such sources of current, and a condenser circuit connecting the line connection to both such sources of current, the connections being such that both sources of current are at all times in connection, directly or inductively, with the line.

20. A telegraph system comprising two sources of current of different potentials and a current reversing device having a line connection and opposite contacts connected to said sources of current, and condensers bridged around said contacts and connecting the line connection with such sources of current, and resistances of low ohmic and high impedance value, interposed between said contacts and said sources of current.

In testimony whereof, I affix my signature, in the presence of two witnesses.

STEPHEN D. FIELD.

Witnesses:

H. M. MARBLE,

FRANK E. RAFFMAN.