Feb. 21, 1939. W. W. CRAMER ET AL 2,147,690

TELEGRAPH REPEATER

Filed Aug. 30, 1935 2 Sheets-Sheet 1

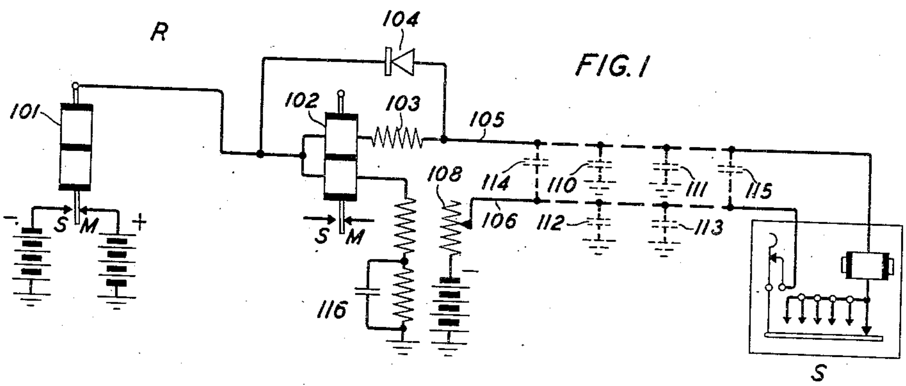


FIG. 1

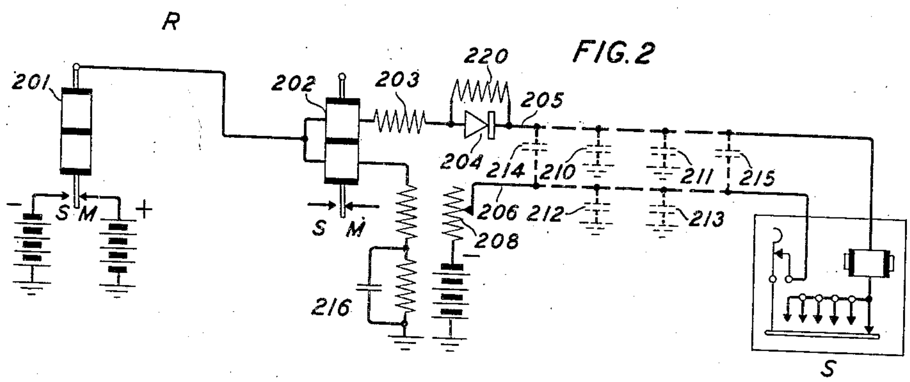


FIG. 2

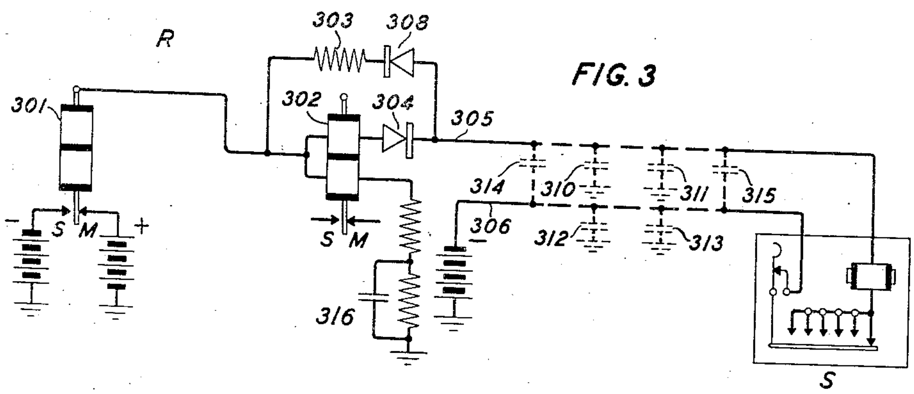


FIG. 3

INVENTORS W. W. CRAMER
G. C. CUMMINGS

BY J. W. Schmied

ATTORNEY

Feb. 21, 1939.

W. W. CRAMER ET AL

2,147,690

TELEGRAPH REPEATER

Filed Aug. 30, 1935

2 Sheets-Sheet 2

FIG. 4

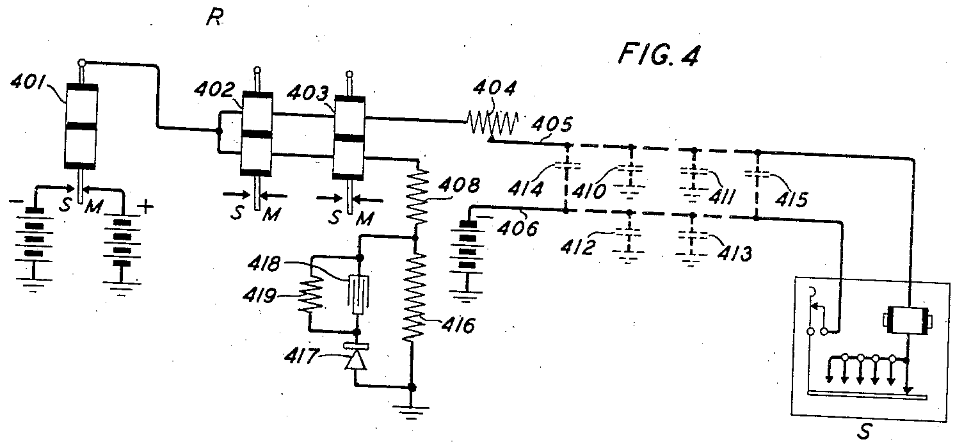
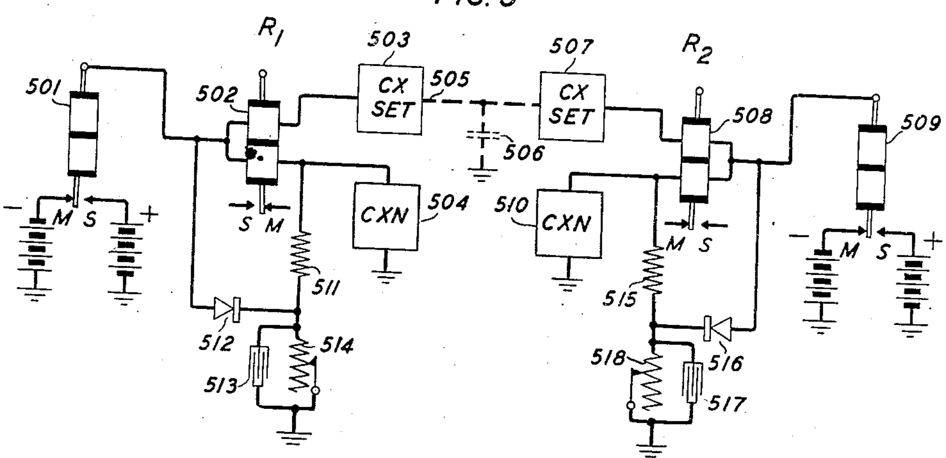


FIG. 5



INVENTORS W. W. CRAMER
G. C. CUMMINGS

BY J W Schmied

ATTORNEY

Patented Feb. 21, 1939

2,147,690

UNITED STATES PATENT OFFICE

2,147,690

TELEGRAPH REPEATER

Walter W. Cramer, Rutherford, and George C. Cummings, Orange, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application August 30, 1935, Serial No. 38,528

21 Claims. (Cl. 178—71)

This invention relates to telegraph repeaters, and more particularly, to telegraph repeaters of the balanced type in which one relay must be held inoperative while another relay transmits signal impulses through the winding of the inactive relay.

An object of the invention is to prevent the inactive relay from being operated by line discharges when the active relay is operating.

Another object is to provide a repeater of simple design which may be effectively operated in conjunction with any one of a plurality of comparatively high capacity lines, such as long subscribers' loop circuits.

Another object of the invention is to arrange for the counteraction of line surges through a repeater relay without the necessity of increasing the line current beyond that used in ordinary practice.

The present day tendency is to interconnect telegraph subscribers through switchboards which are equipped with repeaters. The tendency is, furthermore, to use longer and longer subscribers' loop circuits and to include the conductors for such loops in cables so that their capacity to ground, as well as their mutual capacity, becomes quite appreciable. The discharge surges from the line, consequently, are becoming more and more pronounced and it is becoming necessary to provide against their effect upon the relay operations.

When a marking potential is applied to a high capacity line, the so-called "marking surge" acts to charge the line to a given potential, both with respect to ground and with respect to the return conductor. This surge is in a direction such that the inactive relay is held to marking. When a spacing potential is applied to the line through the line winding of the inactive relay, a surge in the opposite direction or "spacing surge" takes place to discharge the line with respect to ground. This surge tends to operate the inactive relay to spacing, which, of course, is not desired. In certain types of repeater circuits these conditions are reversed.

In accordance with a feature of the invention, a uni-lateral device is connected in circuit with the inactive relay in such a manner that it will prevent the relay from "kicking off" during the spacing surge referred to above.

In accordance with a further feature of the invention, the unilateral device is associated with an impedance to form an asymmetric multiple network which provides two paths, one for the normal current and one for a transient current.

In accordance with the invention, the unidirectional device may be used for passing the normal line current and the impedance for limiting the surge current; the unidirectional device may be used for by-passing the surge current around the relay winding, and the impedance may be used for control of the normal signaling current; or combinations of these arrangements may be provided.

According to a more specific feature of the invention, circuit means are provided in combination with the unidirectional device for absorption of a transient discharge which may either be the surge impulse or a counter-effective transient impulse.

The invention will now be described as applied in different manners to a typical telegraph repeater circuit and reference will be made to the attached drawings, in which

Figs. 1, 2, and 3 show a half duplex repeater of the balanced type in which the unidirectional device is associated with the line winding of the inactive relay in different manners, and

Figs. 4 and 5 show the device associated with the balancing winding of the inactive relay.

In Figs. 1 to 4, inclusive, the invention is illustrated in connection with a subscriber's loop, whereas in Fig. 5 the invention is illustrated in connection with a composite telephone line.

In the drawings, only enough of the repeater station is shown in the various figures to facilitate the understanding of the principles and operations of the invention. Thus, in each repeater only those parts are shown which cooperate with one line or loop circuit, it being understood that for the purposes of the invention the connections to the other line circuit may be made in any desirable manner, and may be made in the same manner as those illustrated.

The embodiments to which the invention will be applied, while being preferred, are merely given as examples; other ways or modifications in which the advantages and features of the invention may be utilized will be obvious to one skilled in this art.

In order that the operation of the invention may be clearly understood, the line circuit shown in each of the circuit arrangements in the drawings will be assumed to be of considerable length and to be composed practically entirely of a pair of cable conductors enclosed by a lead sheath. The line circuit will thus have appreciable mutual distributed capacitance between the two conductors, and also grounded distributed capacitance between each conductor and the cable sheath. These capacitances are diagrammatically illustrated in the drawings by dotted condensers.

Referring now particularly to Fig. 1, the sending relay 101 of repeater R is actuated in any suitable manner and transmits positive and negative impulses through the upper or line winding of receiving relay 102 and over the line circuit 105, 106 to actuate the distant subscriber's station S, it being a requirement of the circuit that the armature of receiving relay 102 be held firmly on its right-hand or marking contact while pulses are being transmitted from sending relay 101. The distributed capacitance between line conductor 105 and ground is represented by condensers 110 and 111, and between conductor 106 and ground by condensers 112 and 113, and the mutual distributed capacitance between conductors 105 and 106 is represented by condensers 114 and 115.

The subscriber's station S may be equipped with standard teletypewriter apparatus and thus will have a receiving winding responsive to incoming signals for operation of the translating or recording device, and transmitting or distributor contacts responsive to actuation of the keyboard to transmit impulses into the line circuit.

With the armature of relay 101 on its right-hand contact, as shown, a marking impulse is sent over the line to actuate receiving apparatus at station S. This marking circuit is traced from positive battery through the right-hand contacts of relay 101, through the upper winding of relay 102, resistance 103, conductor 105, station S, conductor 106, to negative battery through variable resistance 108. A unidirectional device 104 is connected in parallel with the upper winding of relay 102 and resistance 103 but is poled in a direction so that very little or no current flows through it during the marking impulse. Another circuit involving the lower winding of relay 102 is traced from positive battery through the right-hand contacts of relay 101 through the lower winding of relay 102 to ground through balancing network 116. With the same number of turns in the windings of relay 102, the current in the lower winding is about one-half of that in the upper winding, and tends during marking condition to move the armature to spacing.

When sending relay 101 closes its left-hand contacts, negative battery is connected to negative battery over the line circuit described above and the current through the lower winding of relay 102 is reversed to hold the armature to marking as the line current becomes zero. However, the line capacities 110 and 111 will now be charged to a negative potential with respect to ground and the capacities 114 and 115 will discharge through the line winding of relay 102. This transient current in the upper winding of relay 102 would tend to operate the relay to break its right-hand contacts were it not for the fact that the unidirectional device 104 is connected in such a way that the major part of the transient current is shunted through it instead of traversing the upper winding of relay 102 and resistance 103. By this means, the reversed flux which would ordinarily be generated by the upper winding of relay 102 is insufficient to overpower that of the lower winding and cause the armature of relay 102 to leave its right-hand or marking contact.

When the line circuits described above are again closed to marking potential, condensers 110, 111, 114 and 115 will again be charged to positive potential and the charging current will pass with its full strength through the upper winding of relay 102. This causes a transient condition in relay 102 during which the upper winding is more powerful than the lower winding. However, the additional flux generated by this transient current is in a direction to hold the armature relay 102 more firmly on its right-hand or marking contact and no difficulty is experienced upon the charge of the line capacity on the marking impulse.

Fig. 2 shows an arrangement very similar in its action to that of Fig. 1 except that a unidirectional impedance network consisting of resistance 220 and unidirectional device 204, is inserted in series with the line circuit instead of being connected as a shunt path for the upper winding of the receiving relay as shown in Fig. 1.

In Fig. 2, the transmitting circuit for the marking impulse is traced from positive battery through the right-hand contacts of sending relay 201, the upper winding of relay 202, resistance 203, resistance 220 in parallel with unidirectional device 204, line conductor 205, station S, line conductor 206, to negative battery through variable resistance 208. When this condition was first established, the line current was in a direction to meet a low resistance path through unidirectional device 204 and a heavy transient current, due to the reversal of charges on condensers 210 and 211 and to charging of condensers 214 and 215 which represent the line distributed capacity, traversed the upper winding of relay 202 in a direction to cause the latter relay to hold its right-hand contacts firmly closed. When sending relay 201 reverses the direction of current in the line, however, the unidirectional device 204 presents a large resistance to the line current and the charging current of condensers 210, 211, 214 and 215, as well as the spacing impulse, is forced to traverse resistance 220 which reduces the current surge sufficiently to prevent relay 202 from breaking its right-hand or marking contacts.

Referring now to Fig. 3, a circuit is shown which combines some of the features of the circuits shown in Figs. 1 and 2. In this case, two unidirectional devices are used to provide separate paths for the marking and spacing currents. Thus with the armature of sending relay 301 on its right-hand or marking contacts, positive battery is connected through the upper winding of relay 302, unidirectional device 304, line conductor 305, station S, to negative battery over line conductor 306. Unidirectional device 304 is connected in such a way that its resistance is low to the current in the circuit described above. Unidirectional device 308 in series with resistance 303 is connected in parallel with the upper winding of relay 302 and unidirectional device 304, but device 308 is poled in the opposite direction to device 304 and the circuit element comprising unidirectional device 308 and resistance 303 is of sufficiently high impedance during the marking impulse to have a negligible shunting effect on the upper winding of relay 302. As in the previous cases a parallel circuit is provided to energize the lower, balancing winding of receiving relay 302, this circuit being traced from positive battery through the right-hand contacts of relay 301, through the lower winding of relay 302 to ground through balancing network 316. As in the previous cases, the transient current due to the marking charge of line capacities 310, 311, 314 and 315 traverses the upper winding of relay 302 but tends to keep the armature of relay 302 firmly against its right-hand contact.

When relay 301 closes its left-hand contacts to send a spacing charge which is in the opposite direction to the marking charge, unidirectional device 304 effectively prevents the charging current of condensers 310, 311, 314 and 315 from traversing the upper winding of relay 302, while unidirectional device 308 and resistance 303 provide a low resistance parallel path so that the spacing impulse is transmitted to station S.

In Fig. 4, the sending portion of a terminal repeater is disclosed in which the unidirectional device 417 is connected in the balancing circuit for the receiving relay 402 rather than in the line circuit. This arrangement is advantageous because it removes the unidirectional device from the line circuit. In this case, when sending relay 401 closes its right-hand contacts, positive battery is connected through the upper windings of receiving relay 402 and break relay 403 in series, through variable resistance 404, line conductor 405, substation S, to negative battery over line conductor 406. When the condensers 410, 411, 414 and 415 are charged to this condition, the transient current through the line windings of relays 402 and 403 keeps the armatures of these relays on their right-hand or marking contacts. A parallel circuit is traced from positive battery through the right-hand contacts of relay 401, lower windings of relays 402 and 403, resistance 408, to ground through resistance 416. A network consisting of condenser 418, resistance 419, and unidirectional device 417 is also connected in this circuit but due to the poling of unidirectional device 417, no appreciable current flows in it.

When relay 401 closes its left-hand contacts to send a spacing impulse, line condensers 410, 411, 414 and 415 charge through the upper windings of relays 402 and 403, sending a transient wave through these relays, which would ordinarily cause them to break their right-hand or marking contacts. In this case, however, the current through the lower windings of relays 402 and 403 and the balancing network finds a low impedance path through unidirectional device 417 and the large condenser 418. A transient current, therefore, flows through the lower windings of relays 402 and 403 which effectively neutralizes the transient in the upper windings and prevents these relays from opening their right-hand contacts. Resistance 419 is provided to discharge condenser 418 after the circuit has reached a steady state.

In Fig. 5, an arrangement is shown for applying the features of the invention to a composite telephone and telegraph circuit. In this case, as in Fig. 4, a unidirectional device is connected in the local circuit for the balancing network of the receiving relay to provide balancing transients during spacing impulses without introducing transmission losses. When transmitting relay 501 is actuated to marking, it closes its left-hand contacts and negative battery is connected through the upper winding of receiving relay 502, through the compositing set 503, over line conductor 505, through compositing set 507, the upper winding of receiving relay 508, to negative battery through the left-hand contacts of relay 509. Thus, no current flows in the line circuit during marking. At the same time, a parallel circuit is closed from negative battery through the left-hand contacts of relay 501 through the lower winding of relay 502, and the duplex balancing circuit to ground. The current in this circuit holds relay 502 in marking position.

The balancing circuit in this instance may comprise the usual line balancing resistances 511 and 514 and capacity 513 and also a separate balancing unit 504 for balancing the impedance of the compositing set 503 in the line circuit.

Unidirectional device 512 is connected in parallel with the lower winding of relay 502 and resistance 511 in such a way that when relay 501 operates to spacing, condenser 513 will be charged to a positive potential with respect to ground through the unidirectional device 512 and the current through the lower winding of relay 502 which tends to operate the relay to spacing will be of very small value. Line condenser 506 then will also be charged to positive potential, but the line current which traverses the upper winding of relay 502 is in a direction to cause the relay to remain firmly upon its right-hand or marking contacts.

When relay 501 closes its left-hand contacts to transmit a marking impulse, line capacity 506 is charged to a negative potential through the upper winding of relay 502. In this case, however, the transient current in the upper winding of relay 502 is in a direction to tend to operate relay 502 to spacing; however, condenser 513 now charges in a direction through the lower winding of relay 502 to hold the relay in marking position. A heavy transient current is therefore generated in the lower winding of relay 502 which opposes the transient in the upper winding and effectively prevents relay 502 from opening its right-hand contacts.

In a similar manner, relay 509 may transmit marking and spacing impulses to receiving relay 502 without causing relay 508 to open its left-hand contacts because of the similar circuit arrangement involving balancing network 510, unidirectional device 516, condenser 517, and resistance 518. When relay 509 is operated to spacing, the line winding of relay 502 will oppose the biasing winding and the line current will be sufficient to operate the relay to spacing.

For a complete system extending from the subscriber's station S in the various figures to another similar subscriber's station, the entire system shown in the drawings, except relays 101 and 102 in Fig. 1 and corresponding relays in the other figures, may be duplicated. Thus, for example in Fig. 1, the contacts S and M of relay 102 would constitute sending contacts for the other line circuit corresponding to the contacts of relay 101; one winding of relay 101 would be connected to the incoming line and the other winding would be included in a biasing circuit similar to that including the lower winding of relay 102 and the network 116. In Fig. 5, the windings of relay 501 may be connected like those of relay 508, and the contacts of relay 502 like those of relay 509 for operation with a line similar to line 505.

What is claimed is:

1. A polarized signal relay having two windings for producing opposed fluxes resulting in an operating flux, a signaling circuit including a line circuit and balancing circuit means, said windings being connected in said signaling circuit, and unidirectional circuit means and impedance means in multiple relation and associated with one of said windings to prevent a discharge of said signaling circuit from reversing the direction of said operating flux.

2. A polarized signal relay having a line winding and a balancing winding, a signaling circuit including a line circuit and balancing circuit means connected to one side of said line and balancing windings respectively, signaling means connected to the other side of said windings for alternately charging and discharging said signaling circuit, and unidirectional circuit means and impedance means in multiple relation and connected to one of said windings to prevent said charging and discharging of the signaling circuit from operating the relay armature by proportioning the discharging currents through said windings without substantially affecting the charging currents therethrough.

3. A polarized signal relay having a line winding and a second winding, a signaling circuit including a line circuit and balancing circuit means, said windings being included in said signaling circuit, signaling means for oppositely energizing said windings to produce a resultant operating flux during sending of a current impulse and for energizing said second winding to produce a holding flux in the same direction as the operating flux during sending of a no-current impulse, asymmetric circuit means including a unilateral device and a by-path therefor connected to one of said windings to cause during a no-current impulse the flux produced by said second winding to be larger than the flux produced by a surge current from the line circuit through said line winding.

4. A polar signaling relay, a line circuit including a winding of said relay, a balancing circuit including another winding of said relay, signal transmitting means connected to apply alternating potentials of opposite polarities simultaneously to both of said circuits thereby producing an alternating current through one of said windings, and a multiple network including unidirectional circuit means connected to said circuit including the other of said windings for reducing the current flowing therein during the application of one of said potentials with respect to the current flowing therein during the application of the other potential to prevent said relay from operating during said applications of potentials.

5. The combination in accordance with claim 4 in which said multiple network comprises a unidirectional cell for passing currents in one direction therethrough and opposing currents in the other direction, and an impedance branch for by-passing the said opposed currents about said cell and limiting them.

6. A polar signaling relay, a line circuit including a winding of said relay, a balancing circuit including another winding of said relay, said circuits being connected at a common apex point, signaling means for alternately applying opposite voltage polarities to said apex point and for thereby producing an alternating current in one of said windings, a multiple network including a unidirectional cell and an impedance branch and connected to limit the current flow in one direction during one half cycle through the other of said windings with respect to the current flow in the opposite direction during the other half cycle therethrough so that the resultant flux produced by said windings will be continuous in one direction during the operation of said signaling means.

7. A polar signaling relay, a line circuit including a line winding of said relay, a balancing circuit including another winding of said relay, said circuits being connected to a common apex point, signaling means for alternately applying opposite current polarities to said apex point, a rectifying branch connected to said line circuit to provide a low impedance path for line current only when one of said polarities is applied, and impedance circuit means connected in multiple relation to said rectifying branch to limit the line current when the other polarity is applied to said apex point.

8. The combination in accordance with claim 2 in which said unidirectional circuit means comprises an impedance serially connected to one of said windings and an asymmetric cell connected in multiple relation to said one winding.

9. The combination in accordance with claim 6 in which said impedance branch is serially included in said line circuit for control of the normal line current strength and said unidirectional cell is connected in a by-path about the relay winding included in said line circuit to provide a low impedance path for surge currents in said signaling circuit of direction opposite that of the normal line current.

10. The combination in accordance with claim 4 in which said multiple network is connected in said balancing circuit and comprises a current limiting branch for balancing the currents through said windings when one of said signaling potentials is applied simultaneously to both of said windings and further comprising a rectifying device connected in parallel to said branch for admitting additional current through said other winding when the other potential is applied.

11. The combination in accordance with claim 6 in which said multiple network is connected in said balancing circuit and further includes transient charge absorbing means serially connected to said unidirectional cell and effective substantially coincidentally with transient discharges in said line circuit so that the said resultant flux will be continuously unidirected and of substantially constant strength during the operation of said signaling means.

12. A polarized signaling relay, a line circuit including a winding of said relay, a balancing circuit including another winding of said relay, said circuits being connected to a common apex point, signaling means for alternately applying different voltage polarities to said apex point, a condenser and a rectifying device connected in a series circuit included in said balancing circuit, a discharge impedance connected across said condenser and a balancing impedance connected in multiple relation to said rectifying device.

13. A polar signaling relay, a high capacity signaling circuit including a winding of said relay, signaling means for alternately charging and discharging said circuit, a unilateral device in series connection with said winding to at least partly prevent the discharge of said signaling circuit from passing through said winding, a second unilateral device in multiple connection with said winding to at least partly by-pass said discharge.

14. A polarized signaling relay, a line signaling circuit including a line circuit, balancing circuit means, and windings of said relay, a multiple network included in said balancing circuit and comprising an impedance branch for control of normal current in said balancing circuit and an asymmetric impedance branch including a unidirectional device and transient charge absorbing means in series relation.

15. A polarized signaling relay, a signaling circuit including transmitting means, a line circuit, a balancing circuit and windings of said relay, a multiple network included in said balancing cir-

cuit and comprising a current limiting impedance branch, and an asymmetric impedance branch including a unidirectional device and transient charge absorbing means in series relation for apportioning the normal and transient currents in said windings to prevent kick-off of said relay.

16. A telegraph system including a polarized signaling relay having opposing windings for producing a resultant operating flux, a line circuit including said windings, balancing circuit means included in said line circuit, and signaling means for charging said line circuit and produce a resultant flux in said relay in one direction and for alternately discharging said line circuit, an asymmetric network including a unilateral device connected with said line circuit for preventing the said discharging of the line circuit from reversing said resultant flux.

17. The combination in accordance with claim 1 in which said impedance means is serially included in said signaling circuit.

18. In a telegraph signal repeating system, a relay winding for passing impulses between a transmitting circuit and a capacitance circuit, and a multiple branch circuit including an asymmetric branch and connected to said winding to permit normal impulse currents to pass through said winding and to reduce transient currents through said winding due to the capacitance of said capacitance circuit.

19. In a telegraph signal repeating system, a relay having an operating winding for passing impulses between a transmitting circuit and a signal line circuit including substantial capacitance, and having a balancing winding for passing impulses from said transmitting circuit to a balancing line circuit including substantial capacitance, and a multiple branch circuit including an asymmetric branch and connected to one of said windings to permit normal impulse currents to pass through said one winding and to reduce transient currents through said one winding due to the capacitance of the associated line circuit.

20. In a signal repeating system, a relay winding connected between a transmitting circuit and a capacitance circuit, and a multiple branch circuit having an impedance branch and an asymmetric branch and connected to said winding to permit the flow through said winding in one direction and to substantially reduce the flow through said winding in the other direction of transient currents between said transmitting circuit and said capacitance circuit.

21. In a telegraph signal repeating system, a relay having an operating winding for passing impulses between a transmitting circuit and a signal line circuit including substantial capacitance, and having a balancing winding for passing impulses from said transmitting circuit to a balancing line circuit including substantial capacitance, and a multiple branch circuit including an impedance branch and an asymmetric branch to provide a low and a relatively high impedance to transient currents in either direction through said multiple circuit, one of said windings being connected to pass transient currents in both directions from its associated line circuit, and said multiple branch circuit being connected to the other winding to proportion the transient currents due to said capacitances through said windings in each direction for preventing said relay from responding to operations of said transmitting circuit.

WALTER W. CRAMER.
GEORGE C. CUMMINGS.