

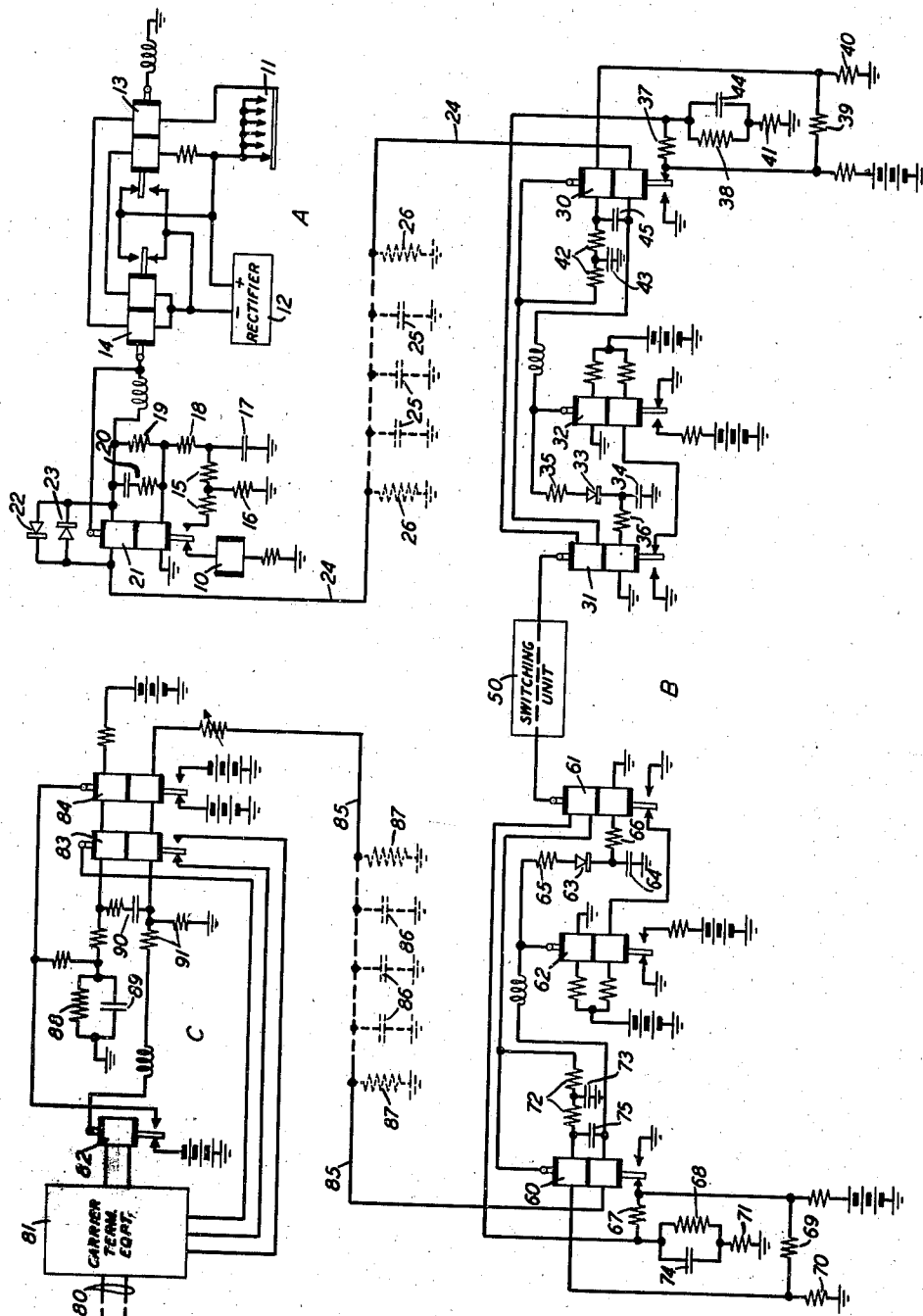
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2,379,910

TELEGRAPH SYSTEM

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UNITED STATES PATENT OFFICE

2,379,910

TELEGRAPH SYSTEM

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5 Claims. (Cl. 178-69)

This invention relates to telegraph transmission systems and more particularly to telegraph systems adapted to work over inferior transmission lines having high electrostatic capacity and low leakage resistance.

More particularly this invention relates to improvements in the telegraph transmission systems disclosed in United States Patents 2,131,870 granted to Cramer, October 4, 1938, and Cramer et al. 2,143,000, granted January 10, 1939, which patents are hereby made a part of this specification as if fully included herein.

In the systems disclosed in the above-identified patents, the bias or distortion of telegraph signals transmitted over telegraph lines is substantially independent of and unaffected by the leakage resistance or changes in the leakage resistance of the transmission path. As explained in these patents, the compensation for changes in the leakage resistance of the line is obtained by properly choosing the transmitting potentials and the bias supplied to the receiving relay.

While the systems disclosed in the above-identified patents are operative over long telegraph lines subject to considerable variation and leakage resistance, and over lines having a moderate amount of line capacity, it has been discovered that these systems do not operate particularly well over lines having high electrostatic capacity.

In accordance with the present invention, the circuits are rearranged so that they will operate satisfactorily over high capacity lines and at the same time prevent the leakage resistance of the lines from adding to or changing the distortion of the signals transmitted over the line.

In accordance with the present invention, transmitting potentials are applied to the ends of the transmission conductor in accordance with the disclosures of the above-identified patents. However, the circuits are rearranged so that the effects of the high capacity of the transmission path are greatly reduced or eliminated.

At the end of the system at which positive and negative potentials of equal magnitudes are applied to the signal conductor in accordance with the signals to be transmitted, the receiving relay circuit is arranged so that it will follow the signals transmitted by the equipment at this end of the line and at the same time repeat the signals received by the station. This is accomplished by rearranging the circuit of the biasing winding of this relay so that current through it is reversed when spacing impulses are transmitted from this end of the line. By causing this relay to respond to signals transmitted in both directions, the re-

quirement that the relay fail to respond to surges transmitted over the line is eliminated. Hence the receiving conditions applied to the relay alone may be employed to determine the adjustments of the relay.

In addition, further improvement is secured by connecting a pair of oppositely poled non-linear circuit elements or copper-oxide rectifiers around or in shunt with the line winding of the relay. The constants of these rectifier elements are so related to the winding of the relay to which they are connected and the currents and potentials of the system that during the reception of signals and during steady state conditions, these elements pass a little or no current. However, when signals are transmitted from this end of the line, the rectifiers will by-pass a large portion of the surge currents which charge and discharge the line capacity.

At the opposite end of the line, where ground is connected to the transmission conductor during the transmission of marking pulses and where a spacing potential of opposite polarity to the marking potential at the distant or first end and twice its value or magnitude is applied to the line during transmission of spacing pulses, the requirement that the receiving relays fail to respond to charging surges has been removed by providing an auxiliary repeating relay operated under control of the main receiving relay having a special biasing or locking winding which prevents the repeating relay from following the short momentary operations in the main receiving relay during the transmission of signals from this end of the line due to the surge currents which charge and discharge the cable capacity.

In addition, special networks are provided for varying the bias of the receiving relays in accordance with the character of the signals received by these relays. Networks of this type are described in greater detail in the copending application of Kinkead Serial No. 462,576 filed on Oct. 19, 1942, now Patent No. 2,360,878, granted Oct. 24, 1944.

The foregoing objects and features of this invention as well as other objects and features thereof may be more readily understood from the following description when read with reference to the attached drawing which shows a typical embodiment of the invention. As is well understood, the claims appended hereto specifically point out novel features of this invention and are not limited to the specific embodiment of this invention disclosed and described in detail herein.

The figure of the drawing shows a typical embodiment of this invention as applied to two long

telegraph lines having a high electrostatic capacity and variable leakage resistance.

A represents an outlying telegraph station connected to a telegraph conductor 24 extending to a central point B. The conductor 24 may have a high value for the distributed capacity 25 indicated in dotted lines in the drawing, and variable leakage resistance 26 also indicated by dotted lines in Fig. 1.

As is understood by those skilled in the art, both the leakage resistance 26 and the capacity 25 may be concentrated at one or more points along the line, but in the usual line and circuit both of these quantities will be distributed more or less uniformly along a considerable portion of the line or transmission path.

As understood by those skilled in the art, the line 24 may comprise any suitable low frequency telegraph transmission path including both open wire lines and cable circuits as well as the so-called telegraph transmission paths of any of the simplex or composited telephone and telegraph lines or systems.

The outlying station A is provided with a selector or receiving magnet 10 and a suitable receiving instrument which in a preferred embodiment of this invention will comprise a printing instrument such as described in greater detail in United States Patent 1,745,633, granted to S. Morton et al. on February 4, 1930, and 1,904,164, granted to S. Morton et al. on April 18, 1933. Both of these patents are hereby made a part of this application as if fully included herein.

Station A is also provided with transmitting contacts 11 which are controlled either by means of a keyboard, key or other suitable type of transmitting instrument in accordance with the signals it is desired to transmit from station A. The operation of the contacts 11 is repeated by both relays 13 and 14 which follow these signals and cause them to be repeated over line 24. Relays 13 and 14 are shown in their marking positions, in which positions they cause a negative potential, from rectifier 12 to be applied to line 24. When contacts 11 open, relays 13 and 14 are operated to the position opposite to the position shown in the drawing at which time they apply positive potential from rectifier 12 to line 24. A single rectifier is employed at station A as the source of power consequently the pulses of positive and negative current transmitted over the line or the magnitude of the potential applied to the line at this station during both of said conditions will be substantially the same.

The pulses of current transmitted from relays 14 and 13 flow through the upper winding of the receiving relay 21 and to the repeater station B at the distant end of the line. The receiving relay 21 is also provided with a lower or biasing winding, a circuit of which extends from ground through the lower winding of relay 21 and thence to ground through the shunting resistance 18, 15 and 16. The circuit of the biasing winding of relay 21 also extends from ground through the lower winding of this relay and resistance 19 to the armature of transmitting relay 14. Hence when the polarity of the potential applied to the line is reversed, current flowing through the lower winding of relay 21 will be reversed and cause relay 21 to follow the signals transmitted over the lines as will be described hereinafter.

Resistances 15 and 16 and condenser 17 are employed to vary the bias of relay 21 in accordance with the signals received from this line,

as set forth in detail in the above-identified co-pending Kinkead application.

A network comprising a condenser and resistance 20 is connected between the main line and the circuit of the biasing winding. This network tends to cause the surges transmitted to and received from the transmission conductor 24 to flow substantially equally through both the upper and lower windings of relay 21 in opposite directions and thus greatly reduce the effect of the surge current upon the operation of this relay.

In order to further reduce the effects of the line surges due to charging and discharging of the line capacity, the rectifier elements 22 and 23 are connected in the reverse direction around the main line winding of relay 21. The values of these rectifiers are so chosen that during normal operation of the system and during idle periods, they pass a very small portion of the current flowing through the upper winding of relay 21. However, during transmission from station A, the charge and discharge of the line capacity 25 causes the voltage across the upper winding of relay 21 to raise and this in turn causes the impedance of one or the other of the unilateral conducting devices 22 or 23 to decrease so it will pass a considerable portion of this charging or discharging current and thus prevent it from affecting the operation of the receiving relay at station A. For a more detailed description of the operation of non-linear circuit elements as applied to telegraph systems and relays, reference is made to United States Patent 2,147,690, granted to Cramer et al. February 21, 1939, which patent is hereby made a part of this application as if fully set forth herein.

The circuits at station A operate in substantially the same manner during the reception of signals over this system as described in the above-identified applications of Cramer and Cramer et al.

At the repeater or switching point B, the transmission conductor 24 is connected to a circuit which extends through the lower winding of relay 30 to ground through the marking contacts of relay 32. Hence relay 30 follows the signals transmitted by the transmitting device 11. Relay 30 is provided with a network comprising resistance 42 and condenser 43 for altering the bias current flowing through the upper winding of this relay during the reception of signals so that this bias current varies in such a manner as to compensate for variations in the received current due to the particular characteristics of each of the code combinations received over the line. The operation of networks of this type has been described in greater detail in the co-pending application of Kinkead filed on the same day as this application.

Relay 30 follows the signals received over conductor or line 24 and repeats them to the upper winding of relay 31 and causes this relay in turn to repeat the signals through the switching unit 50 to the other repeater shown to the left in the drawing. At this time transmitting relay 32 remains in the position shown in the drawing, hence no current flows through the lower winding of relay 31 at this time. It should be noted that relay 31 in effect receives polar signals because the upper winding terminal of the upper winding of this relay is connected to the mid-point of a potentiometer comprising resistances 37, 38 and 41, while the other terminal of this winding is connected to the armature of the receiving relay 30. The armature of this relay moves alternately be-

tween ground and the full battery potential. Hence the current flowing through the upper winding of relay 31 is reversed under control of relay 30 in accordance with the received signals.

When signals are received through switching unit 50, they will flow through the lower winding of relay 32 and be repeated by this relay through the lower winding of relay 30 to the transmission conductor 24 and thence to station A.

Due to the surge currents causing the capacity 25 of line 24 to be alternately discharged and charged during the operation of relay 32, it has been found practically impossible to prevent the armature of relay 30 from responding for short intervals of time to the surge currents.

In order to prevent relay 31 from also following these short momentary operations of the armature of relay 30, a path is completed through the lower winding of relay 31 at this time from battery through the spacing contact and armature of relay 32, resistance 35, rectifier 33 and resistance 36 to ground through the lower winding of relay 31. Condenser 34 is also connected from rectifier 33 to ground. Hence the upper terminal of condenser 34 is charged to a positive potential. When relay 32 moves to its marking position, the above-traced circuits from the lower winding of relay 31 are interrupted. However, the upper terminal of condenser 34 immediately starts discharging through this winding and tends to maintain the armature of relay 31 in its marking position and thus prevents this relay from following the momentary operation of the armature of relay 30. Thus at this end of the system, the repeating relay 31 is prevented from following momentary improper operation of the receiving relay 30 during the time signals are transmitted from this station.

Condenser 45 is connected between the main line winding and the biasing winding of relay 30 and serves to improve the operation of relay by causing charging and discharging currents to this condenser to flow through the biasing winding thus tending to reduce the tendency of relay to operate improperly.

Assume now for the purpose of illustration that during the normal marking condition, as shown in the drawing, a line current of thirty milliamperes flows in line 24 due to the negative potential applied to the line by relays 13 and 14 from rectifier 12. Further, consider the transmission of signals from station A to station B. During spacing pulses the positions of the armatures of relays 13 and 14 will be reversed and cause a positive potential from rectifier 12 to be applied to line 24. This positive potential is equal in magnitude to the negative potential applied to the line during marking pulses.

As set forth in the above-identified Cramer applications, a biasing current flows through the lower winding of relay 21 which produces an effect upon the armature of this relay which is substantially twice the effect of the current flowing through the line winding. Assume that this current is sixty milliamperes and that the windings of the relay 21 are substantially the same. If current flowing through the lower winding of this relay at this time tends to hold the armature of this relay in its marking position and current flowing through the upper winding tends to operate the armature to spacing position, the net effect upon the armature will be equivalent to thirty milliamperes tending to hold the armature of relay 21 in its marking position.

When spacing potential is applied to line 24,

the directions of the two currents are reversed, while their magnitudes remain substantially the same. This means that the net effect upon the armature of relay 21 is now reversed so that this relay will operate to its spacing position and thus repeat the spacing pulses to selector magnet 10 to provide a copy at station A of message signals transmitted therefrom.

During the transmission of signals from station A, the line capacity 25 is charged and discharged through the upper winding of relay 21. As pointed out above, the currents flowing through this winding are opposed to the currents which actually control the operation of the armature of this relay and since the charging currents may be of considerable magnitude, they may interfere with the proper operation of the relay. In order to reduce the effects of these charging currents, two copper-oxide rectifiers or other suitable non-linear resistance elements are connected around the upper winding of this relay. One of these elements tends to by-pass the surge currents of one polarity, while the other by-passes surge currents of the opposite polarity. In this manner the charging surges of both polarities are prevented from seriously interfering with the operation of relay 21 at this time.

These pulses of positive and negative currents are transmitted over line 24 through the lower winding of relay 30 to ground through the armature and marking contact of relay 32. The application of these substantially equal positive and negative potentials to the line at station A will, therefore, cause substantially equal currents to flow over line 24 and through the lower winding of relay 30. Under these circumstances, as pointed out in the above-identified Cramer applications, variations in the leakage resistance of line 24 will not add to or subtract from the distortion of the signals transmitted over the line. In other words, both the positive and negative pulses are affected in the same manner, i. e., their magnitudes are varied in like manners and to substantially the same extent by variation in leakage resistance of the line and hence relay 30 will respond to both of these types of pulses equally well. Under these circumstances no additional distortion or bias is added to or taken away from any of the signals transmitted over the line 24 due to variations in the leakage resistance 26 of this line.

The receiving relay usually employed to respond to signals of this type, such as described in the above-identified patents to Cramer, is generally not provided with any electrical or mechanical bias because the relay usually receives pulses of positive and negative current which are of substantially equal magnitude for operating its armature to either one or the other of its positions.

When a receiving relay is operated over such high capacity lines so that the pulses do not reach their steady state value within a single pulse interval, the response of the relay is in part determined by the length of the previous pulse, as set forth in the above-identified copending application of Kinkead. In order to compensate for the effects of the high line capacity, condenser 43 and resistance network 42 are connected to the upper or biasing winding of relay 30 and so arranged that current flowing through the upper winding of this relay is controlled by received signals and is in such a direction as to counteract the effects of high line capacity. For example, during the application of long marking pulses to line 24 at station A, the line current through the lower

winding of relay 30 will reach its maximum value. Under these conditions, a positive potential from the marking contact of relay 30 and its armature is applied to the upper terminal of condenser 43 and causes a current to flow through the upper winding of this relay which tends to oppose the current flowing through the lower winding of this relay. During the application of the long spacing pulse of line 24, current through the lower winding of this relay will fall substantially to zero at which time the armature of the relay will apply ground potential to the upper terminal of condenser 43 and cause a reverse current to flow through the upper winding of relay 30. This reverse current tends to cause the relay to operate more readily to its marking position. Thus after long pulses of either polarity are applied to line 24, a biasing current flows through the upper winding of relay 30 which tends to aid the operation of relay 30 to the opposite position. By arranging the constants of condenser 43, the resistance 42 together with resistances 39 and 40 and the upper winding of relay 30 so that the currents reach their steady state value at substantially the same time as the line current reaches its steady state value, the response of relay 30 is substantially independent of the length of the pulse preceding the pulse to which the relay must respond. Hence, this type of distortion normally encountered due to high line capacity is materially reduced if not altogether eliminated.

Relay 30 in responding to the signals transmitted from station A repeats them to the upper winding of relay 31 by first connecting positive battery and then ground to the lower terminal of the upper winding of this relay. The upper terminal of the upper winding of relay 31 is connected to the mid-point of a potentiometer comprising resistances 37, 38 and 41. Consequently, current flowing through the upper winding of relay 31 is in one direction when the armature of relay 30 is in contact with positive potential connecting to its marking contact, and is in the opposite direction when armature of relay 30 is in its spacing position where it is resting against ground connected to the spacing contact. Since relay 32 is in its marking position and has ground connected to its armature at this time, no current flows through the lower winding of relay 31. Relay 31, therefore, accurately follows the signals transmitted from station A and repeats them through the switching equipment 50.

Relay 31 in repeating signals to the switching equipment 50 connects ground to the circuit extending through its armature during spacing pulses and positive battery through the lower winding of relay 32 during marking pulses. Similarly, when signals are transmitted from switching equipment 50 to station A, they will be transmitted through the armature and marking contact of relay 31 to positive battery through the lower winding of relay 32. These signals will comprise ground spacing pulses and positive battery for marking pulses.

During transmission of signals from the switching equipment 50 to line 24, relay 31 is normally maintained in its marking position and consequently these pulses will be transmitted through the lower winding of relay 32.

Relay 32 will respond to these signals and repeat them over line 24 by connecting positive potential to line 24 in response to the spacing pulses and ground potential in response to the marking pulses. Upon application of positive potential to line 24, a surge of charging current

flows through the lower winding of relay 30 and tends to maintain this relay in its marking position. Upon the application of ground potential to the line 24, the surge of discharge current from the line capacity 25 also flows through the lower winding of relay 30. In this case, however, the surge is in the reverse direction and tends to operate relay 30 to its spacing position for a short interval of time. It is generally undesirable to permit the receiving relay to so respond and it is frequently necessary to adjust the relay so that it is relatively insensitive to these surges. This means that the relay is also relatively insensitive to signals received over line 24. Consequently, the length of line over which the satisfactory signals will be transmitted is greatly reduced.

In accordance with the present invention, relay 30 is adjusted so that it will respond to weak signals from line 24. This means that the armature may leave its marking contacts under the circumstances described above. However, relay 31 is prevented from following the short improper operation of relay 30 at this time due to the fact that during the time spacing potential is applied to line 24, positive potential through rectifier 33 is connected to the upper terminal of condenser 34 and current also flows through lower winding of relay 31 in such a direction as to maintain relay 31 operated. Upon the operation of relay 32 to its marking position, positive battery is disconnected from the upper terminal of condenser 34 and the lower winding of relay 31. The rectifier element 33 prevents condenser 34 from discharging to ground through the armature and marking contact of relay 32 so this condenser starts to discharge through this lower winding of relay 31 and the effect of the discharge current is sufficient to prevent relay 31 from following the short improper operations of the armature of relay 30 at this time.

As pointed out above, the lower winding of relay 31 produces no effect upon this relay during the transmission of signals in the reverse direction so that it does not introduce any distortion or interfere with signals transmitted in the reverse direction, but does prevent improper operation of this relay during transmission from the switching unit 50. By thus preventing improper operation of this relay, the circuit through the lower winding of relay 32 is maintained closed and the transmission of signals from switching equipment 50 through repeater 32 to line 24 is not interfered with and at the same time relay 30 may be a sensitive relay which will respond to weak signals received over a long line.

In the specific embodiment of this invention described herein, the potential connected to the spacing contact of relay 32 is approximately twice the magnitude of the potential developed by rectifier 12 and is of opposite polarity to the potential connected to line 24 by relays 13 and 14 during the transmission of marking condition by them to line 24. Consequently, the line current under these circumstances rises to a value of approximately three times the normal marking current flowing through line 24.

Under the conditions assumed above, where the normal line current is thirty milliamperes flowing in a negative direction, the line current will rise to ninety milliamperes also flowing in a negative direction in response to the transmission of a spacing pulse by relay 32.

The spacing pulse transmitted over line 24 to

station A will cause the current flowing through the upper winding of relay 21 to increase to ninety milliamperes. This current will now overcome the effect of the sixty milliamperes flowing through the lower winding of this relay and will cause the armature of this relay to operate to its spacing position, thus repeating the pulse to the selector magnet 19. At this time it should be noted that the net effect tending to operate the armature of relay 21 is again thirty milliamperes. Hence relay 21 will respond equally well to both marking and spacing pulses transmitted over line 24.

As set forth in the above-identified patent to Cramer, under these circumstances, variations of the leakage resistance 26 of line 24 will effect both the marking and spacing pulses in such a manner that relay 21 responds to both of them equally well independently of the leakage resistance and hence variations in the leakage resistance do not add any distortion to the signals transmitted from station B to station A.

As pointed out above, the line capacity of line 24 may be sufficiently high to prevent the line current from reaching its steady state value during a signal pulse interval so the operating conditions of the receiving relay 21 may vary depending upon the length of the previous pulse transmitted over this system.

In order to overcome or reduce these effects, a network comprises resistances 15, 16 and 18 together with condenser 17 is connected between the biasing winding of relay 21 and the spacing contacts of this relay. When relay 21 is in its spacing position it connects negative potential to the upper terminal of condenser 17 as well as provides an additional path through the biasing winding of this relay thus tending to increase the biasing current. By making the time constant of these circuits substantially the same as the time constant of the main line circuit, it is possible to vary the biasing current flowing through relay 21 in accordance with the length of the previous signals received by the relay. Since the current flowing through the biasing winding opposes the current flowing through the line winding, variation of the biasing current due to the network comprising resistances 15, 16 and 18 and condenser 17 will oppose the effect of the variation of the operating condition of relay 21 which depends upon the length of the previous pulses. Consequently, relay 21 will operate equally well after pulses of any length. In this manner the distortion due to high line capacity is greatly reduced if not completely eliminated.

By rearranging the circuits as described above, it is possible to materially extend the length of the line or the amount of capacity between the line and ground over which systems of this type will satisfactorily transmit telegraph signals.

As illustrated in the drawing, the switch unit 50 is provided between the two repeaters shown at station B. These repeaters are arranged so that any number of circuits may be connected together by connecting the leads extending to the switching unit 50 together. When two or more of these leads are connected together, signals originating on any one lead are transmitted to all of the other leads and thence over the associated lines. Both transmission systems of this type and suitable switching systems are well known. Typical examples of such transmission systems are disclosed in United States Patent 2,069,223 and 2,069,224, granted to G. C. Cummings on February

2, 1937, which patents are hereby made a part of this application as if fully included herein.

The repeater equipment to the left of the switching unit 50 is substantially the same as the repeater unit to the right and operates as described above with reference to the repeater unit to the right and transmits and receives signals over line 85. Line 85 may be subjected to low leakage resistance and have high capacity such as illustrated by the dotted resistances 87 and dotted condensers 86. Line 85 extends to a third station C where repeater equipment is provided for interconnecting line 85 to the channel of a carrier current system 80.

The carrier current system 80 terminates the terminal equipment 81. Signals received from the carrier terminal equipment 81 operate relay 82. Relay 82 repeats the signals over line 85 to station B. In order to secure compensation for variation in leakage resistance in the type of system shown connected to line 85, the potential applied to line 85 at station C should be substantially one-half the spacing potential applied to line 85 by the transmitting relay 82. In order to properly control both the marking and spacing potentials applied to line 85 at station C, resistances 91 are connected between the armature of relay 82 and the lower windings of relays 83 and 84 extending to line 85.

Relay 83 receives signals over line 85 and repeats them to the carrier terminal equipment 81 and causes corresponding signals to be transmitted over the carrier system 80.

A break relay 84 is also provided for controlling the potential of the spacing contacts of transmitting relay 82 as is well understood by those skilled in the art. The operation of relay 83 during the transmission and reception of signals over line 85 is substantially the same as the operation of the receiving relays at the end of the line at which positive and negative potentials are applied thereto as described in the above-identified patents to Cramer except that the network comprising resistance 88 and condenser 89 has been added. This network when connected as shown in the drawing tends to compensate for the effects of the high line capacity as discussed above and in the above-identified copending application of Kinkead.

What is claimed is:

1. In a telegraph system comprising a line having a high electrostatic capacity and subject to leakage resistance, transmitting and receiving apparatus connected to the ends of said line for transmitting and receiving signals over said line the distortion of which is substantially unaffected by variation of said leakage resistance, said receiving apparatus including at one end of said line a receiving relay provided with a main line winding and a local winding, a control circuit for said local winding for applying a bias to said relay, and connections to said control circuit for automatically altering said bias during transmission of signals from said transmitting apparatus at said one end of said line for causing said relay to respond to signals transmitted by said transmitting apparatus at said one end of said line.

2. In a telegraph system, a telegraph transmission line having electrostatic capacity and subject to leakage resistance, transmitting apparatus connected to the ends of said line for applying signalling potentials thereto which are so related to each other and to said line that variations of said leakage resistance do not add dis-

tortion to received signals, receiving apparatus connected to each end of said line, means for applying an electrical bias to one of said receiving apparatus, and apparatus automatically controlled solely by said receiving apparatus for varying said bias.

3. An impulse transmitting system comprising a line, impulse receiving apparatus connected to each end of said line, impulse transmitting apparatus connected to each end of said line for transmitting two different impulse currents over said line, means for so establishing the polarities and magnitudes of said currents with respect to each other and to the electrical characteristics of said line that the bias of said impulses as received at the opposite end of the line is substantially constant and independent of the leakage resistance of said line, repeating apparatus at one end of said line actuated by said impulse receiving apparatus, and means controlled by the transmitting apparatus at said one end for preventing the operation of said repeating apparatus during the operation of said transmitting apparatus.

4. An impulse transmitting system comprising a telegraph transmission line, impulse receiving apparatus connected to each end of said line, impulse transmitting apparatus connected to each end of said line for transmitting two different impulse currents over said line, means for so establishing the polarities and magnitudes of said currents with respect to each other and to the electrical characteristics of said line that the

bias of said impulses as received at the opposite end of the line is substantially constant and independent of the leakage resistance of said line, repeating apparatus at one end of said line actuated by said impulse receiving apparatus, means controlled by the transmitting apparatus at said one end for preventing the operation of said repeating apparatus during the operation of said transmitting apparatus, bias means for the receiving apparatus at the other end of said line, and means controlled by the transmitting apparatus at said other end for reversing said bias.

5. In a telegraph system, a telegraph transmission line having electrostatic capacity and subject to leakage resistance, transmitting apparatus connected to the ends of said line for applying signaling potentials thereto which are so related to each other and to said line that variations of said leakage resistance do not add distortion to received signals, receiving apparatus connected to each end of said line, means for applying an electrical bias to one of said receiving apparatus, and means controlled solely by said one receiving apparatus for varying the bias applied thereto to reduce distortion of signals received by said receiving apparatus due to said electrostatic capacity.

RITA SMITH KINKEAD,

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