

Dec. 19, 1939.

G. C. CUMMINGS ET AL

2,183,708

SIGNALING SYSTEM

Filed March 3, 1938

3 Sheets-Sheet 1

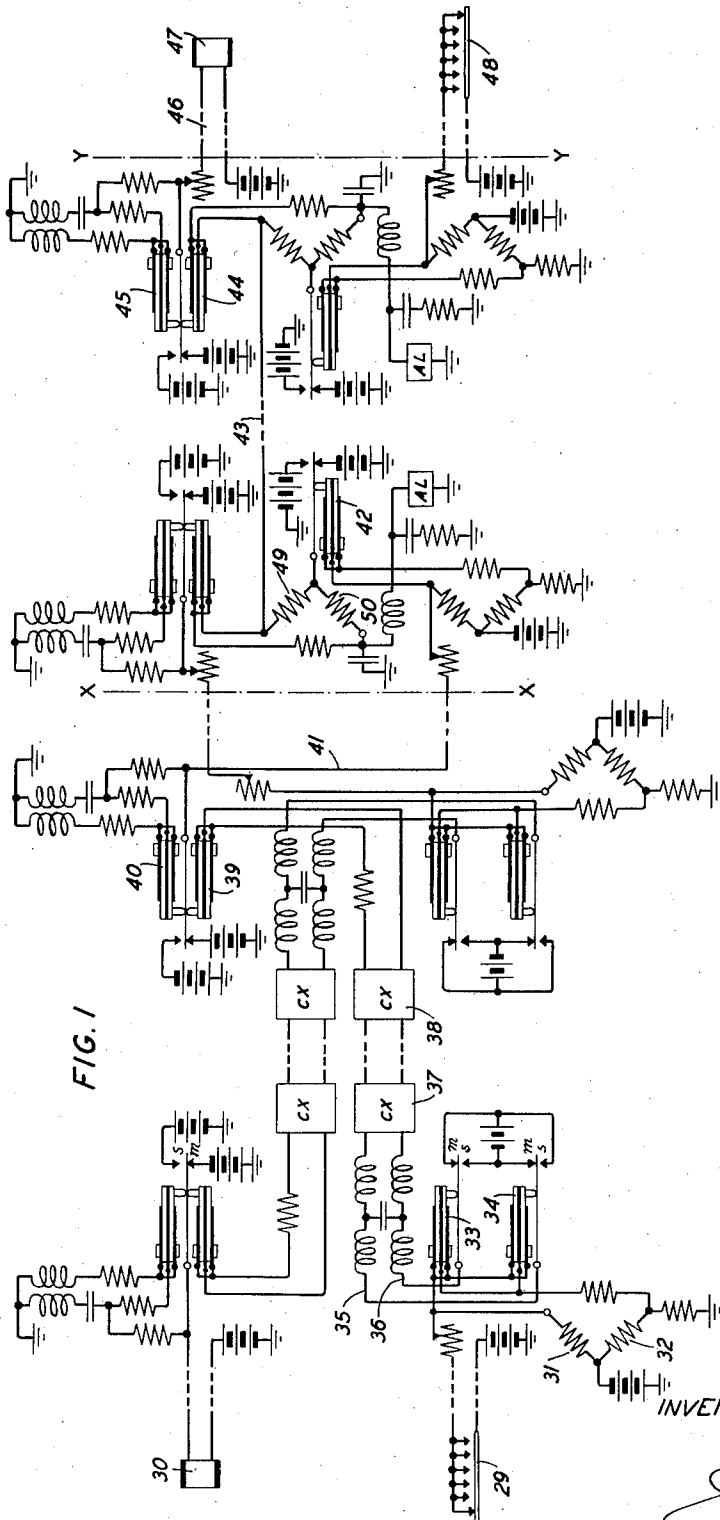


FIG. 1

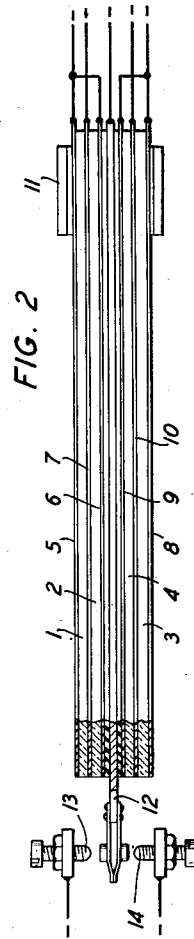


FIG. 2

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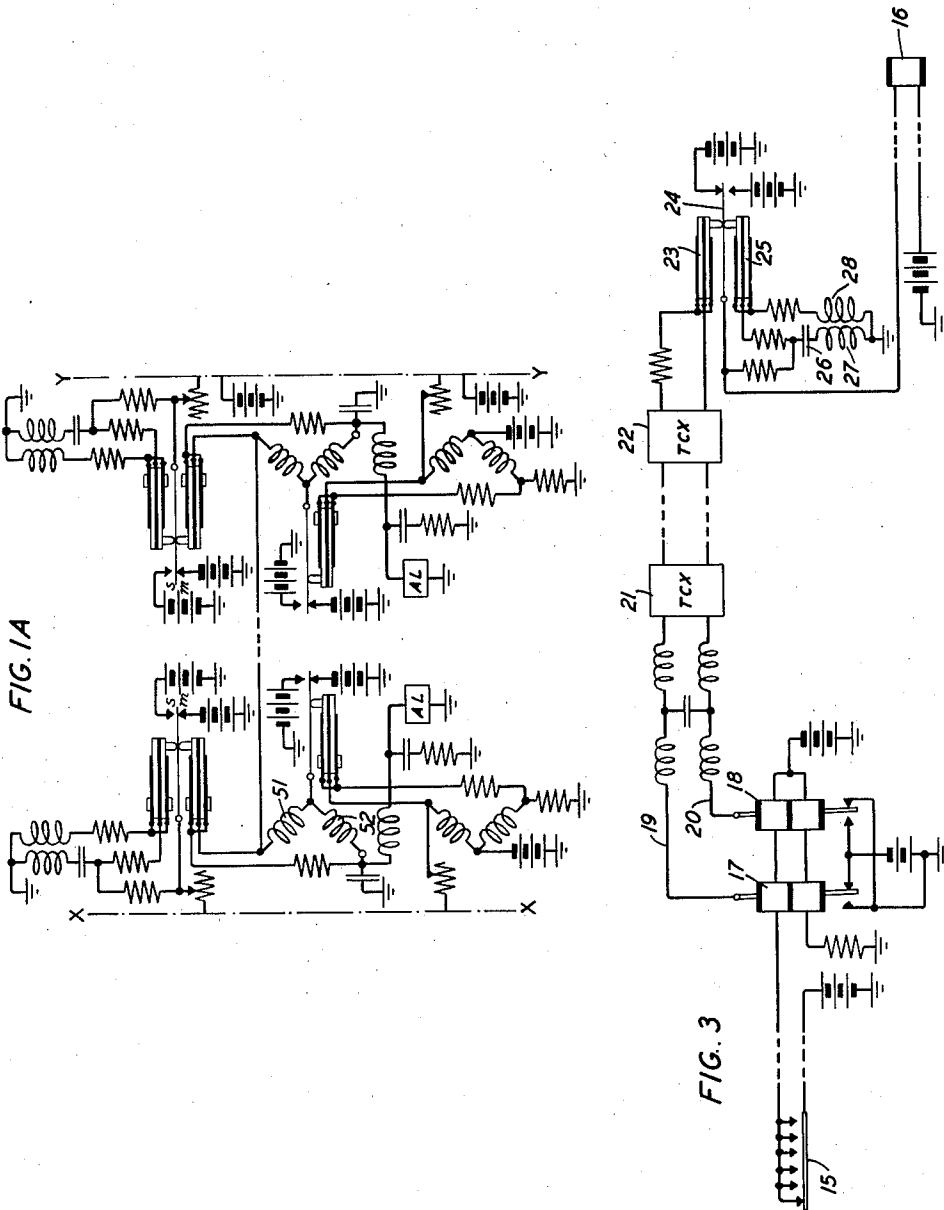
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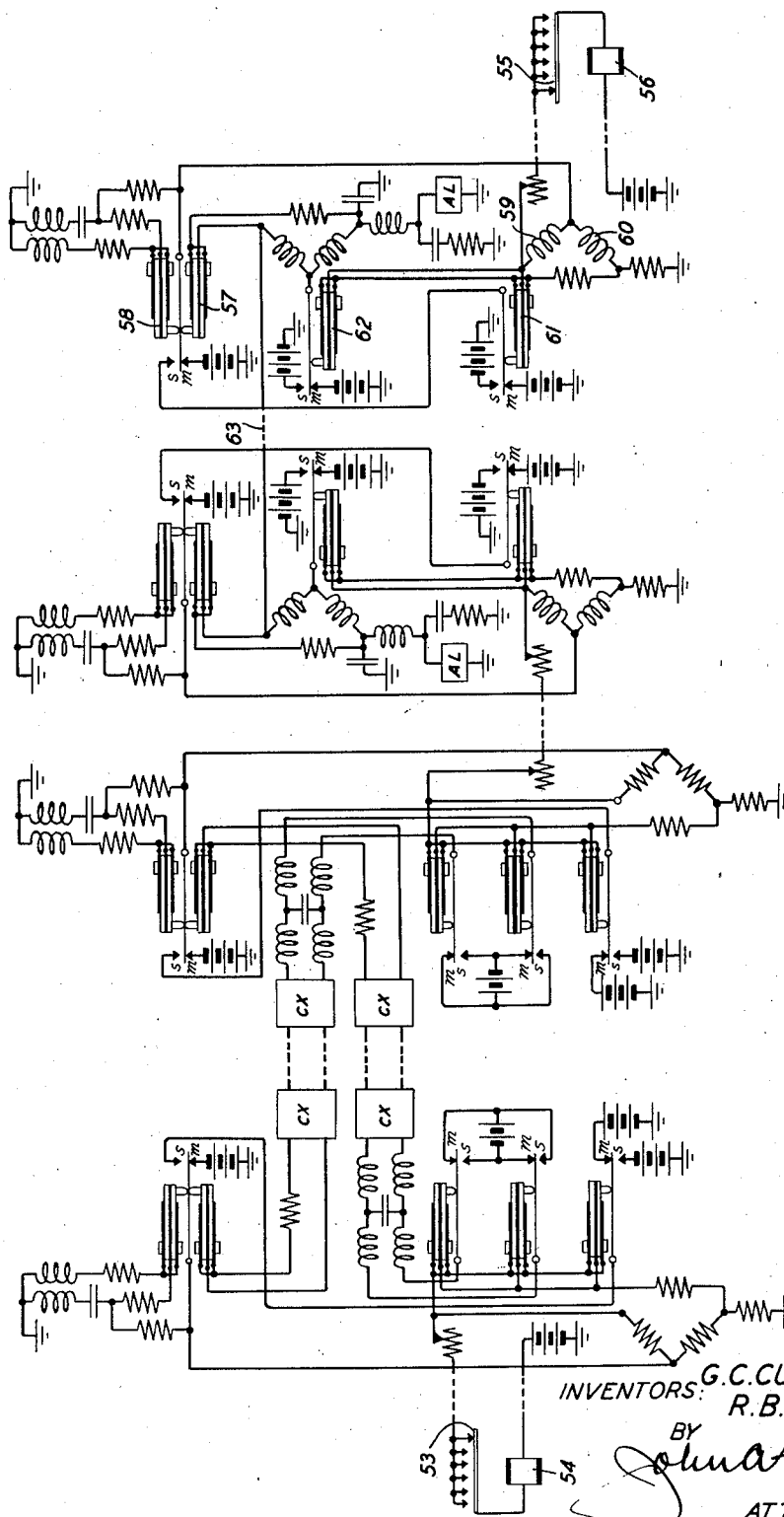
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FIG. 4



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2,183,708

SIGNALING SYSTEM

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Application March 3, 1938, Serial No. 193,650

8 Claims. (Cl. 178—58)

This invention relates to signaling systems and particularly to duplex telegraph systems.

The object of the invention is to effect economical, speedy and reliable operation of telegraph circuits either over longer lines or lines in poor condition either of which would be unsuitable for ordinary apparatus or would require higher grade and more sensitive apparatus.

A feature of the invention is the use of what might be termed condenser type relays, that is, relays which respond to a difference in potential rather than an electric current and which require for their operation only that amount of energy which may be measured by the charging current of a small condenser. By way of example, such a relay is shown herein as a piezoelectric crystal relay including as an element one of the types of piezoelectric materials which produce a large mechanical effect, of which several are known and having a movable element similar in construction and operation to the motor element used by Sawyer in his Reissue Patent 20,213, December 22, 1936. In general, also, a relay of this nature is shown in Patent 2,166,763, issued to Warren P. Mason on application Serial No. 131,160, filed March 16, 1937.

A further feature of the invention is the use of condenser type relays having a plurality of elements whereby polar and differential relay effects may be had by energizing the various distortion elements in various combinations and directions.

Crystal relays of the nature herein shown prove to be extremely quick in action, to be reliable, to require little maintenance and to have a long life. The peculiar advantage of these relays lies in the fact that they respond to potential differences and hence their use in circuits of this nature is advantageous since their operation is not slowed up through electrical impedance nor their response limited materially by the length or the condition of the line. Ordinary high resistance joints or leaky conditions which on other electromagnetically operated lines would seriously interfere with the operation of the system will not here cause faulty operation and hence the cost of maintenance of the system will be lower or alternatively the provision of more expensive and more sensitive apparatus will be avoided.

A further feature of the invention is the use of condenser type relays having a plurality of elements wherein a main or controlling element may be aided during its movement by another

element under the influence of transient conditions set up by the movement of the main or controlling element. Extremely quick action is attained in this manner since the aiding element of such a multiple element relay responds to transient potentials.

The drawings consist of three sheets containing five circuit diagrams and one plan view of a relay partly in section.

Fig. 1 shows a full duplex system with permutation code sending and receiving means conventionally illustrated at each end. The subscriber's station shown at the left terminates in a four-wire metallic telegraph repeater. This is connected through the four wires to a similar repeater at another point and this repeater in turn is connected over two wires to a differential duplex repeater at a further point and which in turn is connected by a single wire to a similar differential duplex repeater to which the subscriber loops at the right-hand end are connected.

Fig. 1A shows a slight variation in the circuit of the two differential duplex repeaters between the lines XX and YY of Fig. 1.

Fig. 2 shows the way in which a double-element crystal relay is constructed.

Fig. 3 shows a one-way connection between a sending means through the appropriate end of a metallic telegraph repeater over one channel of a four-wire circuit into the appropriate end of a metallic telegraph repeater and thence to a receiving loop.

Fig. 4 is a circuit diagram of a system similar to that of Fig. 1 but with the exception that this is half duplex while Fig. 1 showed a full duplex system.

In Fig. 2 there are two pairs of crystals 1, 2 and 3, 4 which show a marked piezoelectric effect. Each crystal is faced on each side with a light metal foil so that the foils 5 and 6, which are placed on the outside of the two crystals 1 and 2, are connected together to form one terminal of this relay element. A foil 7, placed between the crystals 1 and 2, forms the second terminal of this relay element. In like manner, foils 8 and 9, placed on the outside of crystals 3 and 4, are connected together to form one terminal of this relay element and foil 10 is placed between them to form the other terminal. All of these elements are rigidly clamped at the point 11 and through the movement of their free ends control contact 12, cooperating with contacts 13 and 14.

When a difference of potential is placed be-

tween the two terminals of either set of crystals that set of crystals will become distorted and will tend to move the element 12 in one direction or the other. Through having two sets of crystals to move the contact element 12, differential and polar effects may be produced.

It is believed that the operation of the circuits will best be understood through the description of the circuit of Fig. 3 in the first instance. In this case when signals are to be sent from the sender 15 to the receiver 16, the contacts of the sender 15 are operated according to some permutation code. Each marking impulse is a closed circuit and each spacing impulse is an open circuit. While the circuit is closed the relays 17 and 18 will both have their armatures moved toward the right. During the spacing impulse the armatures of relays 17 and 18 will move to the left. The change from a marking to a spacing impulse will reverse the polarity of the battery connected to lines 19 and 20, and this will carry through the composited circuit arrangements 21 and 22. A crystal relay, which may be constructed according to Fig. 2, is here shown as two separate crystal elements for purposes of clarity. The element 23 is connected to the line leading from composite arrangement 22. Under normal conditions, that is, during the sending of a marking impulse, the crystal element 23 is energized in such a manner that the distortion is directed upwardly so that the armature 24 makes contact with its upper contact leading to negative battery. When a spacing impulse is sent the polarity of the battery connected to the conducting sheets of element 23 is reversed and the distortion is now in such a direction as to push the armature 24 downwardly toward its lower contact, which is connected to positive battery. The movement of the armature 24 will operate the receiving relay 16.

Under normal conditions the relay element 25 is energized in such a manner that its distortion is downward but it does not overcome the distortion of the upward element 23 and hence the armature 24 is left on its upper contact. When the polarity of the conducting sheets of crystal element 23 is reversed and the armature 24 first breaks away from its upper contact, the condenser 26, which has been charged from ground on one side to negative battery on the other side, now tends to discharge out over the line through receiving magnet 16 to positive battery, but the discharge current is a transient and until the discharge is complete the middle conducting sheet of crystal element 25 is maintained at the same polarity as before and hence the distortion of the crystal element 25 is still downward in order to aid the first movement of this armature through the action of the crystal element 23. This first movement may be somewhat feeble since there is a certain amount of capacity inductance and resistance between the armature of relays 17 and 18 and the crystal element 23 so that the change from one polarity to another on element 23 is not instantaneous but has to build up in accordance with the constants of the circuit.

When the armature 24 meets its lower contact, connected to positive battery, the discharge of condenser 26, which up to this time has been through the winding of the receiving relay 16, is now accelerated by a direct connection of the armature 24 to positive battery. However, the discharge current of condenser 26 must flow through the inductive winding 27 which is magnetically coupled with winding 28. Due to this discharge current a potential will be created at the terminals

of winding 28 which will be in a direction to maintain the distortion of the crystal element 25 in a downward direction.

After the transient currents in these circuits have come to an end and a stable condition is established, the polarity of the conducting sheets of the element 25 will be found to be reversed and at this time the element 25 will be pushing upwardly and against the now fully established downward thrust of the crystal element 23.

Thus it will be noted that under stable conditions the thrust of the crystal elements 23 and 25 oppose each other but the thrust of element 23 prevails and maintains the armature 24 in the position in which its thrust is exerted. The crystal element 25 is useful in causing a very quick change-over, since it aids the crystal element 23 during the time that crystal element 23 is moving in another direction and during a short period thereafter until stable conditions have been established in the local circuit of element 25.

With this explanation, the rest of the figures should need very little description.

In Fig. 1 we have a full duplex system comprising a sender 29 and a receiver 30, each extending from a station over its own loop to the repeater at the central office. Impulses sent out by the sender 29 coming in to a duplex circuit arrangement comprising resistances 31 and 32 connected at their junction point to battery and at their other point to ground through an approximate artificial line arrangement, operate a pair of crystal elements 33 and 34. These elements reverse the polarity of the battery connected to lines 35 and 36 which extend through appropriate composite arrangements 37 and 38 to a receiving crystal element 39. This crystal element has its aiding component 40 in the same manner that crystal element 23 has its aiding component 25. Element 39 therefore responds to the impulses sent by the sender 29 and this is translated by a reversal of the polarity of battery connected to line 41. Line 41 extends into another duplex arrangement similar to that comprising resistances 31 and 32 and operates a crystal element 42. This relay has its armature connected to the mid-point of a duplex arrangement controlling line 43 which at its distant end controls a crystal element 44 with its aiding pair 45. The crystal elements 44 and 45 change the polarity of the battery connected to line 46 and thus operate the receiving relay 47. Transmission in the other direction from sending contacts 48 to receiving relay 30 is similar in all respects and since the line 43 is in a duplex arrangement, transmission between 29 and 47 may be carried on at the same time that transmission from sender 48 is being carried on with receiver 30.

In Figs. 1A, which may replace that portion in Fig. 1 between the lines XX and YY, it will be noted that the resistances 49 and 50, forming the duplex arrangement, are now replaced by inductances 51 and 52, respectively. The operation of this circuit is the same fundamentally. There may be practical reasons in specific cases why inductances 51 and 52 would be preferred to the resistances 49 and 50.

Fig. 4 shows an arrangement similar to that of Fig. 1 with the exception that half-duplex working is employed, that is, instead of having a separate loop for the sending and receiving units both sending and receiving units 53 and 54 in one case and 55 and 56 in the other are connected to the same loop. Whereas before the receiving instrument 47 was operated directly by the armature 75

of elements 44 and 45, the corresponding elements 57 and 58 now extend to the mid-point of the duplex arrangement 59 and 60, which duplex arrangement was used solely in the previous case in connection with the sender 48. In addition to this, a break relay 61 is provided so that if transmission is proceeding from the sender 53 to the receiving relay 56 and the operator thereat desires to take control of the line he sends a break impulse, that is, a prolonged spacing impulse. This will operate the crystal element 61 so as to place negative battery on the upper contact of elements 57 and 58 and this will render the action of elements 57 and 58 ineffective so that impulses being transmitted into receiving relay 56 have no further effect. At the same time the crystal relay 62 will send a spacing impulse over the line 63, which will eventually appear as a spacing impulse on the receiving relay 54 and when this is noted by the operator thereat he will cease using his sender 53 and allow the operator at the distant end to transmit from the sender 55 to the receiver 54.

What is claimed is:

1. A duplex telegraph signaling system comprising an established connection from one station over a line circuit to another station, means at each said station for normally impressing a potential of one polarity on said line, sending means at each said station for reversing the polarity of the potential impressed on said line for signaling the other of said stations and a condenser type relay comprising crystal elements interleaved with conducting elements at each said station responsive to said potential changes for receiving said signals.

2. A duplex telegraph signaling system comprising an established connection from one station over a line circuit to another station, sources of equal and opposite potentials at each said station, means at each said station for normally impressing a potential of one polarity on said line, sending means at each said station for switching from one source of potential to the other for signaling the other of said stations and a condenser type relay comprising crystal elements interleaved with conducting elements at each said station responsive to said potential changes for receiving said signals.

3. A duplex telegraph signaling system comprising an established connection from one station over a line circuit to another station, means at each said station for normally impressing a potential of one polarity on said line, sending means at each said station for reversing the polarity of the potential impressed on said line for signaling the other of said stations, and means responsive to said potential changes at each said station for receiving said signals, said means comprising a plurality of crystals having one set faced with conducting sheets connected to be affected by distant potential changes and another set faced with conducting sheets connected to be affected by local potential changes.

4. A signaling system comprising a line, means at one end of said line for impressing a potential on said line, signaling means for reversing said impressed potential, a multiple element condenser type relay comprising crystal elements interleaved with conducting elements at the other end of said line having one element connected to said line and responsive to said potential reversals and another element connected in a local circuit con-

trolled by movement of said first element and responsive to transient potentials set up thereby, said elements cooperating to control a signal receiving means thereat.

5. A signaling system comprising a line, means at one end of said line for impressing a potential on said line, signaling means for reversing said impressed potential, a multiple element condenser type relay comprising crystal elements interleaved with conducting elements at the other end of said line, one element of said relay being connected to said line and responsive to the said impressed potential, and another element of said relay being in a circuit arrangement affected by the movement of said first element and responsive to transient potentials set up thereby, the forces of said elements being aiding during the existence of transient conditions, and in opposition during stable conditions, and a signal receiving means controlled by said condenser type relay.

6. A duplex telegraph signaling system comprising an established connection from one station over a line circuit to another station, means at each said station for normally impressing a potential of one polarity on said line, sending means at each said station for reversing the polarity of the potential impressed on said line for signaling the other of said stations, a condenser type relay comprising crystal elements interleaved with conducting elements at each said station responsive to said potential changes for receiving said signals and a local circuit for each of said condenser type relays responsive to the movements thereof for setting up local and transient aiding potentials.

7. A duplex telegraph signaling system comprising an established connection from one station over a line circuit to another station, means at each said station for normally impressing a potential of one polarity on said line, sending means at each said station for reversing the polarity of the potential impressed on said line for signaling the other of said stations, and a multiple element condenser type receiving relay comprising crystal elements interleaved with conducting elements at each of said stations having one element connected to said line and responsive to said potential reversals created at the other end thereof, said relay having a self-controlled local circuit connected to another element thereof, said circuit being constructed and arranged to energize said other element by aiding transient potentials during the movements of said relay and to energize said other element by opposing steady potentials during the stable periods thereof.

8. A duplex telegraph signaling system comprising a line, connected at each end through a potentiometer circuit to a common path, a potential changing means at the mid-point of each potentiometer circuit and a condenser type relay comprising crystal elements interleaved with conducting elements having its terminals bridged across said potentiometer at each end of said line, said relays being responsive in their movements to said potential changing means at the distant ends of said line respectively, and local self-controlled circuit for each of said relays for supplying aiding transient potentials to said relays during the movements thereof.

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