

July 2, 1940.

W. W. CRAMER ET AL

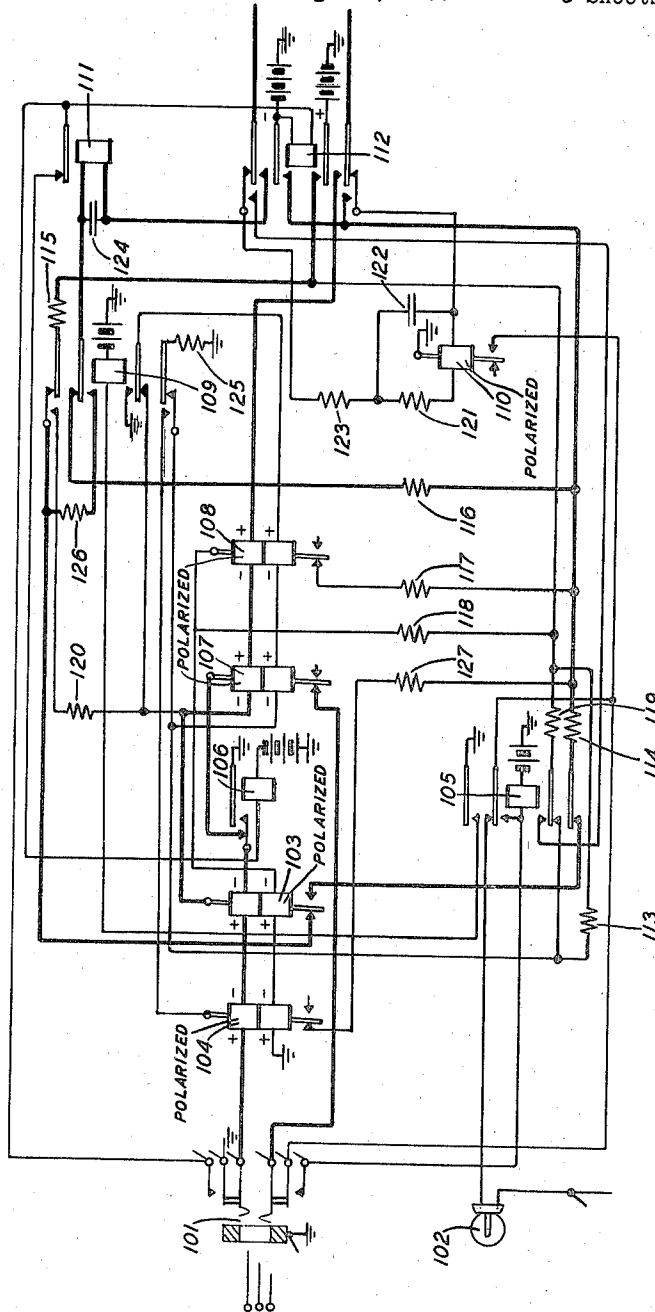
2,206,663

TELEGRAPH SYSTEM

Filed Aug. 20, 1938

3 Sheets-Sheet 1

FIG. 1



INVENTORS: W. W. CRAMER
F. S. KINKEAD

BY *g W Schmied*
ATTORNEY

July 2, 1940.

W. W. CRAMER ET AL

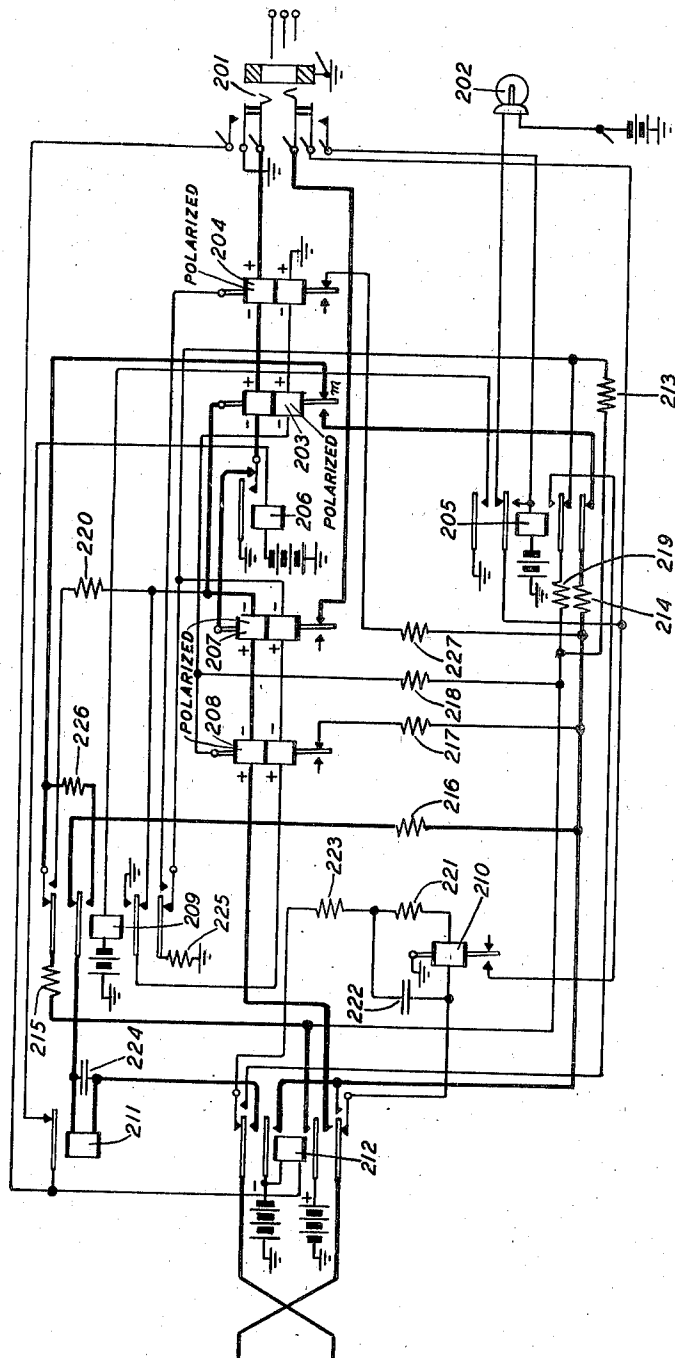
2,206,663

TELEGRAPH SYSTEM

Filed Aug. 20, 1938

3 Sheets-Sheet 2

FIG. 2



INVENTORS: W. W. CRAMER
F. S. KINKEAD

BY

J. R. Schmied

ATTORNEY

July 2, 1940.

W. W. CRAMER ET AL

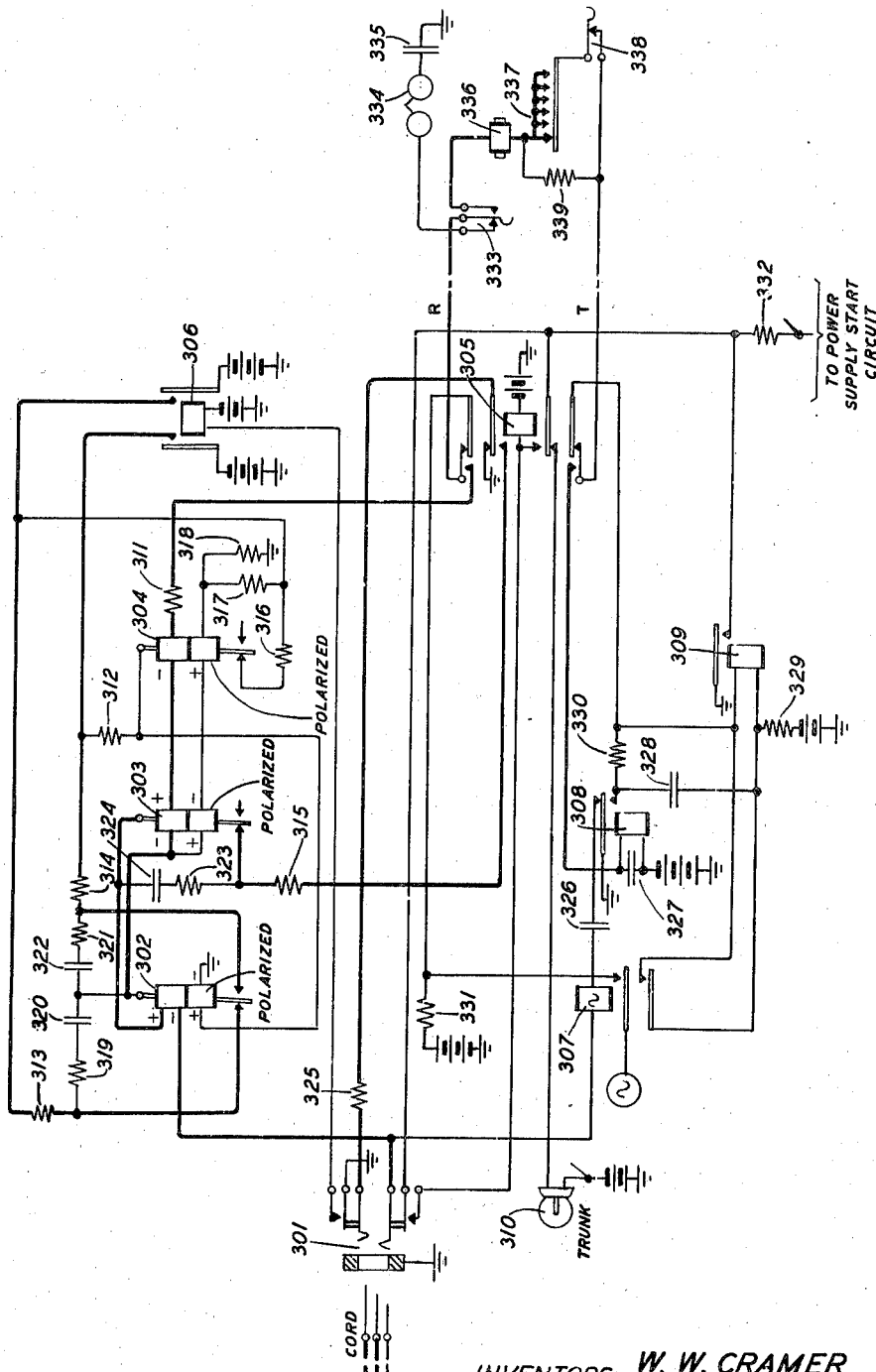
2,206,663

TELEGRAPH SYSTEM

Filed Aug. 20, 1938

3 Sheets-Sheet 3

FIG. 3



INVENTORS: W. W. CRAMER
F. S. KINKEAD

BY *g W Schmidt*
ATTORNEY

UNITED STATES PATENT OFFICE

2,206,663

TELEGRAPH SYSTEM

Walter W. Cramer, Portland, Oreg., and Fullerton
S. Kinkead, New York, N. Y., assignors to Bell
Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application August 20, 1938, Serial No. 225,898

12 Claims. (Cl. 178—2)

The present invention relates to telegraph and teletypewriter exchange systems wherein a plurality of subscriber's lines, connected to switching exchanges, may be flexibly interconnected by means of cords or links as desired.

The invention relates particularly to improvements in the control of the supervisory signals regulating the interconnections.

A particular object of this invention is to prevent the reception of false supervisory signals in telegraph exchange system interconnections between telegraph subscribers.

Another object of this invention is to provide a positive control of the supervisory signal circuit, during the transmission of both marking and spacing signals over a telegraph interconnection between two telegraph stations through a switching medium containing supervisory signals.

A feature of this invention is a loop circuit interconnecting an outgoing and incoming trunk circuit, in which current flows both during the marking and spacing interval.

A further feature consists in a supervisory signal circuit control relay, the winding of which is in the transmitting path in a loop connecting an outgoing and incoming trunk circuit which relay is held operated by current flowing around the loop during the transmission of both marking and spacing signals.

A further feature of the invention consists in a telegraph loop circuit, one end of which is permanently terminated in battery of one polarity and on the other end of which polar signals are impressed through the armature of a sending relay, so that for one transmission condition the batteries are in series aiding relationship and, for the other, the batteries are opposed and of equal value, and intermediate said armature and said end permanently terminated, there is a source of potential which supplies current around the loop when said batteries are opposed.

A further feature of this invention is a resistance in the loop circuit, in parallel with the closed contacts of the device which transmits toward the polar transmitting end of the loop, said resistance being short-circuited by said contacts for one transmitting condition, and in series with the loop, so as to reduce the loop current, for the other transmitting condition.

A further feature of this invention is a subscriber's extension line, loop and station circuit, providing polar transmission toward the subscriber station, in which current flows around

the loop during both the marking and spacing condition.

These and other features will become apparent in the detailed description of the invention together with the claims below.

Circuit arrangements embodying the invention are disclosed in the accompanying drawings in which:

Fig. 1 and Fig. 2 taken together illustrate an outgoing and incoming telegraph trunk circuit used in interconnecting two telegraph switching stations. The figures disclose identical apparatus but in reversed relation. A call over the interconnected figures may be originated at either end and completed at the opposite end. The figures operate in a different manner as will be shown in detail, depending upon whether they are functioning as the originating or completing end of a trunk.

It is to be understood that there may be and generally will be, multiple jack and lamp appearances at each end of the trunk, so that the trunk is available at a number of operator's positions, for interconnection to other circuits by means of the operator's cord circuits at the various positions. The trunk circuit will function with any of a number of well-known types of cord circuits providing means for extending the tip and ring connections of the trunk jacks through a transmitting circuit including the winding of a supervisory relay responsive to the supervisory conditions imposed by the trunk circuit. The invention herein is not so limited, however, as the trunk circuit may be modified in a variety of ways, by one skilled in the art, to cooperate with various cord circuits. The cord circuit per Fig. 1 of the pending application of Kinkead and Singer, Serial No. 93,368, filed July 30, 1936, is illustrative of a cord circuit with which the trunks per Figs. 1 and 2 as well as the extension line loop and station circuit per Fig. 3, described below, will function.

Fig. 3 is an extension line loop and station circuit used in interconnecting a subscriber's station remote from the telegraph switching station with the switching station where it may be extended to other circuits. In this circuit, also, the jacks and line lamps may be multipled so as to be available at a number of operators' positions at the telegraph switching station. The extension line circuit is similar in many respects, especially in the transmission features to a trunk circuit per either Fig. 1 or Fig. 2 but it is connected to a subscriber's loop and station circuit instead of to another similar circuit.

Current is maintained in the loop circuit for both the marking and spacing conditions in much the same manner as current is maintained in the loop connecting the trunks per Fig. 1 and Fig. 2.

5 The invention will be understood from the detailed description which follows. First the operation of Fig. 1 and Fig. 2 will be described. One of each of these circuits is interconnected by means of the two conductors extending to the
10 right of Fig. 1, which join two corresponding conductors extending to the left of Fig. 2.

When the calling plug of a cord is inserted in jack 101, the upper and lower subarmatures of the jack are operated to engage their respective
15 front contacts. Ground is connected through the upper subarmature and front contact, over a conductor to the armature of relay 111, where it branches. One branch follows a path through the winding of relay 112 to negative battery, and
20 the second branch passes through the armature and back contact of relay 111, through the winding of relay 106 to negative battery. Both relays 106 and 112 are operated.

The operation of relay 106 opens the loop extending from the tip of jack 101, through the top winding of relays 104 and 103, the front and break
25 contacts of the make-before-break combination of relay 106, the armature and left-hand or marking contact of relay 107 and the ring of the jack, by opening said front and break contacts of relay
30 106, and connecting ground to the tip conductor, while the ring conductor is open. This operation in turn lights a supervisory lamp in the calling cord in a well-known manner. The
35 lamp will remain lighted until it is extinguished by the release of relay 106 in a manner to be described below, as a signal that the distant operator has answered. Battery flowing from the cord, over the tip conductor, through the top
40 windings of relays 104 and 103, to the ground at relay 106 is dominant over the current flowing in the bottom windings of relays 104 and 103, over a path to be hereinafter traced, and the armatures of both relays 104 and 103 are operated
45 to their left-hand or marking contacts.

The operation of relay 112 performs a number of functions. It terminates the tip side of the loop extending to Fig. 2 permanently in negative
50 battery. It connects positive and negative battery to the marking and spacing contacts of relay 103, respectively, which relay transmits over the loop to Fig. 2, so that positive and negative battery will be connected in series-aiding relation to the ends of the loop for the marking condition,
55 and opposed negative battery will be connected to the ends of the loop for the spacing condition. The operation of relay 112 also extends the tip and ring of the loop of Fig. 1 to Fig. 2. Further it supplies battery to the bottom windings of
60 the two pairs of relays, 103 and 104 and 107 and 108, respectively. The operation of relay 112 also disconnects the circuit through the winding of relay 110 from the loop to Fig. 2. All of these circuits will be traced in detail hereunder.

65 The manner in which the insertion of the calling plug in jack 101 causes lamp 202 to light, as a signal to the distant operator to answer the call, will now be described. After the operation of relay 112, we may trace a circuit from
70 negative battery, through the top, inner armature and front contact of relay 112, resistance 116, the top, inner, back contact and armature of relay 109, the winding of relay 111, the top, outer, front contact and armature of relay 112,
75 through the bottom, outer armature and back

contact of relay 212, the winding of relay 210, resistances 221 and 223, the top, outer, back contact and armature of relay 212, the bottom, outer armature and front contact of relay 112, the
5 windings of relays 108 and 107, the armature and left-hand or marking contact of relay 103, the top, outer, back contact and armature of relay 109, resistance 115, through the bottom, inner, front contact and armature of relay 112,
10 to positive battery. Relay 210 is a polarized relay, which responds to current flowing over the above circuit, operating its armature to its left-hand contact. Relays 107, 108 and 111 do not receive sufficient current, due to the high resistance of the path through relay 210, including
15 resistances 221 and 223, which are both of high value to limit the current to operate at this time. The operation of relay 210 furnishes ground, through its armature and left-hand contact and the top, inner armature and back contact of
20 relay 205, through the filament of lamp 202, to battery, lighting the lamp.

The distant operator now inserts the answering plug of her cord, not shown, into jack 201. This extinguishes the calling lamp 202 and the
25 supervisory lamp in the cord, connected to jack 101, connects the transmission loop of Fig. 1 to the transmission loop of Fig. 2 and prepares the circuit for communication, all of which will be described in detail hereinafter.

30 When the answering plug of the distant cord is inserted in jack 201, a circuit is completed, from battery, through the winding of relay 205, through the bottom, front contact and subarmature of jack 201, which have been actuated into engagement by the insertion of the answering
35 plug, through the left-hand contact and armature of relay 210, to ground, operating relay 205. Relay 205 locks, over a path, from battery, through the winding of relay 205, the top, inner, front contact and armature of relay 205, through
40 the left-hand contact and armature of relay 210, to ground. The operation of relay 205 breaks the circuit through the lamp filament at its top, inner armature and back contact, extinguishing
45 the lamp. The operation of relay 205 also provides a circuit, from ground, through its top, outer armature and front contact, through the winding of relay 209 to battery, operating relay
50 209. The insertion of the cord answering plug in jack 201 provided a circuit also, from ground through the top, subarmature and front contact of jack 201 through the winding of relay 212 to battery operating relay 212. The parallel path
55 through the armature and back contact of relay 211, through the winding of relay 206, to battery, is opened, at the armature and back contact of relay 211, before relay 206 can operate by the operation of relay 212. The detailed description
60 of how this is performed and how the supervisory lamp in the calling cord connected to jack 101 is extinguished will be temporarily deferred until after some preliminary discussion of the associated circuits.

65 When relay 212 operates it joins the transmission loops in Fig. 1 and Fig. 2 together, at its top and bottom outer armatures and front contacts. It also supplies positive battery, through
70 its bottom, inner armature and front contact, through resistance 219, the bottom, inner armature and front contact of relay 205, the top, front and back contacts of the make-before-break combination of relay 212, through resistances 223 and 221, the winding of relay 210, the bottom back and front contacts of the make-before-break
75

combination of relay 212, through the top, inner, front contact and armature of relay 212 to negative battery, to hold relay 210 operated.

The transmission loop connecting Fig. 1 and Fig. 2 may now be traced. We may start at negative battery connected to the top, inner armature and front contact of relay 112, and continue through resistance 116, the top, inner, back contact and armature of relay 109, relay 109 being unoperated, the winding of relay 111, the top, outer front contact and armature of relay 112, the bottom, outer armature and front contact of relay 212, the top windings of relays 208 and 207, to parallel paths, one branch of which extends through the armature and right-hand or marking contact of relay 203, to the top terminal of resistance 226 and the other branch of which extends, through resistance 220 and the top, outer front and back contacts of the make-before-break combination on relay 209, which is operated, to the top terminal of resistance 226 also, where the branches join. The circuit continues, through resistance 226, the top, inner, front contact and armature of relay 209, relay 211, the top, outer, front contact and armature of relay 212, through the bottom, outer armature and front contact of relay 112, the top windings of relays 108 and 107, through the armature of relay 103. For the marking condition, the circuit continues through the left-hand contact of relay 103, the top, back contact and armature of the make-before-break combination of relay 109, resistance 115, through the bottom, inner, front contact and armature of relay 112, to positive battery. It should be observed that for the marking condition, negative battery which is permanently connected to one end of the loop, is connected to positive battery on the other end of the loop, through the left-hand or marking contact of relay 103. For the spacing condition, when the armature of relay 103 is in engagement with its right-hand contact, the circuit extends over a path, through the bottom, outer, back contact and armature of relay 105, resistance 114, through the top, inner, front contact and armature of relay 112, to negative battery. For this condition, the negative batteries at each end of the loop are opposed. Ordinarily for such a condition, no current would flow around the loop. But, as shall be shown later, due to a potentiometer arrangement in which the artificial line through the bottom windings of relays 107 and 108 terminates, a small amount of current, just sufficient to maintain relays 111 and 211 operated, flows around the loop during the spacing condition. Relays 111 and 211 control relays 106 and 206 respectively. By maintaining relays 111 and 211 in the operated condition, relays 106 and 206 are prevented from operating during transmission. This in turn prevents the opening of the loops connected to the cords and the reception of false supervisory signals.

The transmission circuit in Fig. 2, connected to the distant answering cord, through the tip and ring conductors of jack 201, is identical with the Fig. 1 loop connected to jack 101. There are three loops therefore involved in the interconnection of Fig. 1 and Fig. 2 and their connecting cords. In transmitting from Fig. 1 to Fig. 2, relays 103 and 104 operate together. Relay 103 receives signals from the cord connected to jack 101 and retransmits them over the loop between Figs. 1 and 2. Relay 104 operates simultaneously with relay 103 in a manner to be described hereinafter but performs no useful function in this

condition. Relay 207 receives the signals transmitted by relay 103 and transmits them into the loop to the distant cord connected to jack 201. Relay 203 operates simultaneously with relay 208, to hold relay 203 on its marking contact for this operation, to prevent retransmission of the signal received by relay 207 back toward Fig. 1. In transmission of signals toward Fig. 1, relay 203 receives from the distant local loop and transmits to relay 107, which receives and retransmits into the local loop connected to jack 101. Relays 204 and 108 hold to prevent back transmission.

The holding and biasing paths through the lower windings of the various pairs of transmitting, receiving, and holding relays will now be traced in detail and their functions will be described. In the case of relays 103 and 104 a circuit extends from ground, through the bottom windings of relays 104 and 103 in series, to the junction point of a circuit which may be traced from negative battery, through the top, inner armature and front contact of relay 112, through resistance 117, the left-hand contact and armature of relay 108, through said junction point, resistance 118 and the bottom, inner, front, contact and armature of relay 112 to positive battery. Resistances 117 and 118 are so proportioned relative to each other, that when the armature of relay 108 is operated to engage its left-hand contact and the two resistances 117 and 118 are in series between positive and negative batteries, the negative potential predominates and current flows through the bottom windings of relays 103 and 104 in a direction so that its effect is to tend to operate the relays to their right-hand or spacing contacts. When relay 108 is operated to its right-hand or spacing contact, the connection through resistance 117 to negative battery is broken, and current flowing from positive battery through resistance 118 and the bottom windings of relays 103 and 104, holds the armatures of relays 103 and 104 on their left-hand or marking contacts. The effect of the current flowing in the loop, heretofore traced, from the tip of the cord, through the tip of jack 101, through the top windings of relays 104 and 103, the front and back contacts of relay 106, the armature and left-hand contact of relay 107, through the ring of jack 101, which tends to operate the armatures of relays 103 and 104 to their left-hand contacts, when the transmitting circuit of Fig. 1 is in the marking condition, is great enough to preponderate over the effect of the biasing current flowing through the lower windings of relays 104 and 103 when the armature of relay 108 is in engagement with its left-hand contact. Therefore, the armatures of relays 103 and 104 are held in engagement with their left-hand or marking contacts when the loop through their top windings is closed, and marking current is flowing through the circuit. When the current through the top windings of relays 103 and 104 drops for the spacing condition, the preponderately negative current, from the junction of resistances 117 and 118, through the bottom windings, operates the armatures of relays 103 and 104 to engage their right-hand or spacing contacts. As the armature of relay 103 is operated to engage its right- and left-hand contacts, positive and negative batteries are connected to one end of the loop connecting Fig. 1 and Fig. 2. As has been pointed out heretofore, the opposite end of said loop is terminated permanently in negative battery.

Now we will trace in detail and describe the operation of the circuit through the bottom or biasing and holding windings of relays 107 and 108. This circuit extends from the armature of relay 103, through the bottom, inner, back contact and armature of relay 109, relay 109 being unoperated, through the bottom windings of relays 108 and 107 in series, to the junction of a branch circuit, which forms a potentiometer. One arm of said potentiometer extends through the bottom, outer, back contact and armature of relay 109, through resistance 125, to ground. The other arm extends to a parallel circuit, one side of which consists of resistance 113, and the other side of which consists of the bottom, inner, back contact and armature of relay 105, which relay is unoperated, in series with resistance 119. At this point the sides of said parallel circuit again join and the arm of the potentiometer extends through the bottom, inner, front contact and armature of relay 112, to positive battery. The circuit through the bottom windings of relays 107 and 108, therefore, resembles an artificial line extending from the armature of relay 103 to a potentiometer. Relay 103 applies positive and negative potential reversals to the top and bottom windings of relays 107 and 108.

When transmitting from Fig. 1 to Fig. 2, the armature of relay 103 is operated alternately to its right- and left-hand contacts. When said armature is in engagement with its left-hand or marking contact, positive battery, connected to one end of the loop is in series with negative battery connected through resistance 116 to the other end of the loop. The effect of the current flowing through the top windings of relays 107 and 108 for this condition preponderates over any current which may flow through the bottom windings of said relays, and maintains the armatures of said relays in engagement with their left-hand or marking contacts. When the armature of relay 103 is in engagement with its right-hand or spacing contact, negative battery is connected to both ends of the loop. Positive battery flows from the potentiometer through the bottom windings of relays 107 and 108 to the apex of the loop where it takes two paths to negative battery. One path is through the armature and right-hand contact of relay 103, over a path heretofore traced. The other path is through the top windings of relays 107 and 108 and around the loop. The effect of the current through the bottom windings of relays 107 and 108 for this condition is to hold the armatures of these relays in engagement with their left-hand or marking contacts. This is necessary in the case of relay 107 to prevent the opening of the loop connected to the local cord.

Supplying some current around the loop at all times, whether the armature of relay 103 is on its marking or spacing contact is an important feature of this invention. It has been shown that in the case of transmission from Fig. 1 to Fig. 2 for the spacing condition, negative batteries are opposed, but the constants of the potentiometer arms, resistance 114, the loop resistance, and the batteries are so chosen, that sufficient current flows to hold both relays 111 and 211 in an operated condition. This prevents the reception of false supervisory signals, as heretofore described.

The circuit for the biasing and holding windings of relays 203 and 204 is exactly similar in its connections and functions with that for

relays 103 and 104 and it is not considered necessary to trace and discuss it here in detail.

Due to the operation of relays 205 and 209 in Fig. 2 heretofore described, while their corresponding relays 105 and 109 in Fig. 1 remain unoperated, for a connection between Fig. 1 and Fig. 2 originating in Fig. 1, the detailed connections through the lower windings of relays 207 and 208 are different from those of 107 and 108 and the functions of the connections are also necessarily different. These connections and functions will now be described in detail.

Starting from ground on the bottom inner front contact of relay 209, we may trace a circuit through the associated armature, the bottom windings of relays 208 and 207 in series, to the junction of a parallel circuit. One branch of said circuit continues through the bottom, outer back and front contacts of the make-before-break combination of relay 209, through the armature and right-hand contact of relay 204, resistance 227, and the top, inner, front contact and armature of relay 212, to negative battery. The other branch extends through resistance 213 and the bottom, inner, front contact and armature of relay 212, to negative battery. Therefore, when the armature of relay 204 is in engagement with its right-hand contact, positive and negative batteries are connected, in series-aiding relationship, through resistances 213 and 227, while extending from a junction point between the resistances, there is a circuit to ground through the bottom windings of relays 207 and 208. Resistance 227 connected to negative battery is smaller than resistance 213 connected to positive battery. For this condition, negative battery predominates and the effect of the current through the lower windings is to tend to operate the armature of relays 207 and 208 to their left-hand, or spacing contacts. For the marking condition, the effect of the current flowing through the top or line windings of relays 207 and 208 is dominant and the relays are operated to their right-hand or marking contacts. When the line current drops for the spacing condition, the current through the bottom windings of relays 207 and 208 remains the same, in direction and amount, as for the previous condition, and its effect becomes dominant to operate the armatures of relays 207 and 208 to engage their left-hand contacts. It should be remembered from the description of the operation of the corresponding relays in Fig. 1 that, when relays 207 and 208 are operated to their spacing contacts, relays 203 and 204 are maintained on their right-hand or marking contacts, so that the amount, the direction and the effect of the current through the bottom windings of relays 207 and 208 is the same for both the marking and spacing conditions of relays 207 and 208.

When transmission is in a direction from Fig. 2 to Fig. 1, the armature of relays 203 and 204 are operated alternatively to their left- and right-hand contacts. In tracing the transmitting loop between Fig. 1 and Fig. 2 in Fig. 2, it will be recalled that the path divided into a parallel circuit after passing through the top winding of relay 207. One branch passed through the armature and right-hand contact of relay 203 to the top terminal of resistance 226 where it joined a path shunting said armature and contact, through resistance 220. As relay 203 is operated therefore, when it is on its right-hand or marking contact, there is a relatively large current flowing around the loop from positive and neg-

ative batteries connected to the ends of the loop at relay 112. When the armature of relay 203 is operated to engage its left-hand or spacing contact, the shunt around resistance 220 is removed and the current in the loop is reduced for the spacing condition. Relay 204, which responds to the same impulses as relay 203, breaks its connection through resistance 227, to disconnect negative battery from the bottom windings of relays 207 and 208. The effect of the current from positive battery, through resistance 213 and the bottom windings of relays 207 and 208, is to hold the armatures of these relays on their right-hand or marking contacts, while the reduced spacing current is flowing in the top windings of these relays, to prevent the spacing signal from being retransmitted toward the cord connected to jack 201.

The detailed description of the manner in which a disconnect signal is transmitted from Fig. 2 to Fig. 1 will now follow.

When the distant operator removes the plug of her answering cord from jack 201, the jack is restored to the normal unoperated condition, breaking the circuits through the top and bottom subarmatures and front contacts. Relay 212 releases. This breaks the circuit connecting the loop between Fig. 1 and Fig. 2 at the top and bottom, outer armatures and front contacts of relay 212. Relay 211 releases, as the loop circuit through Fig. 2 is broken. Relay 111 releases, because the loop from Fig. 1 to Fig. 2 is connected to the high resistance circuit through relay 210 heretofore traced and described. Since the ground connection at jack 201, which operates relay 206, is disconnected, the release of relay 211 at this time will not affect relay 206. The plug of the calling cord is still connected to jack 101, however, supplying ground to relay 106, and when relay 111 releases, relay 106 operates, opening the ring circuit of the local loop to the calling cord and grounding the tip connection. This lights a supervisory lamp in the calling cord as a signal to the operator to remove the plug from jack 101.

There is a provision in the circuits to prevent the line lamp 202 from relighting during the period between registration of the disconnect signal and the actual removal by the operator of the plug connected to jack 101. This is performed as follows:

When relay 212 releases, it reconnects the circuit through relay 210 to the tip and ring of the loop to Fig. 1, at the top and bottom, outer armatures and back contacts of relay 212. Relay 103 in Fig. 1 is on its left-hand, or marking, contact due to the ground connection on the armature of relay 106. Positive battery is connected through the left-hand contact and armature of relay 103, to one side of relay 210 winding, at the bottom, outer armature and back contact of relay 212, and negative battery is connected to the other side of the winding of relay 210, from relay 112 through resistance 116, through the top, outer armature and back contact of relay 212. The effect of the current in this circuit is to maintain the armature of relay 210 on its left-hand contact, so that relay 205 remains operated, preventing lamp 202 from relighting.

When the calling cord is disconnected from jack 101, jack 101 restores to normal, removing the ground from relays 106 and 112 which release. When relay 112 releases, positive and negative batteries, which were supplied to the winding of relay 210 are removed and relay 210 re-

leases. When relay 210 releases, it removes ground from the winding of relay 205, releasing relay 205. Relay 205, in turn, removes ground from the winding of relay 209 which also releases. The circuits per Fig. 1 and Fig. 2 are thus restored to normal.

It was assumed, in the preceding description of the operation of Fig. 1 and Fig. 2, that the call originated at the Fig. 1 terminal. A call may also originate at the Fig. 2 terminal by inserting the plug of a calling cord in jack 201. In such event, the operation of Fig. 2 and Fig. 1 would be reversed. Fig. 2 would function in the manner in which Fig. 1 operated in the above description and Fig. 1 would function as Fig. 2. In this case battery would be supplied to the loop between the figures from relay 212 instead of relay 112. Relays 205 and 209 would remain unoperated. Relays 105 and 109 would operate. Positive and negative impulses would be impressed on the loop between the figures at the contacts of relay 203, while transmitting toward Fig. 1. Resistance 120 would be alternately inserted in series with the loop and shunted, by the operation of relay 103, in transmitting toward Fig. 2 and all of the other incidental operations, which are performed differently in the two figures, in the case of a call originating in Fig. 1 would be performed by Fig. 2 instead of Fig. 1 and vice versa.

Condensers 124 and 224 shunt the windings of relays 111 and 211 respectively to counteract the adverse effect on transmission of the inductance of the relay windings.

It will be observed that when a call is originated in Fig. 1, relay 109 remains unoperated. The circuit from negative battery through the top inner armature and front contact of relay 112, and resistance 127 through the marking contact and armature of relay 104 remains open at the bottom outer front contact of relay 109. Relay 104 performs no function, therefore, when a call is originated in Fig. 1. When a call originates in Fig. 2, the corresponding circuit, through resistance 227 and the marking contact and armature of relay 204, is open at the bottom outer front contact of relay 209. There is, therefore, a three-relay repeater in the end of the trunk wherein a call originates cooperating with a four-relay repeater in the completing end of the trunk.

The detailed operation of Fig. 3 will now be described.

On a call originating at the trunk end of the circuit, the calling plug of a well-known cord is inserted in jack 301. The subarmatures, associated with the tip and ring of jack 301, are actuated into engagement with their associated front contacts. A circuit may now be traced from ground, through the upper subarmature and front contact of jack 301, through the winding of relay 306 to battery, operating relay 306. A circuit may also be traced from battery, through the winding of relay 305, through the bottom, front contact and subarmature of jack 301, to the open, front contact of relay 309, preparing for the operation of relay 305, which remains unoperated at this time.

The operation of relay 306 supplies positive battery through its right-hand armature and front contact, through resistance 313, to the left-hand or marking contact of relay 302. It also supplies negative battery, through its left-hand armature and front contact, through resistance 314, to the right-hand or spacing contact of relay 302. The operation of relay 306, further,

closes a circuit, which extends from ground, through the bottom winding of relay 302 to a branch circuit, one arm of which extends through the armature and left-hand or marking contact of relay 304, through resistance 316, through the right-hand front contact and armature of relay 306 to positive battery, and the other arm of which extends through resistance 312, through the left-hand front contact and armature of relay 306, to negative battery. The operation of relay 306 also closes a circuit which extends from the armature of relay 302, through the bottom windings of relays 303 and 304 in series, to the junction point of a circuit forming a potentiometer, one arm of which extends through resistance 318 to ground, and the other arm of which extends through resistance 317 and the right-hand front contact and armature of relay 306 to positive battery. The operator now applies ringing current from the cord, which passes through the ring of jack 301, through the winding of relay 307, and condenser 326, through the back contact and armature of relay 308 to ground, operating relay 307. The operation of relay 307 supplies ringing current, through the bottom, inner armature and front contact of relay 307, through the top, outer armature and back contact of relay 305, over the ring of the subscriber's loop, through the armature and left-hand contact of power switch 333, through ringer 334 and condenser 335 to ground, operating the ringer.

In response to this signal the subscriber operates the armature of his power switch to engage its right-hand contact. A circuit may now be traced, from negative battery, through resistance 329, through the winding of relay 309, through the bottom outer armature and break contact of the make-before-break combination of relay 305, over the tip conductor of the loop to a parallel circuit, one arm of which comprises break key 330 and sending contacts 337, and the other arm of which consists of resistance 339. Said arms then join and the circuit continues through the winding of receiving relay 336, through the right-hand contact and armature of power switch 333, through the top, outer back contact and armature of relay 305, through resistance 331, to positive battery. Relay 309 operates, supplying ground through its armature and contact, through the bottom subarmature and front contact of jack 301 and the winding of relay 305 to battery, operating relay 305. Relay 305 thereupon locks from battery through its winding and its bottom inner front contact and armature to ground through the armature and front contact of relay 309.

The operation of relay 309 furnishes ground also through resistance 332, to operate a relay in the power supply start circuit. This power supply start circuit is well known in the art, and it is not therefore thought necessary to show or describe it in detail herein. It starts two motor generator sets to furnish positive and negative electromotive force for telegraph transmission to the bus bars supplying the various circuits per Fig. 3. This start circuit is not necessary for the proper functioning of the invention but is provided for economy so that the motor generator sets will be operated only when required.

During the interval that relay 305 is unoperated, ground is furnished through the bottom, inner, back contact and armature of relay 305, through resistance 325, to the tip of the cord, while the circuit from the ring of the cord, which extends through the top winding of relay 302 and

the armature and left-hand contact of relay 303, through resistance 315, is opened at the top, inner, front contact of relay 305. This controls a relay in the cord circuit in a well-known manner to maintain a supervisory lamp lighted as a signal that the subscriber has not answered. When relay 305 operates, ground is removed from the tip of the cord conductor and the tip and ring of said conductors are joined, to form a continuous loop, and the supervisory lamp in the cord circuit is extinguished in a well-known manner. The operation of relay 305 transfers the tip of the subscriber's loop, from the circuit through the bottom, outer, front contact and armature of relay 305, through the winding of relays 309, and resistance 329, to negative battery and connects it, instead, through the bottom outer back and front contacts of the make-before-break combination of relay 305, through the winding of relay 308, to negative battery. The operation of relay 305, further, disconnects the ring of the subscriber's circuit from the connection through the top, outer, back contact and armature of relay 305, through resistance 331, to positive battery and connects it, instead, through the top, outer, back and front contact of the make-before-break combination of relay 305, through resistance 311 and the top windings of relays 304 and 303 in series, to the armature of relay 302. In tracing the circuit through the bottom winding of relay 302, parallel paths were disclosed through resistances 312 and 316 to negative and positive battery respectively. The value of resistance 312, relative to the value of resistance 316 is high, so that when the armature of relay 304 is on its left-hand or marking contact and resistances 312 and 316 are in circuit, positive battery predominates, and the effect of the current flowing in the bottom winding of relay 302 tends to operate the armature of relay 302 to its spacing contact. This effect is opposed by the effect of the line current, flowing in the local loop through the top winding of relay 302, which holds the armature of relay 302 on its marking contact. When the current in the local loop drops for the spacing condition, the armature of relay 304 remains on its marking contact and the effect of the current flowing in the bottom winding of relay 302 operates the armature of relay 302 to its right-hand or spacing contact. When the local loop is receiving from the subscriber, relays 303 and 304 are operated simultaneously between their marking and spacing contacts. Relay 303 when in the spacing condition with its armature operated to the right, opens the local loop. Relay 304 at the same time, however, disconnects the connection through resistance 316 to positive battery from the bottom winding of relay 302. The effect of the negative current through resistance 312, however, is such that the bottom winding of relay 302 holds the armature of relay 302 in engagement with its marking contact to prevent the retransmission of the received signal back toward the subscriber's loop.

A circuit has heretofore been traced from the armature of relay 302, through the bottom windings of relays 303 and 304 in series, to the junction of a circuit forming a potentiometer. One branch of said potentiometer consists of resistance 318 connected to ground. The other branch consists of resistance 317 and the right-hand front contact and armature of relay 306 connected to positive battery. The values of the various resistances and batteries are so chosen that when the armature of relay 302 is on its marking con-

tact, the effect of the current in the top windings of relays 303 and 304 is such that the armatures of relays 303 and 304 are held in engagement with their left-hand or marking contacts. When the armature of relay 302 is on its spacing contact, negative battery, connected through said contact to one end of the subscriber's loop, opposes negative battery permanently connected to the other end of said loop through the winding of relay 302. The positive current from the potentiometer, however, flows through the bottom windings of relays 303 and 304, and takes two paths to negative battery. One path is through the contact of relay 302. The other path is around the loop. Under these circumstances the armatures of relays 303 and 304 are held in engagement with their marking contacts, preventing the retransmission of the signal from relay 302 back into the local loop. However, the current around the trunk-subscriber loop is maintained so that it never drops to zero. Maintaining some current in the loop at all times is one of the important features of this invention. This maintains relay 308 operated continuously while the subscriber loop is established. Relay 308 supplies ground over a local circuit to relay 309, which in turn maintains relay 305 locked in an operated condition. This in turn prevents the false operation of the supervisory relay in the cord circuit, connected to jack 301, and prevents the reception of false supervisory signals.

In transmitting toward the subscriber's station, relay 302 operates its armature between its marking and spacing contacts. Receiving relay 336 follows these operations. The armatures of relays 303 and 304 are held in engagement with their marking contacts during transmission in this direction. For transmission from the subscriber, the sending contacts 337 are operated. These open and close the circuit according to the code of the letter transmitted. When the contacts are closed resistance 339 is short-circuited. When the contacts are opened, resistance 339 is in series with the loop. This results in full loop current for the marking condition and substantially reduced current for the spacing condition. Relays 303 and 304 follow these signals. Relay 303 opens and closes the local loop to the connecting cord. Relay 304 functions to hold relay 302 on its marking contact as heretofore described.

In the case of a call originated by the subscriber, power switch 333 is operated to close the subscriber loop. A circuit may then be traced from positive battery, through resistance 331, through the top, outer armature and back contact of the make-before-break combination of relay 305, over the ring of the subscriber loop through the armature and right-hand contact of power switch 333, the winding of the receiving relay 336, through the sending contacts 337 and break key 338, both in parallel with resistance 399, through the bottom, outer, back contact and armature of the make-before-break combination of relay 305, through the winding of relay 399 and resistance 329 to negative battery. Relay 309 is operated. A circuit may then be traced from ground, through the armature and front contact of relay 329, through the bottom, inner armature and back contact of relay 305 and the filament of lamp 310, to battery, lighting lamp 310. In response to this signal, the operator inserts the plug of her cord in jack 301. This operates the top and bottom subarmatures of jack 301 into engagement with their respective

front contacts. Relay 306 is operated as heretofore described. Relay 305 is operated over a circuit from ground through the armature and front contact of relay 309 through the bottom subarmature and front contact of jack 301 and the winding of relay 395 to battery. The operation of the circuit from this point is the same as heretofore described.

The subscriber may disconnect by operating his power switch to break the loop. This releases relay 308, which in turn releases relay 309. The release of relay 309 releases relay 305. This breaks the local loop to the cord circuit at the top inner armature and front contact of relay 305 and connects ground to the tip of the loop, leaving the ring of the loop open. This in turn causes a relay in the cord circuit to function, to light the supervisory lamp, as a signal that the subscriber has disconnected. The operator removes the plug of the cord from jack 301, releasing relay 306 and restoring the circuit to normal.

The circuit through the bottom, outer contact of relay 307, which has not been heretofore described, short-circuits the winding of relay 309 during ringing. This prevents the false operation of relay 309 during ringing and in turn prevents the reception of a false supervisory signal, which would indicate that the subscriber had answered.

Condenser 328 makes relay 309 slow in releasing so that it will hold up while relay 305 is operating.

Condenser 327 is intended to reduce the transmission impairment caused by the inductive effect of relay 308.

Resistance 319 and its associated condenser 320 provide a contact protection arrangement for the armature and left-hand contact of relay 302. Resistance 321 and condenser 322 provide a similar arrangement for the same armature and its right-hand contact.

What is claimed is:

1. A direct current full metallic telegraph loop circuit comprising a main telegraph loop extending between a first end and a second end, a first source of electromotive force impressed between said first end and ground, a second source of equal electromotive force of polarity opposing said first electromotive force impressed between said second end and ground for a first signal transmitting condition and means connected to said loop for maintaining current in said loop while said condition prevails.

2. A direct current full metallic telegraph loop circuit having equal opposed potentials impressed between ground and the opposite ends of the main loop for one signal transmitting condition, said circuit being characterized in that it includes means supplying loop current for said condition.

3. In a telegraph circuit, a first telegraph station, a second telegraph station, a direct current full metallic telegraph loop circuit connecting said stations, means at each of said stations for transmitting telegraph signals to the other of said stations, and means connected to said loop for maintaining some current circulating in said loop at all times in one and the same direction throughout communication in either direction.

4. In a telegraph circuit, a first telegraph station, a second telegraph station, a full metallic telegraph loop circuit connecting said stations, polar relay means at said first station for transmitting marking and spacing telegraph signals

to said second station, polar relay armature transition time intervals between said signals and means connected to said loop for supplying unidirectional current continuously to said loop while said signals are being transmitted and during said intervals.

5. In a telegraph loop circuit, a full metallic telegraph loop circuit, a relay, a winding on said relay in series in said loop circuit, a contact on said relay, supervisory signal means connected to said loop circuit controlled by said contact, means connected to said loop circuit for transmitting marking and spacing signals through said loop and means, also connected to said loop circuit for supplying current to said loop while both of said signals are being transmitted, to hold said relay in an operated condition.

6. In a full metallic telegraph loop circuit, a sending relay, marking and spacing contacts on said relay, a first source of electromotive force of a first polarity connected to said marking contact, a second source of equal electromotive force of opposite polarity connected to said spacing contact, an armature controlled by said sending relay to engage said contacts alternately, a receiving relay, a line winding and a balancing winding both on said receiving relay, a supervisory signal control relay, a winding on said control relay, a telegraph loop, a first resistance and a second resistance, a telegraph path extending from said armature, through said line winding, the winding of said control relay and said loop to said spacing contact and a path, parallel to said telegraph path, extending from said armature through said balancing winding to a branch circuit formed by said first and said second resistances, one of which is terminated in ground and the other of which extends to ground through a source of electromotive force of polarity opposite from that of the source of electromotive force connected to said spacing contact.

7. A telegraph loop circuit, a first and second end thereon, a relay, an armature on said relay, a free and a fixed end on said armature, means on said relay for operating said free end alternately to engage a first contact and a second contact both on said relay, a ground, two equal lumped resistances, a first telegraph battery with its negative pole connected to said ground and its positive pole connected through one of said resistances to the first of said contacts, a second telegraph battery with its positive pole connected to said ground and its negative pole connected through the second of said resistances to the second of said contacts, a first connection between said fixed end of said armature and one end of said loop, a second connection between the second end of said loop and said second contact, a receiving relay, a first and a second winding thereon, said first winding being included in series in said loop adjacent to said fixed end of said armature, a circuit extending from said fixed end of said armature, through said second winding on said receiving relay to a parallel circuit comprising a first and second branch, a resistance connected to ground in said first branch, and a resistance connected to positive battery in said second branch.

8. In a teletypewriter switching system, a cen-

tral switching station, a subscriber's station, a line terminating circuit at said central station, a subscriber's station circuit at said subscriber's station, a telegraph loop connecting said circuits, means for connecting a first source of electromotive force of a first polarity and a first potential with reference to ground potential to the first end of said loop circuit, means for connecting the same source of electromotive force of the same polarity and same potential with reference to ground potential to the second end of said loop circuit for a first transmitting condition, means for connecting a second source of electromotive force, of a polarity opposite from said first polarity and of a potential equal to said first potential with reference to ground potential to said second end of said loop circuit for a second transmitting condition so that the sources of electromotive force connected to the opposite ends of said loop are opposed for said first transmitting condition and in series-aiding relationship for said second transmitting condition and means for maintaining current in said loop during both of said conditions.

9. A telegraph loop circuit, a first end and a second end at opposite extremities of said loop circuit, means for connecting sources of electromotive force of opposite polarity and equal differences of potential with reference to ground potential alternately to said first end of said circuit, means for terminating said second end of said circuit permanently in ground through either of said sources of electromotive force, and means connected to said loop for maintaining current in said loop at all times.

10. A first telegraph station, a second telegraph station, a supervisory signal control relay, a winding, an armature and a front contact all on said relay, a full metallic telegraph loop circuit extending in series through said winding connecting said stations, means in said loop circuit for transmitting communication signals in each direction between said stations and means connected to said loop circuit for maintaining electric current in said loop to energize said winding and hold said armature from engagement with said contact at all times during said communication in each direction.

11. In a telegraph loop circuit, means for transmitting a marking signal, means for transmitting a spacing signal, time intervals between said signals and means connected to said circuit for supplying current around said loop circuit while both said signals are being transmitted and during said intervals to hold a supervisory signal control relay in an operated condition.

12. In a teletypewriter switching system, a two-way telegraph path comprising an originating telegraph trunk circuit connected to a completing telegraph trunk circuit, a four-relay repeater in each of said circuits, means in said circuit for operating said completing trunk as an originating trunk, means also in said circuit for operating said originating trunk as a completing trunk, means also in said circuits for operating but three of said four repeating relays effectively in the circuit which is functioning as an originating trunk.

WALTER W. CRAMER.

FULLERTON S. KINKEAD.