July 15, 1941. F. S. KINKEAD 2,249,429

TELETYPEWRITER SWITCHING SYSTEM

Filed March 18, 1939 2 Sheets-Sheet 1

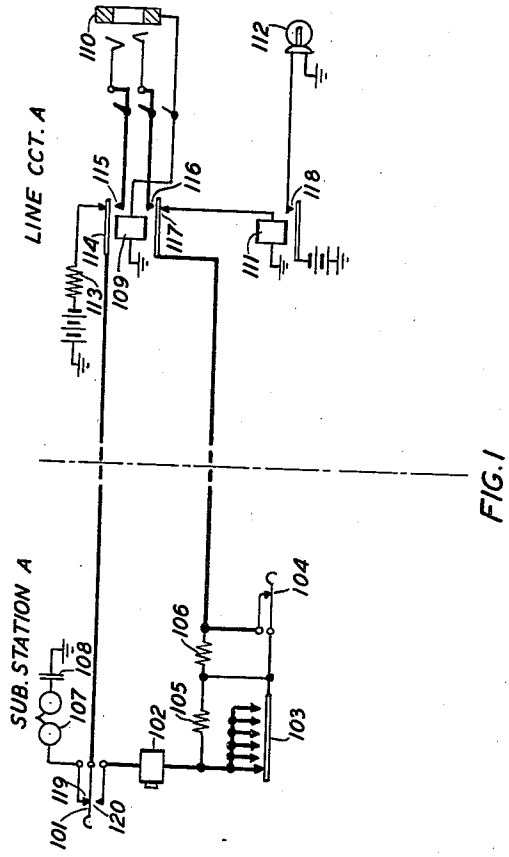

FIG. 1

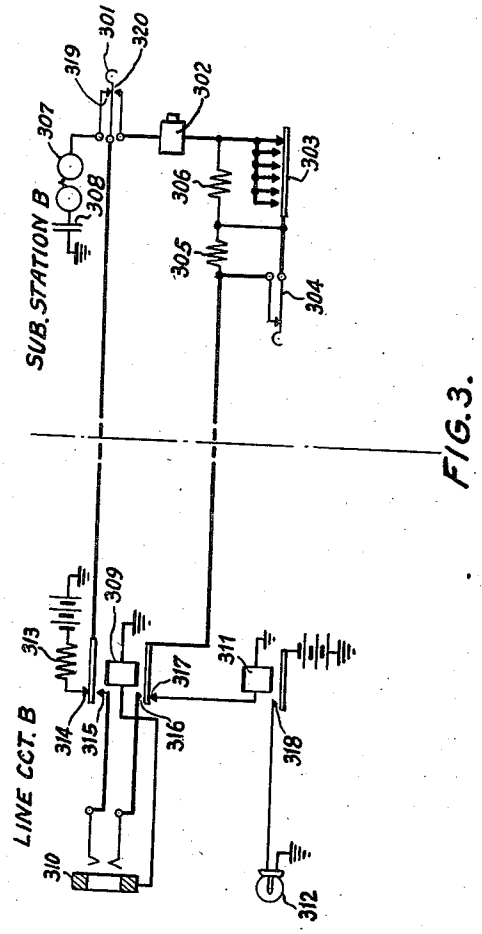

FIG. 3.

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TELETYPEWRITER SWITCHING SYSTEM

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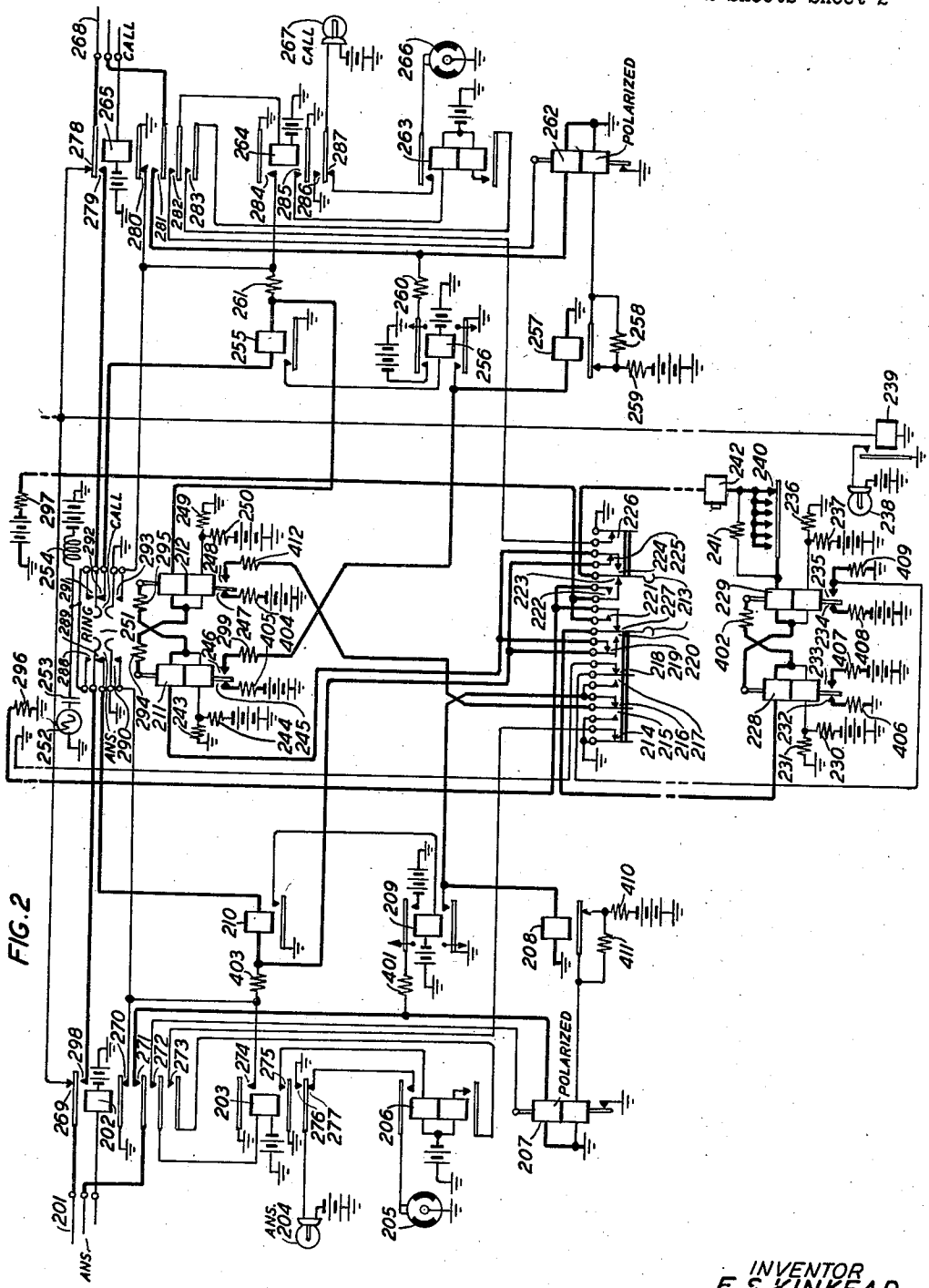

FIG. 2

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TELETYPEWRITER SWITCHING SYSTEM

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Application March 18, 1939, Serial No. 262,681

25 Claims. (Cl. 178—71)

This invention relates to telegraph and teletypewriter switching systems and particularly to new transmission and supervisory features for a switching system including a calling subscriber's station and subscriber's line circuit interconnected through a subscriber's cord circuit to a called subscriber's line and station circuit.

In certain direct current systems of telegraph communication, signaling is performed by opening and closing a telegraph line, so that current of full strength and zero current are transmitted for marking and spacing signals. In other direct current systems, currents of opposite polarity and of the same magnitude are impressed on the line with short intervals of zero current between the signal elements while the armature of the telegraph relay is traveling between contacts. There are also other types of direct current telegraph communication signaling, including an arrangement wherein current of one polarity and of a certain magnitude is transmitted for the marking condition and current of opposite polarity and reduced magnitude is transmitted for the spacing condition.

When such systems of communication signaling are used in teletypewriter switching systems they introduce a major difficulty inherent in each in that relays in the transmission path controlling supervisory signals have a tendency to release.

In addition to communication signals in manual teletypewriter switching systems, it is necessary to transmit calling, disconnect, recall, and break signals to control the connection of subscribers through a manual switchboard as well as to regulate communication between subscribers. The character of the communication signals used in the switching system generally dominates the arrangement of the line, supervisory and break signal apparatus. The reception of false supervisory signals and the non-registering of intended supervisory signals are inherent in the operation of such systems.

Subscribers' teletypewriter switching stations are generally interconnected through associated central switching stations by means of loop circuits. Two general types of loops, namely, closed and open loops, have been used for this purpose. A closed loop is one which is normally closed during the idle period and during communication signaling. It is open for the transmission of calling and supervisory signals. It has a number of serious disadvantages and is being generally replaced by open loop circuits. These latter loops are normally open during the idle period and are closed for calling and communication signaling. One loop conductor is ordinarily grounded for the transmission of supervisory signals. Although open loop circuits are generally more satisfactory than the closed loop circuits, as presently used, they too have a number of disadvantages. Perhaps the most serious of these disadvantages is that the supervisory relay, which is ordinarily a differential relay has a tendency to release during communication signaling, requiring additional apparatus to prevent the registering of false supervisory signals. Further, in the present open loops, in the transmission of calling and supervisory signals, one of the loop conductors is connected to ground. On long loops, the variation in ground potential between the station and the office is at times considerable, seriously interfering with the transmission of these signals. Another objection is that direct current flows from the central station to ground at the subscriber's station while calling and supervisory signals are being transmitted causing electrolysis.

To overcome these objections, the open loop subscribers' circuits and cooperating cord circuits disclosed herein are arranged to maintain unidirectional current in the loop and through the winding of the supervisory relays at all times during communication signaling, including the interval while the armature of the relay which transmits into the loop is traveling between its marking and spacing contacts. Further, the circuits are arranged so that it is not necessary to ground one loop conductor to transmit supervisory signals, thus eliminating the objectionable electrolysis effect and the effect of variation in ground potentials between the subscriber's station and the central station.

In the copending application of W. W. Cramer and applicant, Serial No. 225,898, filed August 20, 1938, there are disclosed means for maintaining unidirectional current through the transmission path in certain telegraph circuits at all times, while the circuits are conditioned for communication, that is, during the transmission of marking and spacing signal elements as well as during the intervals between the transmission of said elements while the armature of the sending relay is traveling. The invention therein is shown as applied to two specific circuits, namely, (1) a full metallic trunk or tie line circuit which would be used ordinarily in interconnecting two teletypewriter private branch exchange switchboards, and (2) a subscriber's extension line circuit used in connecting subscribers' stations remote from a switchboard to the switchboard.

The invention herein now makes it possible to extend the principles disclosed in the above-named application so that they may be applied to an operating system instead of limited to the individual circuits described in said application.

In the invention herein circuits have been devised making possible the positive control of supervisory signals in a connection involving a calling subscriber's line and station circuit inter-

connected through a cord circuit to a called subscriber's line and station circuit.

An object of this invention is to provide a cord circuit wherein relays controlling supervisory signals are positively controlled.

A further object of this invention is to provide a cord circuit cooperating with a subscriber's line and station circuit in a manual teletypewriter switching system in which there is either full current of a specific polarity or reduced current of the same polarity flowing at all times while a connection is established and conditioned for communication, as well as during comunication and during the intervals between the transmission of signal elements, so that relays controlling supervisory signals may be controlled positively.

A further object of this invention is to provide an open loop circuit in which it is not necessary to ground one conductor in order to transmit a supervisory signal, thus overcoming the difficulty of electrolysis and the difficulty due to difference in ground potential between the subscriber's station and the central station.

A feature of this invention is a cord circuit having a two-relay repeater therein, wherein each relay has a line winding and a balancing winding and wherein, connected to said balancing winding, there is a potentiometer device to maintain current through said line winding and the transmission circuit connected thereto during the transmission of both elements of the two-element communication signaling code and during the interval while the armature of the signal transmitting relay is traveling.

A further feature of this invention is a relay having a winding in the transmission path of the cord circuit and means in said cord circuit to maintain unidirectional current through said winding at all times while the circuit is conditioned for communication and while it is transmitting marking and spacing signals and during the intervals between said signals.

A further feature of this invention is an arrangement for changing the biasing current through a polar relay which relay controls the supervisory signals in the cord circuit to compensate for different line leakance conditions.

These and other features will be made apparent in the description which follows.

The invention may be more fully understood from reference to the associated drawings.

Fig. 1 shows a teletypewriter subscriber's station and line circuit which serve in the following description as a calling circuit. The station circuit is shown at the left of the dotted line. It is interconnected by means of two conductors to the line circuit apparatus, shown at the right of the dotted line, which is located at a switchboard in a central office. The jack **110** ordinarily has multiple appearances located at a plurality of positions.

Fig. 2 shows a cord circuit and an operator's position circuit which serve to interconnect calling subscribers to other circuits and to communicate with subscribers. The position circuit is shown at the bottom of the figure below teletypewriter key **213**. The cord and position circuits are located in a switchboard at a central office.

Fig. 3 shows a second teletypewriter subscriber's station and line circuit which serve in the following description as a called circuit. It is the inverse of Fig. 1. The line circuit apparatus shown at the left of the dotted line is located at the switchboard and is connected by means of two conductors to the apparatus at a subscriber's station shown to the right of the dotted line. The jack **310** is also multipled before a plurality of operators at various positions.

The circuits will now be described in detail.

Refer now to Fig. 2. This circuit represents a single cord circuit, which is one of a group of cords at a particular operator's position in a switchboard, and a single position circuit which is flexibly interconnected as required to any cord at a particular position. The circuits as shown are normal for the idle condition. It will be observed that the position circuit shown at the bottom of the figure, below key **213**, is not operatively connected to the transmission circuit of the cord while key **213** is in the position shown.

The circuits through the bottom or biasing windings of relays **211** and **212**, which constitute the cord circuit repeater, terminate in a potentiometer in each case. In the case of relay **212** the potentiometer circuit consists of grounded battery connected through resistances **250** and **249** to ground. For relay **211** the circuit consists of grounded battery connected through resistances **244** and **243** to ground. Similarly the two relays in the repeater in the operator's position circuit, namely relays **228** and **229**, have potentiometers connected to their bottom or biasing windings. For relay **228** the circuit extends from grounded battery through resistances **230** and **231** to ground and for relay **229**, from grounded battery through resistances **237** and **236** to ground.

In the case of each of these relays the circuit through their bottom windings connects to a two-branch parallel circuit. One branch of the parallel circuit extends in each instance through the top or line winding of the same relay. The second branch extends through the armature of a second relay, which forms with the first the second of a pair of repeating relays. Thus a circuit may be traced from a point between resistances **249** and **250**, through the bottom winding of relay **212** to the junction of two parallel branches. The first branch extends through the top or line winding of relay **212** and is continued through the loop circuit connected to the calling end of the cord, to be traced hereinafter. The second branch extends through resistance **294** and the armature of relay **211**, which may be connected to either battery or ground for the marking or spacing condition. Similarly, for relay **211**, the circuit through its bottom or biasing winding extends from a point between resistances **243** and **244** through said winding to a parallel circuit. The first branch of said circuit extends through the top or line winding of relay **211** and then through the tip conductor of the loop connected to the answering end of the cord to be traced hereinafter. The second branch extends through resistance **295** to the armature of relay **212** where it connects to either battery or ground for the marking or spacing condition.

In the case of relay **229** the biasing circuit extends from a point between resistances **236** and **237** through the bottom or biasing winding to a parallel circuit. The first branch extends through the top or line winding of relay **229** to a transmission circuit to be traced hereinafter. The second branch connects to the armature of relay **228** where it is connected to ground through resistance **405** for marking and through resistance **407** to negative battery for spacing. For relay **228** the biasing circuit extends from a point between resistances **230** and **231**

through the bottom or biasing winding of relay 228 to a parallel circuit. The first branch extends through the top or line winding of relay 228 to a transmission circuit to be traced hereinafter. The second branch extends through resistance 402 to the armature of relay 220 where it may be connected through resistance 408 to negative battery for marking or to ground for spacing.

It is by means of these potentiometer arrangements that it is possible to maintain unidirectional current flowing in the transmission circuits while the armature of the opposite relay of a pair of repeating relays is traveling and while it is connected to ground. This will become more apparent in the following description.

When the cord circuit per Fig. 2 is in the idle condition and the position circuit is also in the idle condition and disconnected from the cords, the armatures of the repeater relays 211 and 212 in the cord and 228 and 229 in the position circuit are all held in engagement with their left-hand or marking contacts as indicated. While the cord is idle relays 202 and 265 are released as indicated and teletypewriter key 213 is in the position shown. Relays 202 and 265 while released connect ground to the top or line windings of relays 211 and 212, respectively, to hold these relays in the marking position. These circuits may be traced as follows: For relay 211 the circuit may be traced from ground, through contact 270 of relay 202, resistance 403, contacts 219 and 225 of key 213 in parallel, through the top winding of relay 211, resistance 295, armature and contacts 247 of relay 212 and resistance 404 to negative battery. For relay 212 the circuit may be traced from ground, through contacts 280 of relay 265, resistance 261, top winding of relay 212, resistance 294, armature and contacts 245 of relay 211 and resistance 405 to negative battery. The circuit for relay 228 may be traced from ground, through resistance 296, contacts 227 of key 213, top winding of relay 228, resistance 402, armature and contacts 234 of relay 229 and resistance 408 to negative battery. The circuit for relay 229 may be traced from negative battery through resistance 297, contacts 223 of key 213, printer magnet 242, sending contacts 240, short-circuiting resistance 241, top winding of relay 229, armature and contacts 232 of relay 228, and resistance 406 to ground.

The effect of the current flowing through the top windings of each of these relays for the above condition, which tends to operate the armatures of said relays to their left-hand or marking contacts, preponderates over the effect of the current flowing in the bottom or biasing windings, which tends to operate the armatures to engage their right-hand or spacing contacts and the armatures are all held on their marking contacts while the circuits are idle.

When the circuit per Fig. 2 is idle, the spacing contact 246 of relay 211 is connected through resistance 299 and the winding of relay 257 to ground. When key 213 is in the position shown, the spacing contact 248 of relay 212 is connected through resistance 412 and contacts 216 to key 213 through the winding of relay 208 to ground. When key 213 is operated, the termination of the spacing contact is transferred from ground through the winding of relay 208 to direct ground connected to contact 215 of key 213.

When the cord per Fig. 2 is idle, relays 208 and 257 are released. For this condition a biasing current flows through the bottom windings of relays 207 and 262. For relay 207 the circuit extends from ground, through the bottom winding of relay 207, through the armature of relay 208, shunting resistance 411, through resistance 410 to battery. For relay 262 the circuit may be traced from ground, through the bottom winding of relay 262, the armature of relay 257, shunting resistance 258, through resistance 259 to battery. The effect of the biasing current is to tend to operate the armature of each of these relays to engage the contacts shown. When current flows in the top or line windings of relays 207 and 262, its effect is to tend to disengage the armatures of these relays from these contacts.

1. *The subscriber originates a call*

If the subscriber at station A wishes to call the subscriber at station B, she operates power switch 101 to close contacts 120. This closes a circuit from negative battery, through resistance 113, contacts 114 of relay 109, contacts 120 of key 101, printer magnet 102, sender contacts 103 which short-circuit resistance 105, break key 104 which short-circuits resistance 106, contacts 117 of relay 109 and the winding of relay 111 to ground. Relay 111 is operated, closing contacts 118 to supply battery through the filament of lamp 112, lighting the lamp.

2. *The operator answers the call*

In response to the lighted lamp signal 112, the operator at the central office inserts plug 201 associated with the answering end of the cord per Fig. 2 into jack 110. Relays 202 and 109 operate over a circuit from battery through the winding of relay 202, sleeve of plug 201, sleeve of jack 110, and the winding of relay 109 to ground. The operation of these two relays extends the tip and ring conductors of the subscriber's loop into the cord circuit. A circuit may now be traced from ground, through the top winding of relay 207, contacts 271 of relay 202, the ring of plug 201, ring of jack 110, contacts 116 of relay 109, break key 104 which shunts resistance 106, sender contacts 103 which shunt resistance 105, printer magnet 102, contacts 120 of key 101, contacts 115 of relay 109, tip of jack 110, tip of plug 201, contacts 293 of relay 202, contacts 289 of ringing key 251, winding of relay 210, contacts 219 and 225 of the teletypewriter key 213 in parallel, top winding of relay 211, resistance 295, armature of relay 212, contacts 247 of relay 212, through resistance 404 to negative battery. Relays 207 and 210 operate and relay 211 is held on its marking contact 245. The operation of relay 210 in turn operates relay 209 over an obvious circuit. The operation of relay 209 supplies negative battery through its upper contacts, resistance 401, winding of relay 207 to ground. The current thus furnished augments that supplied around the loop from negative battery connected to contacts 247 to hold relay 207 operated. The resistance of the top winding of relay 207 is low relative to the value of resistance 401. The operation of relay 207 prevents lamp 204 from lighting by disconnecting ground from the armature of relay 207, preventing the operation of relay 203. The armature of relay 212 continues to be held against its marking contact 247 over the circuit heretofore traced to ground through contacts 280.

3. *The operator connects her position circuit to the cord*

In order to communicate with the calling sub-

scriber, the operator at the position where the cord circuit per Fig. 2 is located must connect her position circuit, which is common to all the cords at her position, to the particular cord circuit which has been used in establishing the connection to the calling subscriber. The operator therefore actuates teletypewriter key 213 to its alternate position. This connects the tip of the subscriber's loop heretofore traced through contacts 220 of key 213, the top winding of relay 228, resistance 402, through the armature and marking contact 234 of relay 229 and resistance 408 to negative battery. The connection through the line winding of relay 211, which is disconnected from the subscriber's loop, is extended through contacts 224 of key 213, printer magnet 242, sending contacts 240 and resistance 241 in parallel, the top winding of relay 229, armature and contacts 232 of relay 228, and resistance 406 to ground. The operation of key 213 changes the termination of spacing contact 248 as heretofore described. It also disconnects ground which was connected through contacts 218 from the spacing contact 235 of relay 229. This contact remains connected to ground, however, through resistance 409.

The operator may now communicate with the subscriber. The signals transmitted from the sending contacts 103 in subscriber's station A, Fig. 1, will actuate relay 228. This in turn will actuate the operator's printer magnet 242 as well as relay 211. The operation of relay 211, of course, is ineffectual as the calling end of the cord is not connected at this time, the transmitting conductor being terminated, over a circuit heretofore traced, in ground connected to contacts 280 at relay 265.

4. *The operator calls the called party*

The calling subscriber may request a connection to another subscriber's line connected to the same exchange. The operator will thereupon connect plug 268, associated with the calling end of the same cord circuit per Fig. 2 used in answering the calling subscriber, into jack 310 per Fig. 3, corresponding to the called party's line. Thereupon relays 309 and 265 are operated simultaneously over a circuit from battery, through the winding of relay 265, sleeve of plug 268, sleeve of jack 310, and the winding of relay 309 to ground. The operation of relay 265 connects the tip and ring of the cord circuit to the tip and ring of the called subscriber's loop. The called subscriber's loop is open at power switch 301. The tip circuit extends from negative battery, through resistance 405, contacts 245 and armature of relay 211, resistance 294, top winding of relay 212, winding of relay 255, contacts 292 of key 251, contacts 279 of relay 265, tip of plug 268, tip of jack 310, contacts 315 of relay 309, contacts 319 of power switch 301, through ringer 307 and condenser 308 to ground. The ring circuit extends from open contacts 320 of key 301, through receiving magnet 302, sending contacts 303, which short-circuit resistance 306, break key 304 which short-circuits resistance 305, contacts 316 of relay 309, ring of jack 310, ring of plug 268, contact 281 of relay 265 through the top or line winding of relay 262 to ground. The armature of relay 262 when the relay is unoperated is connected to ground. A circuit may therefore be traced from said ground, through the armature of relay 262, contact 282 of relay 265 and the winding of relay 264 to battery, operating relay 264. This lights the calling lamp 267 as a signal that the called subscriber has not yet answered. The lamp circuit may be traced from ground, through contacts 286 and the filament of lamp 267 to battery. Relay 263 is also operated in turn by relay 264 over a circuit from ground, through contacts 285 of relay 264 and the top winding of relay 263 to battery. The operation of relay 263 at this time is ineffectual, however, as the circuit from interrupter 266 is open at contact 287 due to the operation of relay 264.

Since the tip of the subscriber's loop in Fig. 3 is connected through condenser 308 to ground, relay 255 is released at this time, as is also relay 256. When relay 265 operates, the ground through contacts 280 used to terminate the line winding of relay 212 is disconnected. However, its function is performed by ground through contacts 284 of relay 264, which relay is operated. The operator now rings on the calling cord. Ringing is furnished by operating key 251. The ringing supply is alternating current superimposed on direct current. The supply circuit is in the form of a potentiometer which may be traced from ground, through the source of alternating current 252, condenser 253 and inductance 254 to battery. When key 251 is operated to ring the called party, the ringing circuit is extended through contacts 291 of key 251, contacts 279 of relay 265, tip of plug 268, tip of jack 310, contacts 315 of relay 309, contacts 319 of power switch 301, ringer 307 and condenser 308 to ground. Ringer 307 operates.

5. *Called party answers*

In response to the ringing signal the called party operates power switch 301 to the alternate position to close the loop circuit by closing contacts 320. Relay 262 operates when power switch 301 is closed. This relay will operate whether the switch is closed during the ringing or silent interval. If the power switch 301 is operated while ringing key 251 is operated, relay 262 will be operated over the loop from the direct current supply in the ringing circuit. If the power switch 301 is closed during the silent interval while key 251 is in its normal position, relay 262 is operated from the negative battery supplied around the loop from marking contacts 245 of relay 211. The operation of relay 262 removes ground from the circuit through contact 282 of relay 265 and the winding of relay 264, releasing relay 264. This in turn extinguishes lamp 267 as an indication that the called party has answered.

After the called party answers and ringing key 251 has been restored to normal, relay 255 operates as its winding is included in the loop circuit heretofore traced through the calling end of the cord and the loop is now closed. The operation of relay 255 in turn operates relay 256 over an obvious circuit. The operation of relay 256 establishes a circuit from negative battery through its top contacts and resistance 260 to the ring conductor of the called subscriber's loop, to supplement the operating circuit around said loop for relay 262. This feature is the equivalent of that performed when relay 209 operates, furnishing negative battery through its top contacts to supplement the operating circuit around the calling subscriber's loop for relay 207. Relay 263 is released when relay 264 releases, as ground is removed from the top winding when contacts 285 are open. Relay 263 is provided with a locking path which may be

traced from battery through the bottom winding and bottom contacts of relay 263, contacts 283 of relay 265, through contacts 226 of key 213 to ground but relay 263 is not locked as key 213 is operated at this time and the key remains operated until the subscribers are in communication. When lamp 267 is extinguished the operator may restore her teletypewriter key 213 to normal, disconnecting her position circuit from the cord and reconnecting the tip of the calling subscriber's loop to the cord circuit repeater, or she may leave her position circuit in the communication path momentarily to insure that the calling and called parties have been interconnected satisfactorily.

6. *Subscribers communicate with each other*

The manner in which the circuits function when the operator's position circuit remains in the communication channel will first be described. The circuit connecting subscriber's station A with the repeater in the position circuit may be traced from negative battery, through resistance 408 to marking contact 234 of relay 229, armature of relay 229, resistance 402, top winding of relay 228, contacts 220 of key 213, winding of relay 210, contacts 289 of key 251, around the calling subscriber's loop and back to its termination through the top winding of relay 207 to ground as heretofore traced. For this condition the current flowing in the loop is fixed by a proper choice of battery and resistance values at 25 mils. When the calling subscriber operates the contacts of her sender 103 to send a spacing signal, the shunt around resistance 105 is opened and resistance 105 is inserted in series in the loop. For this condition the current is reduced to 5 mils. When current of 25 mils flows through the top winding of relay 228, its effect preponderates over the effect of the current in the lower or biasing winding of relay 228, holding the armature of relay 228 in engagement with its marking contact 232. When the line current is reduced for the spacing condition to 5 mils, the effect of the biasing current in the lower winding of relay 228 preponderates over the effect of the line current in the top winding of said relay and the armature of relay 228 is operated to engage its spacing contact 233. These signals in turn are transmitted over the transmitting path connecting the armature of relay 228 through the top or line winding of relay 211, and the armature and marking contact of relay 212 to negative battery. Relay 211 follows these signals. In this latter transmitting circuit also the current is 25 milliamperes for the marking condition and 5 milliamperes in the same direction for the spacing condition. When the armature of relay 228 is on its spacing contact 233 and the negative battery connected thereto opposes the negative battery connected to contact 247 of relay 212, which remains on marking, the 5 milliampere current in the transmitting conductor is supplied from the mid-point of the potentiometer connected to the bottom winding of relay 229. This potentiometer is also effective to maintain current in the transmitting conductor while the armature of relay 228 is traveling between contacts 232 and 233. As relay 211 follows the signals repeated from relay 228, the signals are in turn repeated into the called subscriber's loop. For the marking condition negative battery is connected to contact 246 of relay 211. For the spacing condition ground is connected through contacts 246 of relay 211. For the marking condition current of 25 milliamperes flows around the called subscriber's loop. For the spacing condition current of 5 milliamperes is supplied from the potentiometer device around the called subscriber's loop. As the armature travels between the contacts current of 5 milliamperes is maintained in the loop. Receiving magnet 302 at the called subscriber's station follows these signals.

When the called subscriber at station B operates sender contacts 303, the shunt around resistance 306 is alternately closed and opened. The current in the loop is 25 mils for the marking condition when the resistance is shunted and 5 mils for the spacing condition when the resistance is effectively in circuit. Relay 212 is operated between its marking and spacing contacts in response to these signals. The signals are repeated into the circuit extending through the top winding of relay 229 to ground connected through contacts 233 and the armature of relay 228. Relay 229 in turn follows these signals, repeating them into the calling subscriber's loop. Receiving magnet 102 at subscriber's station A responds to these signals. For these two transmitting circuits also the current is maintained at 25 mils for the marking condition and 5 mils for the spacing condition and during the travel time of the transmitting relay.

After the operator has been assured that the parties are properly interconnected, key 213 will be restored to normal. This disconnects the position circuit from the cord. Thereafter, the calling subscriber's transmitter will control relay 211 directly instead of through relay 228. Relay 211 will repeat the calling signals to the called subscriber's station. The called subscriber's sender will control relay 212. Relay 212 will control printer magnet 102 directly instead of through relay 229.

Relays 210 and 255 follow all signals. The small spacing current of 5 mils is not sufficient to hold them operated. The release of relays 210 and 255 during communication signaling tends to release relays 209 and 256, but these latter are slow-to-release relays. Relays 207 and 262 also tend to release on the 5 milliampere spacing condition. It is required that relays 207 and 262 release when the subscribers open the loops. When the loops are opened the leakance path between conductors may be as low as 50,000 ohms. This permits 2.6 milliamperes residual current to flow in the loop. As the relays have to release on this condition, there is a tendency for them to release on the 5 milliampere condition, which represents but 2.4 milliamperes additional current.

The circuits of this disclosure are adapted to meet practical limitations at present encountered in the operation of a practical system. Since the total loop leakance including conductors and terminal equipment in a loop of 38 miles of 19 gauge wire might be as low as 50,000 ohms, these circuits are designed to cooperate with a loop of this order of magnitude. As this leakance is reduced due to changed battery terminal arrangements or by other means, or as relays 207 and 262 are made more critical, it will be possible to make the relays discriminate more closely between the spacing and leakance current without a tendency to release for the spacing condition. As the discrimination is improved it will be possible to dispense with relays 209 and 256

whose function it is to aid relays 207 and 262 respectively during the spacing interval.

7. *Transmitting a break signal between subscribers' stations*

The manner in which a break signal is transmitted between subscribers will now be illustrated.

Let us asume that the subscriber at station B is transmitting to station A and the subscriber at station A wishes to break. To do this break key 104 at station A will be operated. For this condition resistance 105 is inserted in series in the loop. This resistance is of such a value as to permit 10 mils to flow in the loop. Relay 210 which follows signals, operating on 25 and releasing on 5 mils, also releases on 10 mils. The break will be long enough to release relay 209. The release of relay 209 will remove the negative battery connected through its contact from the end of the loop and relay 207 will of course remain connected in the loop without the aid of relay 209. Key 213 is in its normal position for this condition. The tip of the calling subscriber's loop is extended through the line winding of relay 211 and resistance 295 to the armature of relay 212. When the armature of relay 212 is on its spacing contact 10 mils only will flow through the top winding of relay 211. For this condition the effect of current through the bottom winding of relay 211 preponderates and the armature of relay 211 is operated to its spacing contact. When the armature of relay 211 is on spacing, it momentarily transmits only 5 mils around the loop through station B. Relay 255 releases and after a sufficient interval relay 256 also releases. This removes direct ground connected through the bottom contacts of relay 256 to spacing contact 246 of relay 211 and connects said contact instead through the winding of relay 257 to ground.

For the normal spacing condition there is what in effect is a potentiometer comprising two arms connected to the top winding of relay 212. The first arm comprises battery, resistance 250, resistance 249 and ground. The second arm comprises resistance 290, resistance 299 and normally ground through the bottom contact of relay 256. For this condition the direct ground through the bottom contact of relay 256 is removed and the resistance of the winding of relay 257 is inserted in series to ground in the second arm. These resistances and the battery are so proportioned that for this condition the current is changed from 5 mils to 10 mils, so 10 mils flows around the loop through subscriber's station B. The reason for this is to care for the condition when both subscribers try to break at the same time and introduce resistance in each instance into the loop by inserting in the circuits the resistances which normally are shunted by their respective break keys. If there were but 5 mils flowing this current would be further reduced and it might be difficult for relays 207 and 262 to discriminate between the reduced current and the normal leakage current. When relay 256 releases and 257 is effectively connected, relay 257 operates removing the shunt around resistance 258. This lowers the current in the biasing winding of relay 262, the circuit for which normally extends from battery through resistance 259 and the contacts of relay 257 through the bottom of biasing winding and relay 262 to ground. When relay 257 operates, resistance 258 is inserted in series in the circuit. The reason for this is to hold relay 262 operated on the reduced direct current for the double break condition thus preventing a false disconnect.

The voltage impressed on the loop ends for the spacing condition is about 40 per cent of normal, so that the leakage current for this condition is 40 per cent of normal or approximately 1 mil. If the subscriber disconnects during this interval the loop is broken but 1 mil leakance current flows through relay 262. The relay is arranged to release for this condition to give a disconnect signal. The effect of the biasing current in other words when relay 257 is operated, overcomes the 1 mil leakance and relay 262 releases, but if the subscriber has not disconnected and 4 mils are flowing in the loop, the effect of the loop current overpowers the biasing current and relay 262 holds.

8. *The called party recalls the operator*

The manner in which a subscriber recalls an operator while his station is still connected to a cord will now be described. Let us assume that the subscriber at station B wishes to recall the operator.

To recall the operator the subscriber at station B will operate his break key 304 momentarily and then restore it to normal. When the key is operated relay 262 will release momentarily in turn operating relay 264. The operation of relay 264 will light call lamp 267 momentarily. The operation of relay 264 also operates relay 263. On this action relay 263 will lock to ground through contact 226 of key 213 which is in its normal position at this time. When the subscriber at station B reoperates his power switch to close the loop, relay 262 reoperates in turn releasing relay 264. This establishes a circuit from ground through the interrupter 266, the top contacts of relay 263, contacts 287 of relay 264 and the filament of lamp 267 to battery. This will provide a flashing lamp as a recall signal. The operator responds by operating her key 213 to its alternate position. This breaks ground from the holding winding of relay 263 at contact 226 and relay 263 releases, disconnecting interrupter 266 and extinguishing the call lamp.

The flashing feature on both ends of the cord operate similarly and this condition will not be described for a recall sent from subscriber's station A.

9. *The subscribers disconnect*

When the subscriber at station B disconnects relay 262 releases. This connects ground through the armature of relay 262 and contact 282 of relay 265 through the winding of relay 264 to battery operating relay 264. The operation of relay 264 lights lamp 267 as a disconnect signal. Relay 263 also operates over its locking path to ground connected through contacts 226 of teletypewriter key 213 which is now normal. The operation of relay 263 performs no useful function at the moment as the flashing circuit is broken at contact 287. For disconnect during the marking condition relay 257 remains released. With relay 257 released there is full biasing current through relay 262. There is full leakance current through the line winding of relay 262 and for this condition the full biasing current predominates, releasing relay 262 to ring in lamp 267. Similarly, when the subscriber at station A disconnects, lamp 204 is lighted. When the operator removes plugs 201 and 208 the circuit per Fig. 2 is restored to normal.

10. *Busy test*

A busy test feature is furnished in Fig. 2. Before inserting a plug into a jack, the operator touches the tip of her plug to the sleeve of the jack. If a cord is already connected to a multiple appearance of the same jack, battery connected to the winding of relay 262 or relay 265 will be connected to the sleeve of the jack and a circuit will be extended, in the case of the calling cord, through the tip of plug 263, contacts 278 of relay 265, winding of relay 239 to ground, operating relay 239. This will light lamp 238 as an indication that the line is busy. Similarly in the case of the answering plug, a circuit will be extended through the tip of plug 261, contacts 269 of relay 262 and the winding of relay 239 to ground to provide the same test.

11. *General*

Although this invention has been shown herein as applied to a manual switching telegraph system, it is to be understood that the principles of operation disclosed herein may be used as well in mechanical switching telegraph systems, wherein it may be necessary to perform, not necessarily positive control of visual supervisory signals, but functions requiring positive control of a relay having a winding in a communication path which as presently arranged is subject to release due to current reversals or intervals of zero current. Such circuits as the link circuit in a mechanical system, which is generally the equivalent of a cord circuit in a manual system, may be very readily rearranged by one skilled in the art to operate according to the principles disclosed in this invention.

What is claimed is:

1. In a teletypewriter switching system, a cord circuit, an end in said cord circuit conditioned to connect to a subscriber's loop circuit to form with said loop an operable telegraph path, means in said cord for establishing in said path a current of a first value and in a first direction as the first element of a two-element communication signaling code, and means also in said cord for establishing in said path a current of a second value and in the same direction as said first direction as the second element of said two-element communication signaling code.

2. In a teletypewriter switching system, an operator's position circuit, a cord circuit and a subscriber's loop circuit, means in said circuits for interconnecting said circuits to form an operable telegraph path through said circuits, means in said position circuit for establishing in said path a current of a first value and in a first direction as a first element of a two-element communication signaling code, and means also in said position circuit for establishing in said path a current of a second value and in the same direction as said first direction as a second element of said two-element communication signaling code.

3. In a teletypewriter switching system, a cord circuit and an operator's position circuit, means in said circuits for interconnecting said circuits to form an operable telegraph path, means also in said circuits for establishing in said path a current of a first value and in a first direction as a first element of a two-element communication signaling code, and means also in said circuits for establishing in said path a current of a second value and in the same direction as said first direction as the second element of said two-element communication signaling code.

4. In a teletypewriter switching system, a cord circuit, a repeater therein, a flexible switching means in said cord, a communication channel connecting said repeater and said means, and means also in said cord for establishing a flow of current of two different values in the same direction in said channel as two different elements of a communication signaling code as said repeater repeats communication signals toward said switching means.

5. In a teletypewriter switching system, a link circuit, an answering and a calling switch in said circuit, a repeater in said circuit, a first telegraph channel connecting said answering switch and said repeater, a second telegraph channel connecting said calling switch and said repeater, and means connected to said circuit to impose current of two different values in one and the same direction in one of said channels to comprise the elements of a two-current communication signaling code.

6. In a teletypewriter switching system, a switching circuit for flexibly interconnecting one of a plurality of calling circuits with a specified called circuit, a repeater in said switching circuit, a telegraph channel in said switching circuit, a relay having an armature conditioned to travel between a marking and a spacing contact on said relay in said repeater to impose two communication signaling conditions on said channel, and means also in said switching circuit for maintaining the flow of current in said channel while said armature travels.

7. In a telegraph switching system, a cord circuit, a telegraph channel therein, a telegraph repeater in said circuit, a relay in said repeater having an armature conditioned to alternately engage a marking and a spacing contact on said relay for the transmission of communication signals, and means in said circuit for imposing on said channel unidirectional current while said armature is in engagement with each of said contacts and while it travels between said contacts.

8. In a telegraph switching system, a subscriber's line and station circuit, a cord circuit, means for interconnecting said circuits to form an operable telegraph path, means in said circuits for transmitting current of a first value and in a first direction as one element of a two-element communication signaling code in signaling from said station to said cord and control means in said station circuit for changing the value of said current while its direction remains the same as said first direction as a second element of said two-element communication signaling code.

9. In a telegraph switching system, a first subscriber's station, a second subscriber's station, a central switching station intermediate said stations, an operable telegraph communication channel connecting said subscribers' stations through said switching station, means in said channel for transmitting through said channel current of two different values each of the same polarity to form the elements of a two-element communication code as said first station transmits toward said second station.

10. In a telegraph switching system, a subscriber's station, a central switching station, a telegraph loop connecting said stations having a first and a second end terminating in said switching station, a cord circuit at said switching station having a first conductor and a second conductor, means in said circuits for connecting said first conductor to said first end and said second conductor to said second end, a tele-

graph repeater connected in said cord to said first conductor, and a polar relay in said cord having a winding in series in said second conductor.

11. In a telegraph cord circuit, a polar relay controlling supervisory signals, said relay having a winding in series with a telegraph line subject to leakance, means for impressing a potential of a first magnitude on said line at a first time, means for impressing a potential of a second magnitude, substantially different from said first magnitude on said line at a second time, both of said potentials being so conditioned as to change the magnitude and maintain the direction of the leakage current in said line, a biasing winding on said relay, variable resistance means connected to said biasing winding and means for controlling said resistance as said potential is changed to compensate for said changed leakage current.

12. In a telegraph system, an operable telegraph loop, a telegraph repeater connected to the first end and a polar supervisory relay connected to the second end of said loop, a winding on said relay in series with said loop, means connected to said loop for imposing a potential of a first magnitude and a first polarity between the ends of said loop for the marking signaling condition, means for changing said potential to a second magnitude and maintaining said polarity for the spacing signaling condition, and means for changing said potential to a third magnitude and maintaining said polarity for the breaking condition.

13. A telegraph cord circuit connected to a telegraph loop circuit, a first and a second telegraph signaling conductor in said circuits, a polar relay controlling a supervisory signal, said relay having a first winding in series in said first conductor, a first source of potential connected between said conductors for a first open circuit condition, leakage current of a first magnitude flowing in said conductors for said first condition, a second source of potential connected between said conductors for a second open circuit condition, leakage current of a second magnitude flowing in said conductors for said second condition, a biasing circuit including a second winding on said relay, and means connected to said biasing circuit for changing the current in said biasing circuit for said two conditions.

14. In a telegraph switching system, a first subscriber's station, a second subscriber's station, a central station, an operable telegraph path interconnecting said subscribers' stations including a cord circuit at said central station, means connected to said path for imposing on said path currents of two different values, both of the same polarity, to form elements of a two-element communication signaling code, and supervisory signal means in said cord responsive to control means at said first subscriber's station.

15. A system in accordance with claim 14 in which the supervisory signal means is of a plurality of characters.

16. A system in accordance with claim 14 in which the control means is a parallel circuit having a plurality of branches in series in said path.

17. A system in accordance with claim 14 including means connected to said path for stopping the transmission of communication signals from said second station to said first station and conditioning said path for the transmission of communication signals in the opposite direction.

18. A system in accordance with claim 14 in which said supervisory signal is a recall signal to attract the operator's attention to said path.

19. In a cord circuit in a telegraph switching system, a method of preventing the false release of a relay controlling a supervisory signal in said cord which comprises (1) transmitting direct current of different magnitudes and of the same polarity through a telegraph channel in said cord to form the elements of a two-element communication signaling code, and (2) transmitting direct current of the same polarity through said channel during the intervals between the transmission of said signal elements, so that direct current uniform in direction flows through a winding of said supervisory relay at all times while said cord circuit is operably connected in a communication channel.

20. In a teletypewriter switching system, a cord circuit, a telegraph communication path in said circuit, a relay controlling a supervisory signal in said circuit, a winding of said relay in series in said path, and means in said circuit for maintaining a direct current uniform in direction through said winding while communication signals are being transmitted through said path.

21. In a teletypewriter switching system, a subscriber's line and station loop circuit, a cord circuit connected to said line circuit to form therewith an operable telegraph path, means in said circuits for maintaining current through said loop at all times during communication, and means in said circuits in response to the opening of said loop so that no current flows in either loop conductor to operate a supervisory signal in said cord.

22. In a direct current telegraph transmission system, a switching office, a manual cord circuit in said office connected to a subscriber's line circuit from said office to a subscriber's station, means for telegraphing over said circuits by marking current of a certain value and spacing current of a substantially different value and of the same polarity as said marking current.

23. A telegraph system in accordance with claim 22, including means for transmitting a break signal current over said circuits of a value intermediate said marking and said spacing current and of the same polarity as said marking and said spacing current.

24. In a direct current telegraph transmission system, a switching office, a manual cord circuit in said office connected through a first subscriber's line circuit to a first subscriber's station circuit and through a second subscriber's line circuit to a second subscriber's station circuit to form an operable telegraph circuit connecting a first and a second telegraph station, and means in said circuits for telegraphing thereover by marking current of a first value and of a first polarity and spacing current of a substantially different value from and of the same polarity as said marking current.

25. A telegraph system in accordance with claim 24 including means for transmitting a break signal current over said circuits of a value intermediate said marking and spacing current and of the same polarity as said marking and said spacing current.

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