

Dec. 26, 1944.

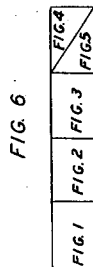
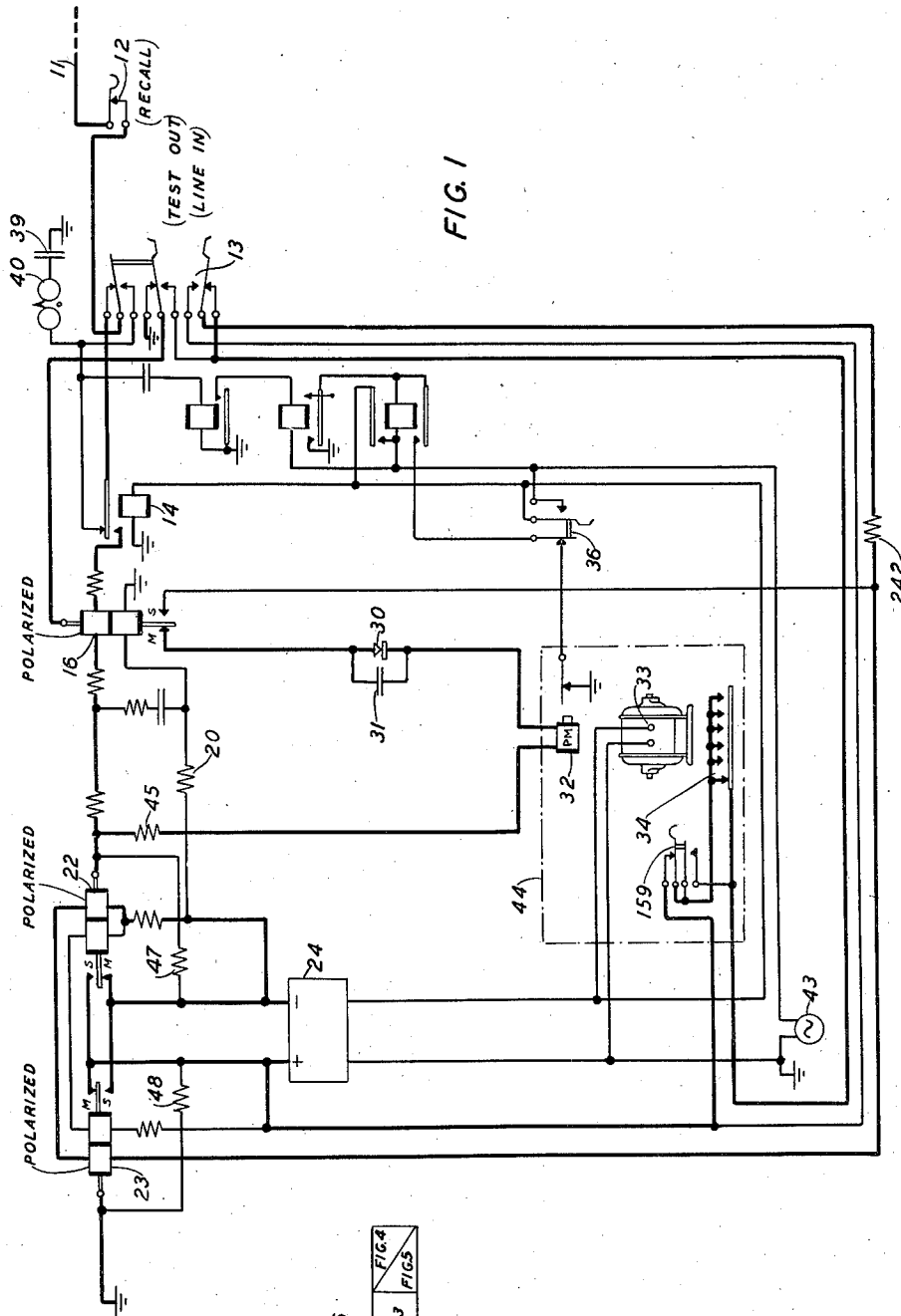
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2,365,816

SUPERVISORY SYSTEM FOR TELEGRAPH CIRCUITS

Filed Feb. 18, 1943

5 Sheets-Sheet 1



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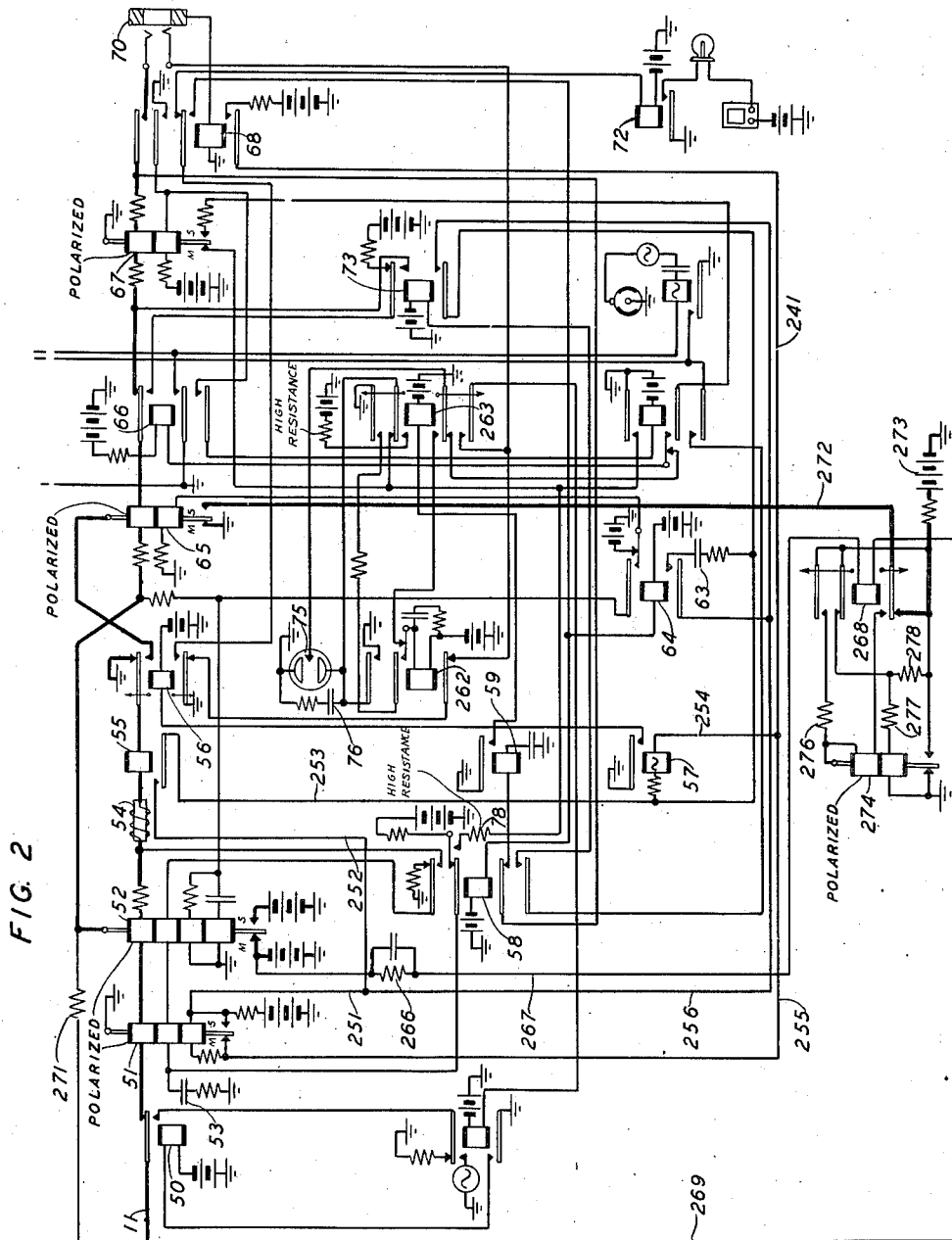
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5 Sheets-Sheet 2



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5 Sheets-Sheet 3

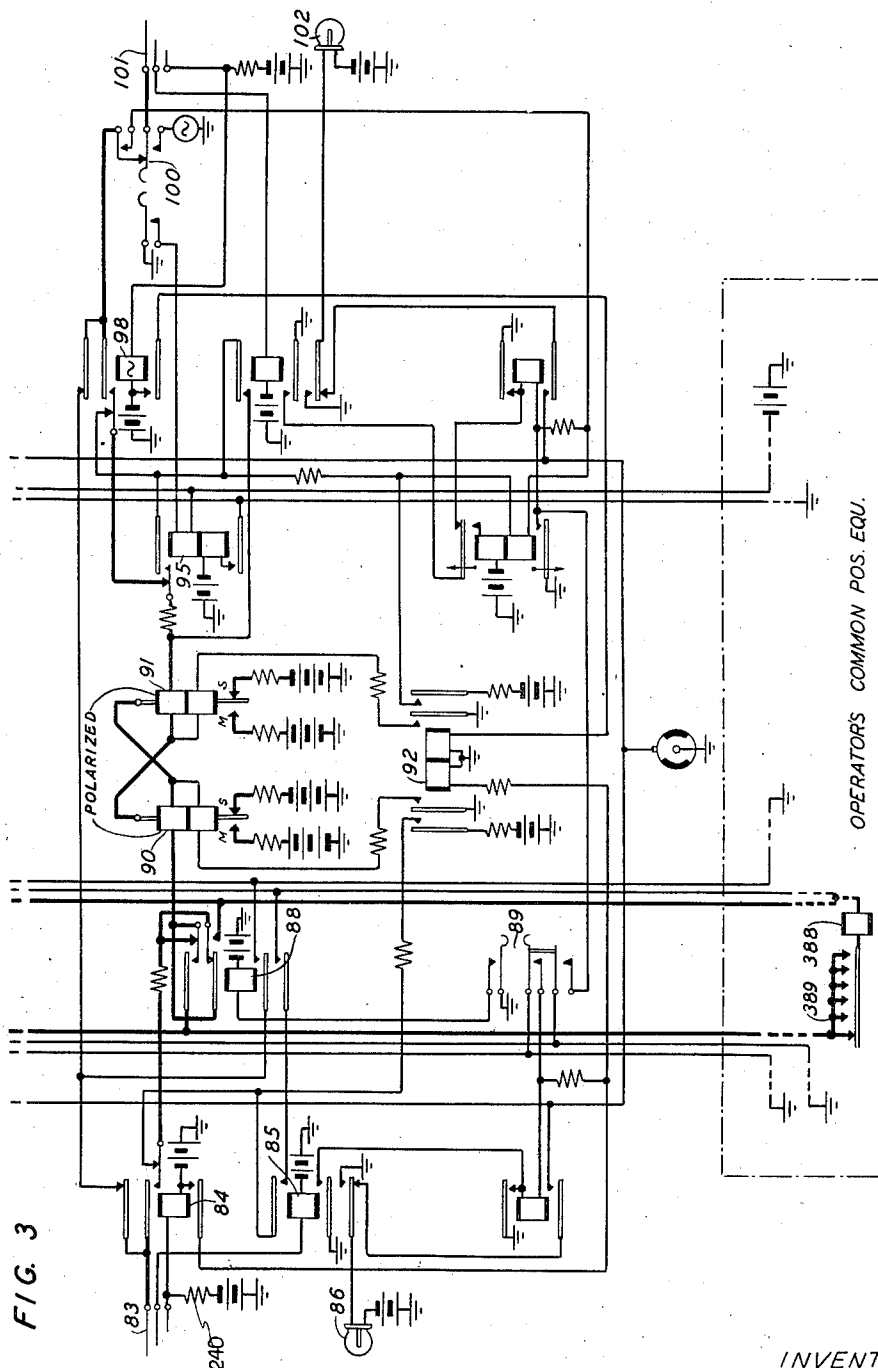


FIG. 3

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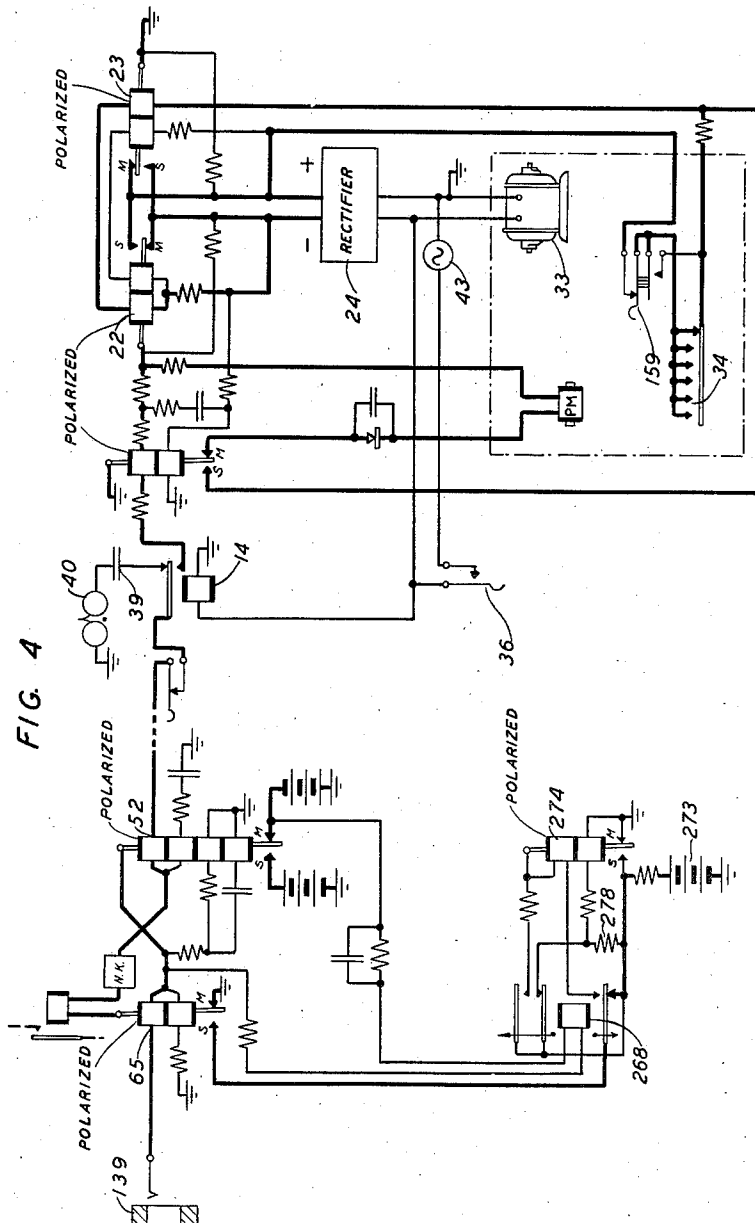
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5 Sheets-Sheet 4



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SUPERVISORY SYSTEM FOR TELEGRAPH CIRCUITS

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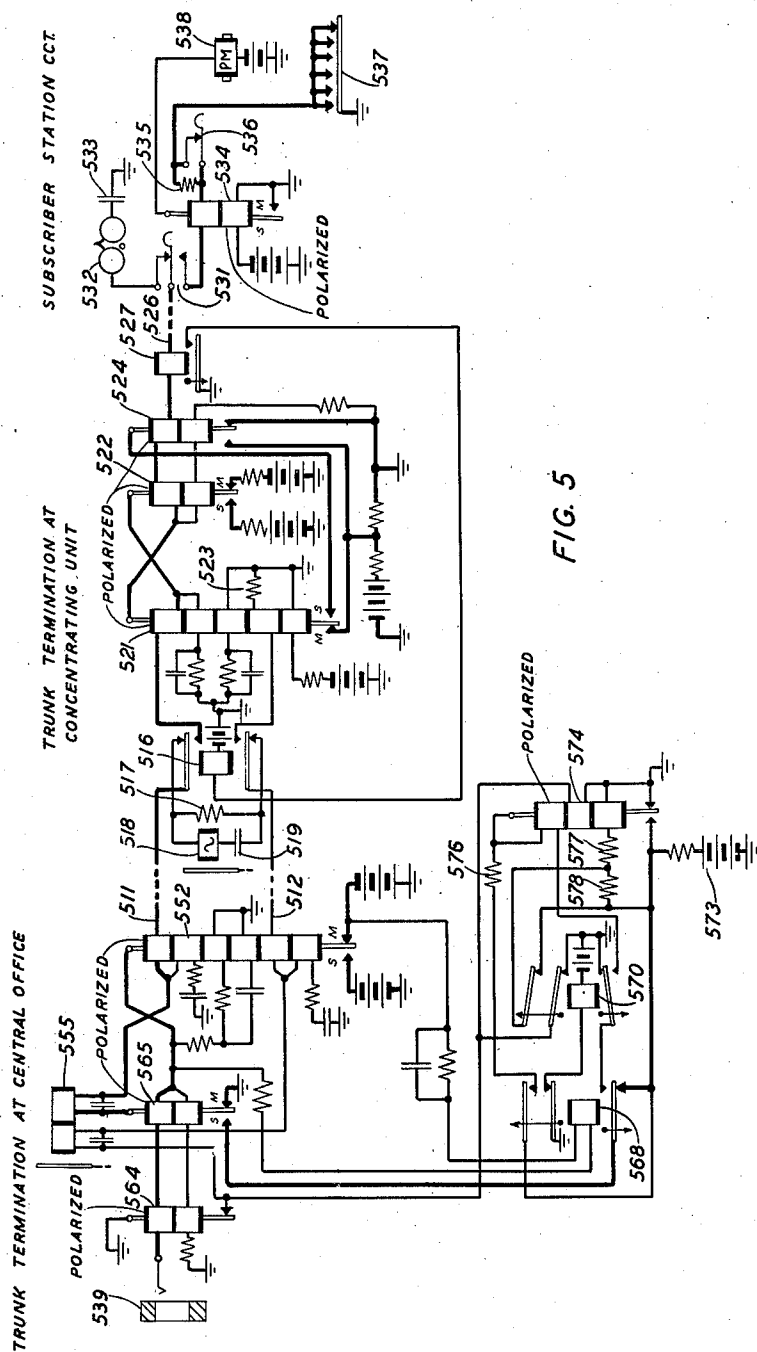


FIG. 5

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SUPERVISORY SYSTEM FOR TELEGRAPH CIRCUITS

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14 Claims. (Cl. 178—69)

This invention relates to telegraph systems and particularly to repeaters through which two stations may be interconnected for communication between the stations.

It has sometimes been the practice in telegraph systems involving switching operations at a central station to provide for signal transmission between a subscriber station and the line terminating repeater of the subscriber line at the switching station on a basis which is polar in one direction and differential in the other direction. A transmission system of this type is shown in Patent 2,143,000 granted January 10, 1939, to W. W. Cramer et al. In the arrangement shown in the foregoing patent, the transmission is polar from the subscriber station to the line terminating repeater, the transmission of signals being accomplished by operation of a pole changer relay system which connects either positive or negative polarity between the telegraph line and ground, the potential being the same for both polarities. At the line terminating repeater, the line is connected to ground during idle intervals and during transmission from the subscriber station, and the relay in the repeater which receives signals from the subscriber station and retransmits them is polar. The relay in the line terminating repeater which repeats signals toward the subscriber station operates to supply the ground connection for one signaling condition and for the other condition supplies a signaling potential of substantially twice the value of that at the subscriber station and in series-aiding relation to the source of signaling potential at the subscriber station as connected by the pole changer relay system when the subscriber station is receiving signals, so that signaling current for transmission to the subscriber station is unidirectional and for one signaling condition is substantially three times as great as the signaling current for the other signaling condition. The repeater relay which repeats signals received from the subscriber station does not follow signals repeated to the subscriber station because there is no reversal of polarity in the transmission of signals to the subscriber station. The receiving relay at the subscriber station is biased so that the relay will operate out of its normal condition only in response to the greater of the two signaling currents which it receives from the line terminating repeater when signals are being transmitted to the subscriber station. Due to this biasing of the receiving relay so that it distinguishes between the two values of signaling current it does not follow signals transmitted from the subscriber station, since one signaling condition generated at the

subscriber station ineffectively opposes the bias and the other supplements the bias.

It has been found that when line terminating repeaters arranged to afford signal transmission as described above are interconnected, as through a cord circuit, to provide for intercommunication between two subscriber stations, and the attendants at the two subscriber stations perform disconnect operations simultaneously or in rapid succession, a condition of mutual oscillatory interaction may arise between the two line terminating repeaters which prevents the disconnect signal initiated by either of the two subscriber stations from becoming effective at the switching station. This condition may also arise when the circuit extending between the subscriber stations includes more than one switching station.

Accordingly, it is an object of the present invention to estop oscillatory interaction between line termination repeaters included in a communication circuit extending between two stations when the two stations initiate like signaling conditions substantially simultaneously.

The invention features an arrangement under the control of the relay in the line termination repeater which receives and repeats signals from the subscriber station, and which will be called the receiving relay hereinafter, for placing the same potential, namely ground, on both transmitting contacts of the repeater relay which transmits signals to the subscriber station, and which will hereinafter be called the sending relay, and for delaying the restoration of the normal potentials to the contacts of the last-mentioned relay, so that if the line termination repeater sending relay seeks to change the potential which it is applying to the line at an instant that the receiving relay is off-normal, such change in potential will be delayed.

In accordance with the preferred embodiment of the invention, there is added to the line termination repeater in a system as hereinbefore described, a slow release relay which is energized under the control of the receiving relay each time that relay goes to the off-normal condition, which is the spacing condition. The added relay, upon being energized, substitutes ground potential for a signaling potential on the spacing contact of the sending relay the substitute ground connection being applied through the operating winding of a second added relay. When the receiving relay returns to the marking condition, the first added relay releases after its delay interval. If the sending relay should go to spacing condition while the receiving relay is in the spacing condition and has energized the first added relay, the sub-

stitute ground connection supplied through the winding of the second added relay will be applied to the line extending to the subscriber station. Assuming that the subscriber station is at this time transmitting a spacing signal, the current through the second added relay will be in the direction to hold that relay on its normal contact. As soon as the subscriber station returns to the marking condition, the receiving relay will be restored to marking but the first added relay will remain operated due to its slow-to-release characteristic. The current through the second added relay will be reversed due to the reversal of battery connection at the subscriber station and will cause the second added relay to operate to off-normal contact. Through the off-normal contact and armature of the second added relay, the spacing battery connection is restored to the spacing contact of the sending relay so that that relay can retransmit over the line to the subscriber station, the spacing condition which caused it to operate to its spacing contact. Thus the retransmission of the spacing signal to the subscriber station following restoration of that station to the normal or marking condition is delayed only by the interval required for the second added relay to operate.

The subscriber effects the transmission of a disconnect signal by disconnecting his signaling potential from the line, thus interrupting the line to direct current. The receiving relay in the line termination repeater may be susceptible of operation to spacing as a result of such opening of the line, possibly due to resonance conditions or in the case of utilization of an accelerating vibratory circuit on the receiving relay, thus retransmitting a spacing signal toward the distant subscriber line termination circuit. If at the same time, the distant subscriber disconnected, the receiving relay in his line termination circuit might operate to spacing and retransmit a spacing signal toward the first subscriber line termination circuit which would cause the sending relay in that circuit to operate to spacing. By virtue of the provision of the first added relays in the toll line termination circuits, which operate when the receiving relays go to spacing, ground is connected to the spacing contact of the sending relays which prevents recharging of the lines from the spacing batteries and permits the capacity of the line to the subscriber to discharge. The second added relays will not be operated to restore the spacing potential to the spacing contacts of the sending relays because there is no battery connection to the line at the subscriber stations and a sufficient current for operating the second added relays cannot flow in the direction required for operation. Were it not for the provision of these relays for removing the spacing potential from the spacing contacts of the sending relays and substituting ground connection, the subscriber lines might become charged in the opposite direction by the spacing batteries on the spacing contacts of the sending relays, thus restoring the receiving relays to marking and causing a marking signal to be retransmitted toward the remote subscriber toll line termination circuit. The same could occur in the remote subscriber toll line termination circuit thus setting up an oscillatory condition which might endure indefinitely and prevent the disconnect signal from being registered at the switching station.

For a complete understanding of the invention, reference may be had to the following detailed

description to be interpreted in the light of the accompanying drawings wherein:

Fig. 1 is a diagrammatic view showing a subscriber station circuit;

Fig. 2 is a diagrammatic view showing a subscriber line termination circuit at a central office;

Fig. 3 is a diagrammatic view showing a cord circuit for interconnecting subscriber toll lines and the cord circuit includes a repeater;

Fig. 4 is a diagrammatic view showing in simplified form a subscriber line termination circuit and subscriber station circuit identical with the line termination circuit and subscriber station circuit shown in Figs. 2 and 1, respectively;

Fig. 5 is a diagrammatic view showing a modified form of the invention; and

Fig. 6 is a diagrammatic view in block form showing how Figs. 1 to 4, inclusive or 1, 2, 3 and 5 are to be arranged to exhibit complete communication circuits between two subscriber stations according to the two embodiments of the invention shown in the drawings.

The subscriber station circuit shown in Fig. 1 and the cord circuit shown in Fig. 3 are identical with corresponding circuits shown in Patent 2,143,000, granted January 10, 1939, to W. W. Cramer et al. and the disclosure of this patent is incorporated herein by reference as part of the present specification. The subscriber line termination circuit shown in Fig. 2 represents a modification of the subscriber line termination circuit shown in the Cramer et al. patent in accordance with the present invention.

Idle condition

Reference will now be made to Figs. 1 to 4, inclusive, arranged as in Fig. 6. With the exception of sending relays 22 and 23 and the receiving relay 16 at the subscriber station, the relays in all four figures are shown in their normal positions. These relays remain in these positions during the time the circuit is idle. Relays 16, 22 and 23 at the subscriber station may, however, be on their spacing contacts during the idle condition.

Key 13 is normally in the position shown in Fig. 1. This key is provided to enable the printing equipment 34 at the subscriber station to be tested locally. The control effected by operation of key 13 is fully disclosed in the Cramer et al. patent and will not be repeated here.

At the central office, the relays of the subscriber line termination equipment shown in Fig. 2 and of the cord circuit shown in Fig. 3 are in their normal positions. The term "normal position" or "normal" is used to indicate the position assumed by the relays when the circuit is idle. Relays 51 and 52 are maintained on their marking contacts by current flowing in a circuit from ground connected to the back contact of the outer upper armature of relay 58 through the second winding of relay 52, middle winding of relay 51, inner upper armature and back contact of relay 58 to grounded battery. Relay 65 is also maintained on its marking contact by current flowing from ground through its lower winding and upper break contact of relay 64 to grounded battery. Relay 67 usually remains on its marking contact as shown in Fig. 2 during idle intervals but need not be so positioned during this time.

Subscriber originates a call

The subscriber originates a call by operating the power switch 36 at the subscriber station. The operation of switch 36 completes a path from

the source of power 43 through the right-hand pair of contacts of the switch for energizing the printer motor 33, rectifier 24 and relay 14. Relay 14 in operating closes the circuit from line 11 extending from the central station through recall key 12, test key 13, armature and front contact of relay 14, thereby disconnecting the line from ringer 40, upper winding of relay 16, resistors, armature and marking contact of relay 22 on which the armature will now be held due to energization of the right-hand or operating winding of relay 22 from energized rectifier 24, rectifier 24 from the negative to the positive terminal thereof, marking contact of relay 23 on which the armature of the relay will now be held due to current through the left-hand or operating winding of relay 23 from rectifier 24, armature of relay 23 to ground. The energized rectifier 24 supplies a source of potential between its terminals and thus in series between ground and line 11 extending to the central exchange. Rectifier 24 on becoming energized also causes current to flow through the lower or biasing winding of relay 16 which holds the armature thereof on its marking contact.

At the central station the line 11 extends through the armature and back contact of relay 50, upper windings of relays 51 and 52, noise suppression choke coil 54, winding of disconnect relay 55 and upper armature and back contact of relay 56 to ground. Current flowing over this line circuit due to the source of potential applied to the line by rectifier 24 will cause relay 55 to operate. Relay 55, in operating, completes a path from battery on the spacing contact of relay 51 over conductors 251 and 252, front contact and armature of relay 55, conductor 253, winding of relay 57, conductors 254 and 255, marking contact and armature of relay 51 to ground. Relay 57 becomes energized over this circuit and completes the energizing circuit of relay 56 which operates. The upper armature of relay 56 transfers the circuit of line 11 from ground on its back contact to its front contact from which a conductive path is extended through the armature and marking contact of relay 65 to ground. At its lower armature and front contact, relay 56 completes an obvious circuit which includes the innermost upper armature and back contact of relay 68 through the winding of relay 72 which becomes energized. Relay 72 completes the circuit of call lamp 69 and indicating or alarm device 71 which indicates to an operator that the subscriber's call is waiting to be answered.

Operator answers

The operator answers the call by inserting an answering plug 83 (Fig. 3) in the answering jack 70 (Fig. 2). This completes a circuit from ground through the winding of relay 68, sleeve of jack 70 and plug 83, and winding of relay 84 to battery. Current flowing in this circuit causes the operation of relays 68 and 84. Resistance 240 connected to grounded battery of the same polarity as that on the winding of relay 84 provides a shunt for the winding of relay 84 to properly control the potential of sleeve of jack 70 and plug 83 and the current flowing through the winding of relays 68 and 84. The operation of relay 68 extends the transmission circuit from the tip of plug 83 through the tip of jack 70, the uppermost front contact and armature of relay 68, the upper winding of relay 67, the back contact and upper armature of relay 66, the upper winding of relay 65 to the armature and marking contact of

relay 52. This transmission circuit is completed in the cord circuit shown in Fig. 3 through the inner upper armature and front contact of relay 84, the back contact and inner upper armature of relay 88, the upper winding of cord circuit repeater relay 90 to the armature of cord circuit repeater relay 91. About the time of insertion of plug 83 in jack 70, the operator also operates key 89. The upper pair of make contacts of key 89 completes the circuit of relay 88 which operates. The upper armatures of relay 88 connect the operator's teletypewriter set comprising recording selector magnet 388 and transmitting contacts 389 in series in the communication circuit between the tip of plug 83 and the armature of repeater relay 91.

Relay 68 in operating completes an obvious circuit through the lower or biasing winding of relay 67. Relay 68 also transfers the ground extended through the lower armature and front contact of relay 56 from the back contact associated with its innermost upper armature to the front contact and the windings of relays 58 and 64. The disconnection of ground from the back contact interrupts the circuit through the winding of relay 72 which releases and in turn extinguishes light 69. Relays 58 and 64 are operated by current flowing in the above circuit through their windings. Relay 58 in operating disconnects a previously traced path from ground through the second winding of relay 52 and middle winding of relay 51 and connects these windings to the transmission circuit of line 11. These windings are now connected between the transmission circuit and the artificial line 53 and it will be noted that the artificial line 53 does not provide any direct current path. No biasing current is required for the receiving relays 51 and 52 because they receive positive and negative signal impulse currents of substantially the same magnitude from the subscriber station. The two lower windings of relay 52 are connected in a vibrator circuit to impart a snap action to relay 52. As soon as the armature of relay 52 is moved out of engagement with its marking or spacing contact due to current of the proper polarity in the upper or operating winding, the vibratory circuit associated with the two lower windings quickly and positively drives the armature to the other contact, current for energizing the two lower windings being supplied by a condenser which has previously become charged through the armature of relay 52 from battery on the marking or spacing contact of the relay.

The operation of relay 58 also interrupts the operating circuit of ringing relay 59 and prepares a circuit for the operation of relay 73 and also connects battery to the lower terminal of condenser 76 through high resistance 78 and the inner upper armature and back contact of relay 263. However, ground is connected to the lower terminal of condenser 76 through the marking contact and armature of relay 67 and the inner upper armature and back contact of relay 263 so that the battery connected through resistance 78 performs no useful function at this time.

The operation of relay 64 connects the lower winding of relay 65 to the transmission circuit through jack 70. This relay also connects a circuit in parallel with the contacts of relay 55 through its lower armature and front contact, a condenser 63 and a resistor in series.

Transmission circuit

With key 89 associated with the cord circuit

in Fig. 3 operated, the transmission path as above traced is now complete between the operator's printer equipment in the lower part of Fig. 3 and the printer equipment 44 at the subscriber station. Communication signaling impulses may now be transmitted from the operator to the subscriber. With relay 84 operated, battery through the front contact and lower armature is supplied over an obvious path through the left-hand winding of relay 92 causing the relay to operate. The two inner armatures of relay 92 complete conductive paths through the biasing windings of repeater relays 90 and 91 to the transmission path. The outer right-hand armature of relay 92 connects negative battery through the make-before-break contacts associated with the inner upper armature of relay 98 and through the make-before-break contacts associated with the upper armature of relay 95 to the upper winding of relay 91. The outer left-hand armature of relay 92 seeks to provide a similar battery connection for the upper winding of relay 90 but the path from the armature is open at the inner upper armature of relay 84 which is operated, and the upper winding of repeater relay 90 is receiving the proper polarity through the tip of plug 83. With these circuits for the windings of repeater relays 90 and 91 completed, the armatures are operated to their marking contacts to provide the normal marking current through the transmission path including the operator's receiving magnet 388 and transmitting contacts 389.

The operator in operating the transmitting contacts 389 of the operator's teletypewriter equipment, interrupts the transmission circuit through jack 70. This provides a spacing condition of no current. This causes the operator's receiving magnet 388 to control the receiving equipment of the operator's printer to produce an operator's copy. The relay 65 of the subscriber line termination equipment shown in Fig. 2 also follows the signals, the relay being biased so that it operates to spacing when no current flows through the operating winding, and repeats them through the operating windings of relays 52 and 51 which do not follow signals generated by relay 65, as will be described later and over line 11 to the subscriber station circuit.

It should be noted that relay 65 transmits by connecting ground to line 11 for marking signal impulses and by connecting positive battery to line 11 for spacing signal impulses. The positive battery connected through the spacing contact of relay 65 to line 11 aids the source of negative potential connected to the line 11 at the subscriber station. The preferred ratio of the two currents for marking and spacing conditions, respectively, is of the order of 1 to 3. To obtain this ratio of current the potential developed by rectifier 24 is substantially one-half the potential of the source connected to the spacing contact of relay 65. The current flowing through the lower or biasing winding of the receiving relay 16 at the subscriber station in Fig. 1 is adjusted to produce substantially one-half the magnetic effect upon relay 16 as is produced by the sum of the two currents flowing through the upper winding of relay 16. However, the magnetic effect produced by the current flowing through the lower winding of relay 16 opposes the magnetic effect of the algebraic sum of the two currents flowing through the upper winding of relay 16. When these conditions are substantially satisfied, relay 16 responds equally well to both the marking and spacing signaling conditions. Relay 16 does

not respond to spacing signals generated at the subscriber station because the spacing signal is represented by a reversal of current and the magnetic effect of the reversed current in the operating winding is to aid the biasing winding in holding the armature of relay 16 on the marking contact.

Relay 16 in responding to the signaling impulses transmitted by the operator repeats them to the printer magnet 32 of the receiving teletypewriter equipment 44 and causes it to record the information transmitted by the operator at the central station. The operating circuit of the printer magnet 32 may be traced from ground through the test key 13, armature and marking contact of relay 16, unilateral conducting device or rectifier 30 in parallel with condenser 31, winding of printer magnet 32, resistance 45, armature and marking contact of relay 22, rectifier 24, marking contact and armature of relay 23, to ground. Rectifier 24 supplies the current for this path causing the operation of printer magnet 32 in accordance with the signals repeated by relay 16.

In the spacing position, receiving relay 16 short-circuits the transmitting contacts 34 and resistance 242. In short-circuiting resistance 242, relay 16 increases the current through the left-hand winding of relay 23 and the right-hand winding of relay 22 and thus provides an additional load for rectifier 24 during the time relay 16 is on its spacing contact. This extra load compensates for the load on the rectifier during the time relay 16 is on its marking contacts causing current to flow through the printer magnet 32. In short-circuiting the transmitting contacts 34 in its spacing position, the relay 16 insures the proper reception of a break signal by a transmitting operator at the subscriber station. With the transmitting contacts short-circuited, it is impossible to transmit signals to line 11 which might interfere with the reception of the break signal or to cause the signal to be recorded by the receiving printer as home copy.

In response to the information transmitted from the central operator, the subscriber will transmit information regarding the party with which the subscriber wishes to communicate, by operating the transmitting contacts 34, of the teletypewriter equipment 44. The operation of transmitting contacts 34 opens and closes the circuit through the right-hand winding of relay 22 and left-hand winding of relay 23. Current flowing through these windings is in such a direction as to maintain the relays on their marking contacts. The current flowing through the other windings of these relays is in such a direction as to cause the relays to be operated to and remain on the spacing contacts. However, the current flowing through the right-hand winding of relay 22 and the left-hand winding of relay 23 overpowers the current flowing through the other windings so that as long as this current flows, these relays remain on their marking contacts. When the circuit of these windings is interrupted by the transmitting contacts 34, the biasing windings of these relays cause the armatures to move to their spacing contacts. In moving to the spacing contacts, the armatures of relays 22 and 23 reverse the connections of the rectifier 24 to line 11 whereby a positive potential is now connected between line 11 and ground instead of negative potential. This causes a spacing impulse to be transmitted over the line 11. The armatures of relays 22 and 23 in moving to their

spacing contacts also tend to reverse the current flowing through the printer magnet 32 at the subscriber station over a circuit traced from ground on the armature and spacing contact of relay 23, rectifier 24 from negative to positive, spacing contact and armature of relay 22, resistance 45, printer magnet 32, unilateral conducting device or rectifier 30, armature and marking contact of receiving relay 16 to ground through the contact of test key 13. The direction of current which would flow through this circuit is opposed by the unilateral conducting device or rectifier 30 so that substantially no current flows through printer magnet 32 at this time, thus causing printer magnet 32 to follow the signal impulses transmitted by transmitting contact 34 to record a home copy of the information transmitted by the subscriber. However, inasmuch as substantially no current flows through the printer magnet 32, it is necessary to provide a compensating load comprising resistances 47 and 48 across the terminals of the rectifier 24 in order to insure substantially constant voltage under both marking and spacing current conditions. With the relays 22 and 23 in the spacing condition, a shunt around resistor 47 comprising the armature and marking contact of relay 22 is removed and a shunt around resistor 48 comprising the armature and marking contact of relay 23 is removed. These resistors form substitute load circuit on rectifier 24 when current of reverse polarity is blocked in the circuit of printer magnet 32 by rectifier 30.

It should be noted that the current through the biasing winding of relay 16 is materially reduced when the transmitting relays 22 and 23 move to their spacing contacts because resistor 48 is inserted between the positive terminal of rectifier 24 and ground. Normally the current through the biasing winding of relay 16 tends to cause this relay to move to and remain upon its marking contact. The current normally flowing through the upper or line winding of relay 16 which is the marking current tends to operate the armature of relay 16 to its spacing contact and maintain it on the spacing contact. However, this current, under marking conditions is insufficient to overpower the biasing current which therefore maintains the relay on its marking contact. When signal impulses are transmitted from the distant station, current through the upper or line winding of relay 16 becomes substantially three times as great as the normal current and thus overpowers and overcomes the magnetic effect of the biasing current that causes this relay to move to its spacing contact. When spacing impulses are transmitted from the subscriber station, the line current reverses so that the current through the upper or line winding of relay 16 will tend to hold the relay upon its marking contact. Hence the reduction of current through the lower or biasing winding at this time does not permit the relay to leave its marking contact so relay 16 does not follow the signal impulses transmitted from the subscriber station.

The path for current through the lower winding of relay 16 may be traced from ground through the lower winding of the relay and resistance 20 to the negative terminal of rectifier 24. With relays 22 and 23 in the marking condition, the circuit is completed from the positive terminal of the rectifier through the marking contact and armature of relay 23 to ground. During the transmission of spacing current from the subscriber station, ground is connected to the

negative terminal of rectifier 24 through the armature and spacing contact of relay 23 thus substantially short-circuiting the lower winding of relay 16 and preventing any current flow there-through.

During the transmission of telegraph signal impulses between the subscriber station and the operator and also during the transmission of signaling impulses to or from the subscriber station at any other time, relay 57 (Fig. 2) is maintained operated either from the contacts of relay 55 or by polar relay 51 reversing the charge on condenser 63 through the winding of relay 57, the charging circuit for condenser 63 being established through the lower armature and front contact of relay 64 which is energized. The function of relay 55 is to register a disconnect condition originated at the subscriber station shown in Fig. 1. Accordingly relay 55 is arranged to release against a low value of leakage resistance, cross-fire and a reasonable value of earth potential when the subscriber removes potential from line 11. Relay 55 when so adjusted will be energized on the longer signal pulses and the steady state marking and spacing currents, it being a neutral relay, but may not remain operated during the transmission of telegraph signal impulses. Relay 51 follows signals generated at the subscriber station. With relay 55 energized and relay 51 on its marking contact, a circuit for relay 57 may be traced from battery on the spacing contact of relay 51 through conductors 251 and 252, armature and front contact of relay 55, conductor 253, winding of relay 57 and conductors 254 and 255 to the marking contact of relay 51 which is engaged by the grounded armature of that relay. When relay 51 goes to spacing relay 57 is energized from ground through the armature and spacing contact of relay 51, conductors 251 and 252, armature and front contact of relay 55, conductor 253, winding of relay 57, conductor 254, and conductor 241 to battery through the lower armature and front contact of relay 68. Condenser 63 has one terminal connected to the armature of relay 55 through a resistor and has the other terminal connected to the front contact of relay 55 through conductor 256 and 252. From this it will be apparent that when relay 55 is energized, it short-circuits the condenser 63 but that when relay 55 releases, which it may do when rapid telegraph signals are being transmitted from the subscriber station and which it should do when the subscriber disconnects, the condenser is inserted in the energizing circuit of relay 57 between ground through the armature and marking contact of relay 51 and battery on the spacing contact when relay 51 is in the marking condition or between ground through the armature and spacing contact of relay 51 and battery on the lower armature of relay 68 when relay 51 is in the spacing condition. Thus as the armature of relay 51 operates between its marking and spacing contacts in following signals, it reverses the polarity on condenser 63 which discharges and recharges through the winding of relay 57. Relay 57 is an alternating current relay and remains operated in response to the discharging and recharging currents of condenser 63 and also holds energized from steady currents of either polarity flowing through the armature and front contact of relay 55, when that relay is energized. Thus, even though relay 55 may release in response to rapid telegraph signals, relay 57 will be held energized, thus preventing the

bringing in of a disconnect indication or other disturbance of the activated condition of the subscriber line termination circuit.

Relay 56 which is operated by relay 57 and when operated extends the communication path of line 11 through to the outer upper armature of jack relay 68, is a slow-release relay which further serves to protect the circuit arrangement from false supervisory signal indications at the central switchboard due to any momentary releases of relay 57 which might occur between cessation of charging current for condenser 63 and reenergization of relay 57 through the armature and front contact of relay 55.

Relay 51 is provided with a third winding in addition to the two windings similar to the windings of relay 52. The third or lower winding is connected to the contacts of relay 51 in such a manner that an additional or biasing current flows through this winding in such direction as to maintain relay 51 on the contact on which it is resting. In other words this winding tends to make relay 51 less sensitive than relay 52. This is desirable in order to prevent false operation of relay 51 on cross-fire currents and other interference received during the time the line 11 is open-circuited at the subscriber station or has no potential connected to it at the subscriber station.

Completion of connection to called subscriber

After the operator at the central station has received all the necessary information from the subscriber she can connect the subscriber to the desired station by inserting the calling plug 101 of the cord circuit into the jack 139 of a called subscriber line termination circuit. This circuit together with the subscriber's station circuit are shown in Fig. 4. They may be identical with the corresponding circuits shown in Figs. 1 and 2 but they have been shown in simplified form. Corresponding elements have been identified by the same reference numerals in Fig. 4 as in Figs. 1 and 2 with the exception of identification of the line termination circuit jack by the reference numeral 139 which is intended to indicate that this is a different subscriber's line termination circuit. The operator will then operate ringing key 100 which causes ringing current to be transmitted through the tip of plug 101 and over the communication path through the subscriber line termination circuit established by the operation of relays in that circuit as a result of the insertion of the plug 101 into jack 139 and over the line to the called subscriber's ringer 40. The called subscriber answers by operating key 36 which completes the circuit of relay 14 to extend the communication path through to ground on the armature of sending relay 23 and which also completes the circuit of the source of power 43 to rectifier 24 and to operating motor 33. A communication path has now been established from the cord circuit to each of the subscriber stations that are to be interconnected. The operator may then disconnect the recording and transmitting apparatus at the central office by opening key 89. This releases relay 88 which disconnects the operator's printer and transmitter and completes the communication path between the two subscriber stations by reconnecting the upper winding of repeater relay 90 in the cord circuit to the tip of plug 83. The circuit of the left-hand winding of relay 92 is interrupted at key 89 when the key is opened but the circuit of the right-hand winding has been completed from

battery through the front contact and lower armature of relay 98 which became energized upon insertion of plug 101 into jack 139 so that relay 92 remains energized to maintain the proper potentials on the biasing windings of repeater relays 90 and 91 and for other purposes.

Break signals

In accordance with the present invention, the marking contact of receiving relay 52 in the subscriber line termination circuit is connected through resistor 266 and conductor 267 to one terminal of slow-release relay 268. The other terminal of relay 268 is connected through conductor 269 and resistor 271 to the armature of relay 52. When the armature of relay 52 is in engagement with its marking contact, the winding of relay 268 is short-circuited. When the armature of relay 52 goes to the spacing contact, an energizing circuit for relay 268 may be traced from battery of one polarity on the marking contact of relay 52 through resistor 266, conductor 267, winding of relay 268, conductor 269, resistor 271, armature and spacing contact of relay 52 to battery of the opposite polarity. Since relay 268 is slow to release, it does not follow rapid oscillation of the armature of relay 52 involved in the retransmission of signals received from the subscriber station of Fig. 1 but remains energized and holds its armatures. When the armature of relay 52 remains on its marking contact for an interval longer than the release time of relay 268, the latter relay releases its armatures.

The lower armature of relay 268 is connected by conductor 272 to the spacing contact of sending relay 65 and the back contact for the lower armature of relay 268 is connected to battery 273. This battery becomes connected to the line 11 extending to the subscriber's station of Fig. 1 when relay 65 goes to its spacing condition with relay 268 released and as previously stated, battery 273 is in series-aiding relation to the marking signal potential at the subscriber's station and has twice the voltage of that potential so that a spacing signal retransmitted by relay 65 is represented by current in the same direction and of substantially three times the magnitude of the marking current which flows when the armature of relay 65 is on its grounded marking contact. The front contact associated with the lower armature of relay 268 is connected to one terminal of the operating winding of a biased polar relay 274, the other terminal of which is connected to the armature of that relay and through resistor 276 to the front contact associated with the outer upper armature of relay 268. The outer upper armature of relay 268 is connected to battery 273 as is also the inner upper armature. The biasing winding of relay 274 has one terminal connected to ground and the other terminal connected through resistor 277 and through resistor 278 to battery 273. The inner upper armature and back contact of relay 268 establishes a direct shunt around resistor 278 when relay 268 is released and the biasing current which flows from battery 273 through the biasing winding of relay 274 is in a direction to drive the armature of relays 274 to its grounded left-hand contact. There is no energizing circuit for the operating winding of relay 274 when relay 268 is released because the circuit of that winding is open at the lower front contact of relay 268. When relay 268 becomes energized, the shunt around resistor 278 is removed and this resistor reduces the current flowing from bat-

tery 273 through the biasing winding of relay 274. With relay 268 energized the circuit of the operating winding of relay 274 is extended over conductor 272 to the spacing contact of relay 65, the armature of which remains on its marking contact except when signals are to be retransmitted to the subscriber station of Fig. 1. From this it follows that even though relay 268 becomes operated and remains operated during transmission of telegraph signals originating at the subscriber station shown in Fig. 1, the circuit of the operating winding of relay 274 will not be completed unless the relay 65 is operated to its spacing contact to retransmit a signal, such as a break, to the subscriber station of Fig. 1. It will be noted that with relay 268 operated, the path from the spacing contact of relay 65 is to ground through the operating winding and armature of relay 274, which is the same potential as that on the marking contact of relay 65, so that no change in the current flowing in the line 11 will result immediately upon the engagement of the armature of relay 65 with its spacing contact. However, with the operating winding of relay 274 included in the circuit of line 11 when relay 65 goes to its spacing contact, the operating winding of relay 274 becomes energized and overpowers the biasing winding if marking potential is applied to the line at the subscriber station, driving the armature away from the left-hand contact. As soon as the armature leaves the left-hand contact, the ground connection is removed from the armature but a conductive path is then traced from the spacing contact of relay 65 through conductor 272, the lower armature and front contact of relay 268, operating winding of relay 274, resistor 276 and front contact and outer upper armature of relay 268 to battery 273. This results in a maintenance of the current through the operating winding of relay 274 to insure that the armature will travel all the way to the marking contact. The operating winding of relay 274 remains energized over this circuit and completes the movement of its armature to the right-hand contact. When the armature reaches the right-hand contact which is connected to battery 273, it establishes a shunt around resistor 276 thereby causing the current through the operating winding of relay 274 and line 11 to be increased to substantially the full spacing current. The establishment of full spacing current is delayed only for the interval required to operate relay 274. This delay occurs only in the retransmission of a break signal to the subscriber station of Fig. 1, which is of no consequence, or on the first character toward the subscriber station if the interval between the time when transmission from the subscriber station stops and transmission toward the subscriber station begins is very short. It does not occur when the subscriber station of Fig. 1 is receiving signals retransmitted by relay 65 because at such time relay 52 remains in the marking condition, the winding of relay 268 is shunted by the armature of relay 52 and spacing battery 273 is connected directly to the spacing contact of relay 65 through the back contact and lower armature of relay 268.

At any time during the transmission of telegraph signals, break signals may be transmitted by either interconnected subscriber to the other through the central office station. Assume that the subscriber at the station shown in Fig. 1 is transmitting and that the subscriber at the station at the right of Fig. 4, which is receiving

the transmitted signals, desires to transmit a break signal to interrupt transmission from the station in Fig. 1.

The initiation of the break signal is accomplished by operation of key 159 at the subscriber station. This key interrupts the circuit of the operating windings of relays 22 and 23 thereby reversing the polarity at the subscriber station. If the sending relay 65 in the line termination circuit at the left of Fig. 4 should be in the spacing condition in response to a spacing signal at the instant that the break is initiated, relay 52 will not be operated to spacing in response to the break signal of spacing nature until relay 65 returns to marking because although the spacing battery 273 supplied through the back contact and lower armature of relay 268, spacing contact and armature of relay 65 and upper winding of relay 52 is opposed by the spacing polarity of the break signal at the subscriber station, the battery 273 is substantially of twice the voltage of the source at the subscriber's station and current corresponding to the normal marking current flows in the line circuit between the subscriber circuit and the line termination circuit under these circumstances. If the relay 65 is in the marking condition or when it returns to the marking condition, relay 52 operates to spacing transmitting a spacing signal through jack 139 and plug 101 into the cord circuit repeater of Fig. 3.

With relay 52 in Fig. 4 operated to spacing, relay 268 operates, removes the shunt from around resistor 278 in the circuit of the biasing winding of relay 274, thereby reducing the biasing current, disconnecting battery 273 from the spacing contact of relay 65, and substituting therefor ground through the armature and operating winding of relay 274 from the right-hand contact of relay 274. Thus if the relay 65 should again be operated to spacing after the break signal has been extended into the cord circuit, the current through the operating winding of receiving relay 52 cannot be reversed, so that relay 52 will remain in the spacing condition. Current which would flow through the operating winding of relay 274 under this circumstance would supplement the biasing winding in holding the armature on the grounded contact so that the relay 274 will not operate to restore the spacing battery 273 to the spacing contact of relay 65.

Repeater relay 91 in Fig. 3 responds to the spacing signal transmitted by relay 52 of Fig. 4 and operates to spacing irrespective of the condition of repeater relay 90, whether marking or spacing. The reason for this is that there is no current through the operating winding of relay 91 when relay 90 is marking and relay 52 is spacing, batteries of like polarity being in opposition, and relay 90 biases relay 91 to spacing whereas when relays 90 and 52 are both spacing, two spacing batteries of opposite polarity are in series-aiding relation to cause current to flow in the opposite direction from that produced by series-aiding marking battery and although relay 90 would be biasing relay 91 to marking, the current produced by the series-aiding batteries on the spacing contacts of relays 90 and 52 would overpower the biasing winding of relay 91 and drive the armature to spacing. Thus the spacing signal is transmitted out of the cord circuit through plug 83 and into the subscriber's line termination of Fig. 2 through jack 70.

Sending relay 65 in Fig. 2 responds to the spac-

ing signal transmitted by relay 91 in Fig. 3 and operates to spacing irrespective of whether receiving relay 52 is in the marking or spacing condition, for the same reasons as those set forth with reference to the operation of relay 91, because similar conditions of marking and spacing polarities and similar biasing conditions exist. If relay 52 is in the marking condition and has been in that condition for a sufficient interval of time to permit relay 268 to release, the armature of relay 65 finds spacing polarity on its spacing contact from battery 273 and at once transmits the spacing signal toward the subscriber's station of Fig. 1. If relay 52 is in the spacing condition, relay 268 will be in the operated condition and the potential will be ground on the spacing contact of relay 274, supplied through the armature and operating winding of relay 274 and the front contact and lower armature of relay 268. The relay 274 will not be energized because the spacing condition of relay 52 indicates a positive polarity coming in on line 11 which is not the polarity required by relay 274 to operate its armature. However, when the line 11 is restored to marking, relay 274 operates its armature to the right-hand contact, thereupon connecting the spacing battery 273 to the spacing contact of relay 65 through the operating winding of relay 274 and effecting the transmission of the spacing signal to the subscriber's station in Fig. 1. When relay 52 has remained on its marking contact for a sufficient interval for relay 268 to become deenergized, that relay releases, interrupting the circuit through the operating winding of relay 274 and connecting spacing battery 273 directly to the spacing contact of relay 65.

In response to the break signal of spacing nature, relay 16 at the subscriber's station in Fig. 1 goes to spacing, interrupting the circuit through the printer controlling selector magnet 32 and short-circuiting the transmitting contacts 34 so that they will be ineffective to operate transmitting relays 22 and 23. At the time that the sending relay 65 in Fig. 2 responds to the break signal, relay 67 also responds to that signal and sets in operation a timing circuit including electron discharge tube 75. The operations controlled by relay 67 are fully described in the Cramer et al. patent hereinbefore identified and the description will not be repeated in the present specification.

Disconnect

At the termination of transmission between the subscribers connected together through the central exchange, the subscribers stop their machines by releasing the power switches 36. This disconnects power from the teletypewriter motors 33, rectifiers 34 and relays 14. Relay 14 releases and connects the line extending from the subscriber line termination circuit to ground through ringer 40 and condenser 39. This removes all sources of potential from the line at the subscriber station. In the subscriber line termination circuit, this interrupts the conductive path through the winding of relay 55 which should release. Relay 55 when it does release interrupts the direct current energizing circuit for relay 57 and if relay 51 remains on one or the other of its contacts so that condenser 63 does not discharge and recharge in opposite directions, relay 57 will be released, thus releasing the relay 56. Relay 56 releases relays 64 and 58 and establishes a circuit through its lower armature and back contact and through the lower armature and back contact of relay 262 to the ring contact spring of jack 70 and through the ring of plug 83 to relay 85 which at its outer

lower armature and front contact completes a circuit for lamp 86 to inform the operator of the disconnect and to indicate to her that plug 83 should be removed from jack 70.

However, relay 55 may fail to release or relay 51 may fail to remain on one of its contacts or both of these failures may occur under circumstances now to be described and it is for the purpose of guarding against such failure that the system comprising relays 268 and 274 have been provided. The circumstances under which relay 55 may fail to release or relay 51 may fail to remain on one contact will first be described as if the relay system comprising relays 268 and 274 were not provided and under these circumstances the spacing battery 273 for the transmitting relay 65 would be connected directly to the spacing contact of that relay.

With the line from the subscriber station to the line termination circuit opened to direct current at the subscriber station, the line capacity will discharge through the winding of receiving relay 52 and cause the armature of that relay to hold, but oscillation may occur due to resonance between the line and the repeater elements of the line termination circuit and such oscillation may cause the armature of relay 52 to go from marking to spacing even if the relay has no vibratory circuit. With a vibratory circuit associated with the third and fourth windings of the relay such circuit will assume control of the armature and oscillate it between its marking and spacing contacts. Thus, although the disconnect has been effected with the line 11 between the subscriber station and the line termination circuit in the marking condition, the receiving relay is driven to the spacing contact and a spacing signal will be transmitted toward the other subscriber station shown in Fig. 4. The subscriber at the station shown in Fig. 4 may have disconnected at about the same time, similarly causing the receiving relay 52 in the line termination circuit to operate to spacing. Thus these two spacing signals are transmitted in opposite directions and each causes the sending relay 65 to which it has been transmitted to operate to spacing. As previously mentioned, the sending relay 65 responds to and retransmits received signals independently of the condition of the receiving relay 52. Accordingly, battery 273, assumed to be connected directly to the spacing contact of relay 65 in each of the line termination circuits, would be connected to the line through the spacing contact and armature of relay 65 and through the winding of receiving relay 52, charging the line through the operating winding of the receiving relay 52 and causing the armature of the receiving relay to return to its marking contact whether or not that relay had a vibratory circuit. This would occur in both of the subscribers' line termination circuits. Upon the return of the receiving relays 52 to marking, they would transmit a marking signal in opposite directions through the cord circuit repeater to cause both of the sending relays 65 receiving such marking signals to return to marking whereupon the line extending from each subscriber's station to its line termination circuit could again discharge to ground through the armature and marking contact of the sending relay 65 thus causing the receiving relay 52 again to operate to spacing and start another cycle like the one just described. In this way an oscillatory condition could be set up which would continue indefinitely. Since in each of the subscriber line

termination circuits the relay 51 is connected in series with the operating winding of relay 52, the currents traveling first in one direction and then in the other as a result of the oscillatory condition would cause relay 51 to follow the oscillations which would maintain the relay 57 energized thus preventing the release of relays 56, and 64 and the operation of the lamp 86 associated with the cord circuit, and the operator would receive no indication that plugs 83 and 101 should be removed from jacks 70 and 139, respectively.

Oscillation between the two line termination circuits may develop even though neither has a vibratory circuit on its receiving relay and even though only one develops oscillation between its repeater elements and its subscriber line of sufficient amplitude to operate its receiving relay to spacing as a direct result of the disconnect on its line. Assume that both subscribers disconnect about the same time, with their lines in marking condition. The lines will be charged negatively at the time of disconnect, and the discharge of the negative charge through the upper windings of relays 51 and 52 in both line termination circuits, and through the armatures and marking contacts of the sending relays 65 to ground, will be in the direction to hold the relays 51 and 52 on their marking contacts. Assume further that oscillation occurs in one of the line termination circuits which causes its relays 51 and 52 to operate to spacing. This will cause a spacing signal to be transmitted toward the other line termination circuit where the relays 51 and 52 will be assumed to have remained on their marking contacts, and where the sending relay 65 will operate to spacing in response to the spacing signal, thus connecting positive potential to its subscriber line and recharging the capacity of that line. This recharging current is in the direction to hold the relays 51 and 52 on their marking contacts. However, the surge of charging current from the positive spacing battery may overcharge the line, which will be followed by a partial discharge of the capacity charge, which is positive. The current through the operating windings of relays 51 and 52 resulting from this partial discharge is in the direction to drive these relays to spacing, and thus a spacing signal may be transmitted toward the remote line termination circuit, operating the sending relay thereat to spacing and charging the capacity of the line positively, restoring the receiving relay to marking. One line termination circuit has thus been drawn into participation in oscillation by the other and such oscillation may continue indefinitely.

The manner in which the circuit comprising relays 268 and 274 prevents the occurrence of oscillation between the line termination circuits will now be described. As previously stated, the receiving relay 52 is susceptible of operation to spacing when the subscriber disconnects and accordingly if oscillations due to resonance occur in the circuit, which operate relay 52, they will also operate relay 51 and prevent the registration of the disconnect signal. Assume first that both relays 52 operate to spacing due to local oscillation. This may occur in both of the subscriber line termination circuits or only in one. As a result of the operation of relay 52 to spacing, slow-release relay 268 is energized, disconnecting spacing battery 273 from the spacing contact of sending relay 65 and substituting a ground connection through the operating winding and armature of

relay 274 to the grounded contact of that armature which the armature normally engages by virtue of the biasing circuit. When the sending relay 65 receives the spacing signal retransmitted by the receiving relay at the remote subscriber line termination circuit, the armature of the sending relay operates to the spacing contact where it finds ground connection through the operating winding of relay 274, corresponding to the connection on its marking contact, instead of finding spacing battery connection. The line continues to discharge to this ground connection and by virtue of the removal of spacing battery 273, no potential is applied to the line extending toward the subscriber station through the operating winding of receiving relay 52 to cause it to return to marking condition. The potential stored in line 11 will be polarized to operate the armature of relay 274 toward its grounded contact so that relay 274 will remain unoperated and spacing battery 273 will not become connected to the spacing contact of sending relay 65 through the winding of relay 274 as it does in the case of a break signal.

Upon the discharging of the line to ground, relay 57 will release and through the chain of operations previously described, will cause the lamp 86 to be lighted to inform the operator of the disconnect. Thus the oscillatory condition is prevented and the establishment of the disconnect indication is assured. The end of the cord circuit shown in Fig. 3 which terminates at plug 101 has a lamp 102 controlled similar to the lamp 86 through the ring circuit of the plug 101 and jack 139 for indicating the disconnect originated at the subscriber station shown in Fig. 4.

Assume now that the subscribers disconnect with their lines in marking condition and that only one termination circuit undergoes local oscillation of sufficient amplitude to drive its relay 52 to spacing. As previously stated, the discharge of the negative charge through the upper windings of relays 51 and 52 and the marking contact of relay 65 to ground is in the direction to hold relays 51 and 52 to their marking contacts, and at the termination circuit which undergoes only low amplitude oscillation or none, relays 51 and 52 will be held on marking and relay 268 will remain deenergized. However, the sending relay may receive a spacing signal from the receiving relay at the remote subscriber line termination circuit. When the sending relay 65 operates to its spacing contact, positive potential will be applied to the line through the spacing contact of relay 65 and the upper windings of relays 52 and 51 because relay 268 is unoperated, and the positive potential will charge the line capacity. This current is in a direction to hold the relays 52 and 51 on their marking contacts. If the line capacity overcharges, then partially discharges, and drives relays 51 and 52 to spacing, or when relay 65 receives a marking signal from the remote subscriber line termination and its armature returns to the marking contact, the line capacity discharge through the upper windings of relays 51 and 52 and the marking contact of relay 65 to ground will cause relays 51 and 52 to operate to spacing, and relay 268 will be operated to remove positive battery connection from the spacing contact of relay 65. The discharge will be in the direction to hold the armature of relay 274 on its grounded contact and the line will be enabled to discharge fully to ground. At the remote line termination circuit the relay 268 will have been operated incident to the transmission of the spacing

signal by its receiving relay, and its line cannot become recharged when a spacing signal is returned to it. Thus oscillation between the termination circuits will be suppressed.

Modified disconnect oscillation suppressing circuit

Fig. 5 shows a modified form of disconnect oscillation suppressing circuit for use in a two-wire trunk circuit interconnecting a concentrating unit switching center and a central office. The modified disconnect oscillation suppressing circuit provides for a longer interval for discharging a line before the polar relay which is operable to restore spacing potential to the spacing contact of the sending relay becomes connected to the line than does the oscillation suppressing circuit shown in Figs. 2 and 4.

In Fig. 5 the fundamental elements of the central office termination and concentrating unit termination of a two-wire trunk circuit and of a subscriber station circuit served by the concentrating unit are shown. These circuits are fully and completely disclosed in copending application Serial No. 462,966 filed October 22, 1942, by W. V. K. Large et al. and the modified disconnect oscillation suppressing circuit associated with the central office termination of the trunk in Fig. 5 is shown but not claimed in said copending application. The disclosure of the copending application is incorporated herein by reference as part of the present specification.

The trunk termination circuit at the central office, shown at the left of Fig. 5, has a jack 539 adapted to receive plug 101 of the cord circuit shown in Fig. 3, through which the trunk termination circuit may be connected to the subscriber line termination circuit of Fig. 2 and through it to the subscriber station of Fig. 1. The tip of jack 539 is connected through the operating winding of a biased polar relay 564 and through the operating winding of sending relay 565 to the armature of receiving relay 552. The relays 565 and 552 in the trunk termination at the central office correspond to the relays 65 and 53 in the subscriber line termination circuit in Fig. 4. The biasing windings of relays 564 and 565 are connected in series to the armature of receiving relay 552. The marking and spacing contacts of relay 552 have negative and positive battery connections respectively. The armature of sending relay 565 is connected through one winding of disconnect relay 555 which corresponds to disconnect relay 55 in the subscriber line termination of Fig. 4 and through the uppermost winding of receiving relay 552 to line 511 which extends to the concentrating unit. There is a connection from the first winding of relay 552 to one terminal of the second winding, the other terminal of which is connected to an artificial line which provides no conductive path for direct current, so that relay 552 is not biased by the second winding. The third and fourth windings of relay 552 have a vibratory circuit associated therewith connected to the armature of relay 552. The armature of relay 564 is grounded and from the marking contact of that relay a path is traced through the second winding of central office trunk disconnect relay 555 and the fifth winding of receiving relay 552 to a neutralizing wire 512 which extends to the concentrating unit. There is a connection from the fifth winding of relay 552 to one terminal of the sixth winding, the other terminal of which is connected to an artificial line which provides no direct current path so that relay 552 is not biased by the sixth winding. The

marking contact of sending relay 565 is grounded and with all of the relays in the marking condition the line wire 511 and neutralizing wire 512 have ground connection at the central office trunk termination.

At the concentrating unit, line 511 is connected to an armature of relay 516, the front contact of which is connected through the first winding of receiving relay 521 to the armature of sending relay 522 which has negative battery connection on its marking contact and positive battery connection on its spacing contact. The armature of sending relay 522 is also connected through the second winding of relay 521, which is a biasing winding, and through an artificial line to ground. The neutralizing wire 512 is connected to an armature of relay 516, the front contact of which is connected through the fourth winding of receiving relay 521 and through a resistor 523 to ground. There is also a connection from ground through the third winding of relay 521 which is a biasing winding and through an artificial line to ground. The fifth winding of relay 521 has a battery connection on one of its terminals and ground connection on its other terminal and provides a steady bias for relay 521. The armature of receiving relay 521 is connected through the operating windings of sending relay 522 and break relay 524 and the winding of concentration unit disconnect relay 527 to line 526 which extends to the subscriber station circuit shown at the right of Fig. 5. The biasing windings of sending relay 522, and break relay 524 are connected in series between the armature of relay 521 and ground. The marking contact of receiving relay 521 has positive battery connection and the spacing contact has ground connection supplied through the armature and marking contact of break relay 524. The spacing contact of the break relay is connected to the marking contact of receiving relay 521 so that if receiving relay 521 should go to the spacing condition while relay 524 is in the spacing condition, marking potential will be applied to the spacing contact of relay 521 and relay 521 will be unable to change the potential applied to line 526 at the concentrating unit.

The copending application of Large et al. shows terminating apparatus for the line 526 at the concentrating unit and link circuit apparatus for connecting line 526 to the operating windings of break relay 524 and sending relay 522. However, in Fig. 5 this apparatus has been omitted and line 526 is shown extending directly from the sending and break relays through the disconnect relay to the subscriber station and specifically to the swinger spring of a key 531 through which connection is made in the idle condition of the station circuit to ground through a ringer 532 and condenser 533 for passing alternating ringing current only. When the subscriber station circuit is to be connected to line 526 key 531 is operated to its lower contact to extend a conductive path from line 526 through the operating winding of line relay 534, break key 536 which is shunted by resistor 535 and transmitting contacts 537 to ground. The marking contact of line relay 534 is grounded and the armature is connected through teletypewriter selector magnet 538 to grounded battery. The lower winding of line relay 534 biases the armature to spacing but when key 531 is operated to its lower contact and current flows over line 526 from the marking contact of sending relay 521 current in the operating winding of relay 534 overpowers the biasing wind-

ing and completes the energizing circuit of selector magnet 538. The effect of operation of transmitting contacts 537 is to open and close the circuit of relays 522, 524, 527 and line relay 534 at the subscriber station thus operating relays 522, 524 and 534 to spacing, and the sending relay 522 repeats the spacing condition over line 511 to the receiving relay 552 in the trunk termination at the central office. Relay 527 is shown slow release and does not release its armature in response to normal spacing signals. Relay 527 does not release when break key 536 is operated, because resistor 535 passes sufficient current to hold relay 527 operated although not enough to prevent operation of relays 522, 524 and 534 to spacing. In the system shown in the copending application of Large et al., the relay corresponding to relay 527 is not slow release, but it controls the release of other relays, one of which is slow release and controls the release of the relay corresponding to relay 516. For the sake of simplicity, the intermediate relays have not been shown, and the delay in the release of relay 516 is indicated by showing relay 527 as being slow release. When relay 521 receives signals from the central office to be repeated to the subscriber station its armature operates between the marking and spacing contacts and when on the spacing contact line 526 is grounded at both ends and the armature of line relay 534 at the subscriber station operates to spacing thereby de-energizing selector magnet 538, which is the spacing condition. The operation of receiving relay 552 in the trunk termination circuit at the central office under the control of sending relay 522 at the trunk termination circuit in the concentrating unit is the same as the operation of the receiving relay 52 in Figs. 2 and 4, under the control of transmitting relays 22 and 23, since sending relay 522 reverses the polarity applied to line 511 in the same manner that the sending relays at the subscriber's station shown in Figs. 1 and 4 reverse the polarity on their respective lines.

The armature of receiving relay 552 when on the marking contact short-circuits the winding of a relay 568 which corresponds to the relay 268 in Figs. 2 and 4 and has its lower armature connected to the spacing contact of sending relay 565. The back contact with which the lower armature cooperates is connected to spacing battery 573 which provides substantially twice the voltage available at the sending relay 522 and is in series aiding relation to the voltage applied to the armature of relay 522 when the relay is in the marking condition and sending relay 565 is in the spacing condition with battery 573 connected to the spacing contact directly, when relay 568 is released, or indirectly, as will be described later. When signals are being retransmitted at a normal rate by relay 552 the relay 568, being slow release, holds its armature. The lower armature then engages a front contact which is connected to the lower armature of a relay 570 for which there is no corresponding relay in Figs. 2 and 4. The grounded inner upper armature of relay 568 cooperates with a back contact connected to one terminal of the winding of relay 570 which has a slow-release characteristic, the other terminal of which is connected to grounded battery. With relay 568 steadily energized during rapid retransmission of signals by relay 552, the relay 570 will be released and its lower armature will engage its back contact which is connected to the upper winding of biased polar relay 574, the other terminal of which is connected

to the armature of relay 574 which normally engages its grounded right-hand contact. Thus a path is traced from the spacing contact of relay 565 through the lower armature and front contact of relay 568, lower armature and back contact of relay 570 and upper winding and armature of relay 574 to the grounded contact which the armature engages. The armature of relay 574 is urged into engagement with the grounded contact due to current in its lower winding, which is the biasing winding, from battery 573 through resistors 578 and 577 and the lower winding of relay 574 to ground. With relay 552 transmitting signals into the cord circuit relay 565 is or should be in the marking condition so that a circuit through the upper winding of relay 574 is not completed. The middle winding of relay 574 has one terminal connected to ground and the other terminal connected to the marking contact of relay 564 which should also be in the marking condition. Thus only the lowermost or biasing winding of relay 574 will be energized.

If the relay 552 should be transmitting a spacing signal at the instant that relay 565 responds to a break signal of spacing nature from the cord circuit, the current through line 511, upper winding of relay 552, right-hand winding of relay 555, armature and spacing contact of relay 565, lower armature and front contact of relay 568, lower armature and back contact of relay 570 and upper winding and armature of relay 574 to ground will be in the direction to aid the biasing winding of relay 574 and this relay will not be operated. The spacing signal of the break will not be retransmitted by relay 565 because the spacing contact is receiving the same potential as the marking contact, namely, ground through the armature and upper winding of relay 574. With relay 564 operated to spacing along with relay 565 a short circuit is removed from around the middle winding of relay 574 and this winding becomes connected in series with the neutralizing wire 512. The circuit of the neutralizing wire is extended through a winding of relay 574 because the circuit of line 511 has also been extended through a winding of relay 574 and it is desired that both circuits shall influence the operation of relay 574 in the same manner that they influence the operation of relays 552 and 521, since both circuits include windings of these two relays. However, the middle winding of relay 574 will not cause movement of the armature to the left-hand contact since the upper winding is aiding the biasing winding in holding the armature on the right-hand contact.

When the relay 522 responds to and repeats a marking signal toward the trunk termination at the central office, the polarity on the upper winding of relay 574 will be reversed and the armature will be operated out of engagement with its grounded right-hand contact. As soon as the armature leaves the grounded contact a substitute circuit for causing the armature to continue to move to its left-hand contact becomes effective, the circuit being from grounded battery 573 through the front contact and outer upper armature of relay 568 which has not yet released its armature because of its slow-release characteristic, to the upper winding of relay 574 through resistor 576. When the armature of relay 574 reaches its other contact battery 573 becomes connected directly to the upper winding of relay 574 through the contact and armature, and resistor 576 is short circuited thus increasing the

current through the upper winding of relay 574 and over line conductor 511 to the full spacing value. This causes the relay 521 to operate to spacing and the break signal is repeated to the subscriber station at the right of Fig. 5. With the break signal of spacing nature repeated to the subscriber station, relay 522 remains in the marking condition and relay 552 also remains in the marking condition. Relay 568 releases its armatures after its delay interval, thus reenergizing relay 570, reconnecting battery 573 to the spacing contact of relay 565 independently of the upper winding of relay 574 and opening the path from battery 573 through resistor 576 to the upper winding of relay 574. Relay 570 in becoming energized prepares a path to the spacing contact of relay 565 from ground on its lower front contact through its lower armature to the lower front contact of relay 568, and connects ground directly to the neutralizing wire by means of the grounded front contact and inner upper armature of relay 570, which ground serves as the terminal point of neutralizing wire 512 independently of the ground connection at the marking contact of relay 564, which becomes disconnected from the neutralizing wire each time relay 564 responds to a spacing signal from the cord circuit of Fig. 3 in unison with relay 565. At its outer upper armature and front contact relay 570 places a shunt around resistor 578 to increase the biasing current in the lower winding of relay 574 and thus to reduce the sensitivity of that relay. It will be noted that the normal condition of the relay circuit comprising relays 568, 570 and 574 during retransmission of signals from the cord circuit of Fig. 3 and toward the subscriber station circuit of Fig. 5 by relay 565 is with relays 568 and 574 unoperated and relay 570 operated. It will also be noted that the retransmission of the break signal of spacing nature to the subscriber station of Fig. 5 has been delayed only by the interval required for relay 574 to operate, which is comparable with the operation of the relay system comprising relays 268 and 274 in Figs. 2 and 4 and the addition of relay 570 has not changed this negligible delay.

A disconnect is effected at the subscriber station in Fig. 5 by operating the swinger of key 531 to its upper contact which connects the ringer and condenser in series with line 526 thus opening the line to direct current. This causes relay 522 to operate to spacing and to transmit a spacing signal over line 511 which drives relay 552 to spacing positively and with or without the presence of the vibratory circuit on its third and fourth windings. With line 526 open to direct current at the subscriber's station circuit relay 527 releases and in turn releases relay 516. This relay disconnects trunk conductor 511 and neutralizing conductor 512 from the first and fourth windings of receiving relay 521 at the concentrating unit trunk termination and forms a loop across these conductors at the concentrating unit through relatively high resistance 517 in shunt with alternating current relay 518 and condenser 519. Relay 518 is an alternating current relay and it is operable in response to ringing current transmitted from the central office to initiate operations which will result in the energization of relay 516 when the trunk is seized at the central office for establishing a communication circuit through to a subscriber station served by the concentrating unit, as is fully described in the co-pending application of Large et al.

With relay 516 released there is no source of current connected to line 511 at the concentrating unit trunk termination but due to the presence of the vibratory circuit on the third and fourth windings of relay 552 at the central office trunk termination, the armature of that relay will be vibrated between its marking and spacing contacts. In the absence of a vibratory circuit the armature of relay 552 would remain on the spacing contact to which it has been driven by the operation of relay 522 to spacing before relay 527 released relay 516 and disconnected line 511 from relay 522. Assuming that the communication system has been in the marking condition at the time the disconnect is effected relays 568 and 574 will be unoperated and relay 570 will be energized. With relay 552 operated to spacing, relay 568 is operated and the spacing battery 573 is disconnected from the spacing contact of relay 565 and a ground connection is substituted through the lower armature and grounded front contact of relay 570. The energizing circuit of relay 570 is interrupted as a result of the energization of relay 568 but the relay 570 is slow to release and thus the spacing contact of relay 565 is not immediately connected to an operating winding of relay 574 upon the operation of relay 568 as is the case of the previously described system shown in Figs. 2 and 4 wherein the spacing contact of relay 565 becomes connected to an operating winding of relay 274 as soon as relay 268 operates as the result of operation of relay 52 to spacing in consequence of the disconnect operation at the subscriber's station. When relay 570 releases after an interval the spacing contact of relay 565 does become connected to the upper winding of relay 574, the short circuit around the middle winding of relay 574 is removed and the sensitivity of relay 574 is increased due to the removal of the shunt around resistor 578. Should the relay 565 respond to a spacing signal resulting from operation of relay 52 in Fig. 2 to spacing in consequence of initiation of a disconnect at the subscriber station in Fig. 1 any time before the release of relay 570, the interconnected line 511 and balancing wire 512 will not be recharged, the windings of disconnect relay 555 and the first and fifth windings of relay 511 will not be reenergized, because spacing battery 573 is disconnected from the spacing contact of relay 565 and that contact is grounded at the lower armature and front contact of relay 570 so that the line 511 and neutralizing wire 512 are afforded ample opportunity to become completely discharged. After the release of relay 570 the spacing contact of relay 565 still has ground connection supplied through the upper winding of relay 574 and its armature and left-hand contact so that the line 511 and neutralizing wire 512, if not already fully discharged, will continue to discharge and will not be recharged. By virtue of the addition of slow-release relay 570 to the system a longer interval of time is afforded for discharging line 511 and neutralizing wire 512 before the lines become connected to the operating windings of relay 574, and the release of disconnect relay 555 is assured. Thus if it should happen that at the time the relay 568 is operated as a result of the disconnect the residual charge on line 511 and neutralizing wire 512 is of sufficient potential and of the proper polarity to operate relay 574, that relay will not be operated because its operating windings do not become connected to the line 511 and neutralizing wire 512 until relay 570 has released and the relay

570 affords ample time for dissipating such residual charge before it releases.

Although certain specific embodiments of the invention have been shown in the drawings and described in the foregoing specification it will be understood that the invention is not limited to such specific embodiment but is capable of modification and rearrangement without departing from the spirit of the invention and within the scope of the appended claims.

What is claimed is:

1. In a telegraph system, an outlying station having a line, a central office station having a terminating circuit for said line including separate repeating relays for directly repeating signals from said line and into said line, means controlled by one of said relays for disqualifying the other of said relays from repeating signals without estopping signal responsive operation of said other relay, and means controlled by the last-mentioned means for requalifying said other relay to repeat signals.

2. In a telegraph system, an outlying station having a line, a central office station having a terminating circuit for said line including separate repeating relays for repeating signals from said line and into said line, means controlled by one of said relays for disconnecting from one of the contacts of the other relay the normally connected source of signaling potential and for substituting on said contact the same potential and polarity as that appearing on the other contact of said other relay whereby to disqualify said other relay from repeating signals, and means controlled by the last-mentioned means for reconnecting the normal source of signaling potential to the first-mentioned contact of said other relay whereby to requalify said other relay to repeat signals.

3. In a telegraph system, an outlying station having a line, a central office station having a terminating circuit for said line including separate repeating relays for repeating signals from said line and into said line, a relay operable by one of said repeating relays upon operation thereof to its spacing condition for disconnecting from the spacing contact of the other of said repeating relays a source of signaling potential normally connected to said spacing contact and for substituting on said spacing contact the same potential and polarity as that appearing on the marking contact of said other repeating relay, and a polar relay connected between said spacing contact and said substituted potential and operable upon closure of a circuit through the armature and spacing contact of said other repeating relay to current of the proper polarity for reconnecting to said spacing contact said normally connected source of signaling current.

4. In a telegraph system, an outlying station having a line, a central office station having a terminating circuit for said line including separate repeating relays for repeating signals from said line and into said line, a relay operable by one of said repeating relays upon operating to the spacing condition for disconnecting from the spacing contact of the other repeating relay a normally connected source of signaling current and for substituting on said spacing contact a connection of the same polarity and potential as that appearing on the marking contact of said other repeating relay, a biased polar relay having its operating winding, armature and the contact normally engaged by said armature serially connected between said spacing contact and said substituted connection, said polar relay being

operable upon closure of a circuit through the armature and spacing contact of said other repeating relay to current of the proper polarity for reconnecting to said spacing contact said normally connected source of signaling current through said operating winding, armature and the other contact of said polar relay.

5. In a telegraph system, an outlying station having a line, a central office station having a terminating circuit for said line including separate repeating relays for repeating signals from said line and into said line, a relay operable by one of said repeating relays upon operation thereof to spacing condition for disconnecting from the spacing contact of the other repeating relay a source of signaling current normally connected thereto and for substituting a connection of the same potential and polarity as that appearing on the marking contact of said other repeating relay, a polar relay having its operating winding, armature and the contact normally engaged by said armature connected in series between said spacing contact and said substituted connection and operable upon closure of a circuit through the armature and spacing contact of said other repeating relay to current of the proper polarity for reconnecting said normally connected source of signaling current to the spacing contact of said other repeating relay, and means including said source of signaling current for maintaining the operating winding of said polar relay energized upon disengagement of the armature thereof from its normally engaged contact to effect transit of said armature to its other contact.

6. In a telegraph system, an outlying station having a line, a central office station having a terminating circuit for said line including separate repeating relays for repeating signals from said line and into said line, a control relay operable by one of said repeating relays upon operation thereof to spacing condition for disconnecting from the spacing contact of the other repeating relay a source of signaling current normally connected thereto and for substituting a connection of the same potential and polarity as that appearing on the marking contact of said other relay, a polar relay having its operating winding, armature and the contact normally engaged by said armature connected in series between said spacing contact and said substituted connection, and operable upon closure of a circuit through the armature and spacing contact of said other repeating relay to current of the proper polarity for reconnecting said normally connected source of signaling current to the spacing contact of said other repeating relay, and means controlled by said control relay upon operation thereof for increasing the sensitivity of said polar relay.

7. In a telegraph system, an outlying station having a line, a central office station having a termination circuit for said line, a repeating relay for sending signals into said line, a repeating relay for receiving signals from said line, said receiving relay being operable to marking condition over a circuit including a source of signaling current at said outlying station and the armature and marking contact of said sending relay, said receiving relay being susceptible of operation to spacing upon disconnection of said source of signaling current and being susceptible of reoperation to marking upon operation of said sending relay to spacing, a control relay operable by said receiving relay upon operation thereof to spacing, and means controlled by said control relay for

disconnecting from the spacing contact of said sending relay a source of signaling potential normally connected to said contact and for placing said spacing contact at the same potential as the marking contact of said sending relay whereby to preclude said reoperation of said spacing relay to marking.

8. In a telegraph system, an outlying station having a line, a central office station having a terminating circuit for said line including separate repeating relays for repeating signals from said line and into said line, means controlled by one of said relays for disqualifying the other of said relays from repeating signals, means controlled by said disqualifying means for requalifying said other relay to repeat signals and means also controlled by said disqualifying means for delaying the operation of said requalifying means.

9. In a telegraph system, an outlying station having a line, a central office station having a termination circuit for said line, a repeating relay for sending signals into said line, a repeating relay for receiving signals from said line, a control relay operable by said receiving relay upon operation thereof to spacing for disconnecting from the spacing contact of said sending relay a source of signaling potential normally connected thereto and for substituting on said contact a connection of the same potential and polarity as that appearing on the marking contact of said sending relay, a polar relay for reconnecting to said spacing contact said normally connected source of signaling current, and a slow-release relay releasable by said control relay for introducing the energizing circuit of said polar relay between said substituted connection and said spacing contact whereby to render said polar relay operable upon closure of a circuit through the armature and spacing contact of said sending relay to current of the proper polarity.

10. In a telegraph system, an outlying station having a line and a source of signaling current, means for connecting said source to said line, a central office station having a terminating circuit for said line including a repeating relay for receiving signals from said line and a repeating relay for sending signals to said line, said receiving relay being susceptible of operation to spacing condition upon disablement of said connecting means, a source of signaling current normally connected to the spacing contact of said sending relay, a supervisory relay in said terminating circuit energizable by signaling current flowing in said line and susceptible of energization from said source of signaling current connected to said spacing contact upon operation of said sending relay to spacing condition with said connecting means disabled, means controlled by said receiving relay upon operation thereof to spacing for disconnecting said normally connected source of signaling current from said spacing contact and for substituting on said spacing contact a connection of the same potential and polarity as that appearing on the marking contact of said sending relay to preclude energization of said supervisory relay from said normally connected source of signaling current, and means controlled by said supervisory relay upon release thereof for displaying an indication of disablement of said connecting means.

11. In a telegraph system, a plurality of outlying stations each having a line, means for connecting each station to its line, a central office station having a termination circuit for each of said lines including a repeating relay for receiving signals from its associated line for retransmission to another station and a repeating relay for sending to its associated line signals received from another station, means at said central office station for interconnecting any two of said termination circuits to establish a communication path between the outlying stations served by said termination circuit, means operable by each of said receiving relays upon operation thereof to spacing for disconnecting from the spacing contact of the sending relay a source of signaling current normally connected thereto and for substituting on said spacing contact a connection having the same potential and polarity as that appearing on the marking contact of said sending relay, and means operable upon signal responsive operation of said sending relay to spacing condition only while said outlying station connecting means remains operated for reconnecting said normally connected source of signaling current to said spacing contact.

12. In a telegraph system, a line, a repeater associated with said line having a relay for repeating signals from said line and a relay for repeating signals into said line, means controlled by one of said relays for disconnecting from one of the contacts of the other relay the normally connected source of signaling potential and for substituting on said contact the same potential and polarity as that appearing on the other contact of said other relay whereby to disqualify said other relay from repeating signals, and means controlled by the last-mentioned means for reconnecting the normal source of signaling potential to the first-mentioned contact of said other relay whereby to requalify said other relay to repeat signals.

13. In a telegraph system, two line sections, a repeater interconnecting said line sections having relays for repeating signals from each line section into the other line section, means controlled by one of said relays for disconnecting from one of the contacts of the other relay the normally connected source of signaling potential and for substituting on said contact the same potential and polarity as that appearing on the other contact of said other relay whereby to disqualify said other relay from repeating signals, and means controlled by the last-mentioned means for reconnecting the normal source of signaling potential to the first-mentioned contact of said other relay whereby to requalify said other relay to repeat signals.

14. In a telegraph system, two line sections, a repeater interconnecting said line sections having a relay associated with each line section for directly repeating signals into the other line section, means controlled by one of said relays for depriving the other relay of signal repeating capability without estopping signal responsive operation of said other relay, and means controlled by said last-mentioned means for restoring signal repeating capability to said other relay.

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