May 12, 1931. G. S. VERNAM 1,804,548

TELEGRAPH EXCHANGE SYSTEM

Filed April 3, 1929 4 Sheets-Sheet 1

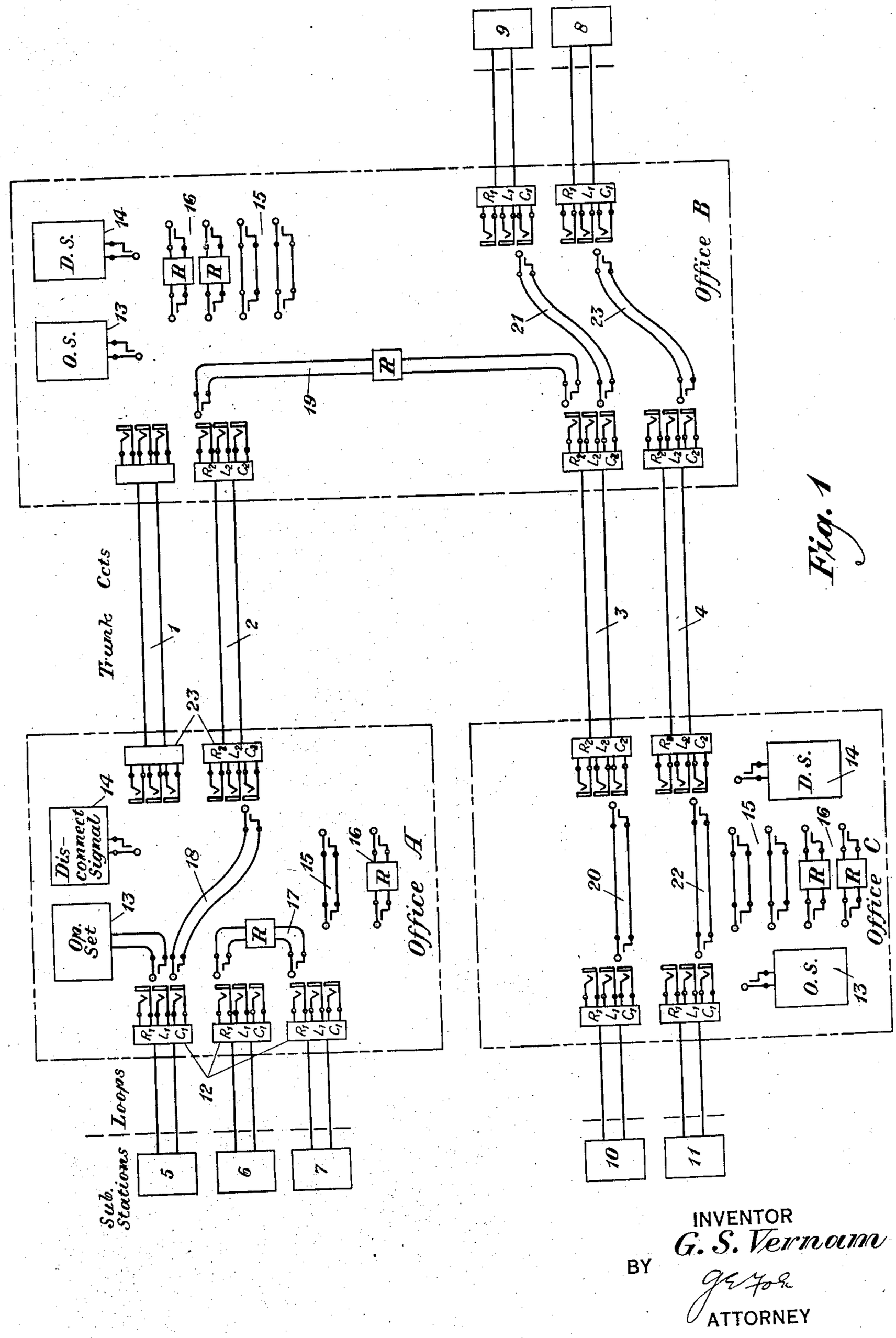

Fig. 1

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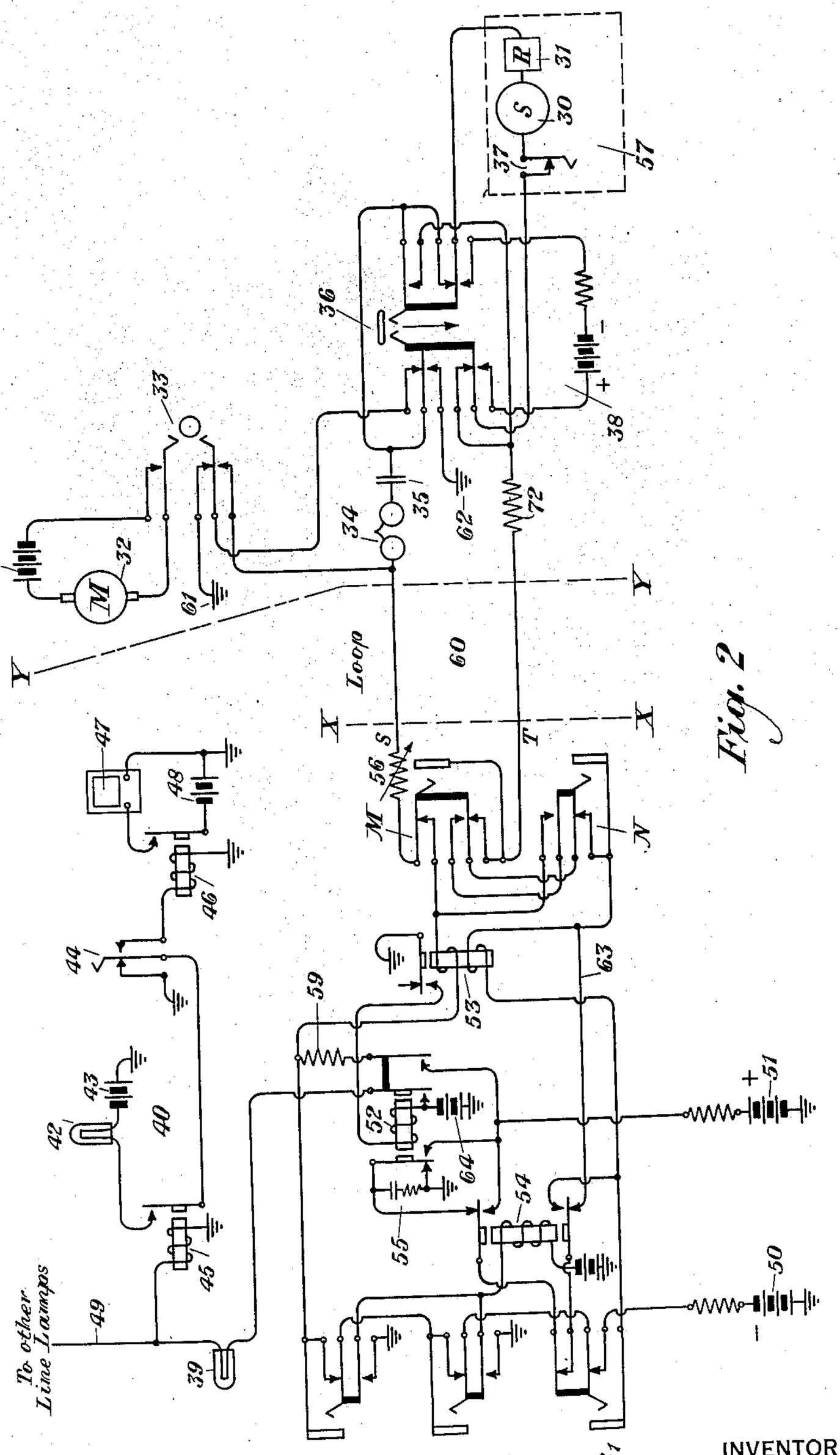

Fig. 2

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Filed April 3, 1929 4 Sheets-Sheet 3

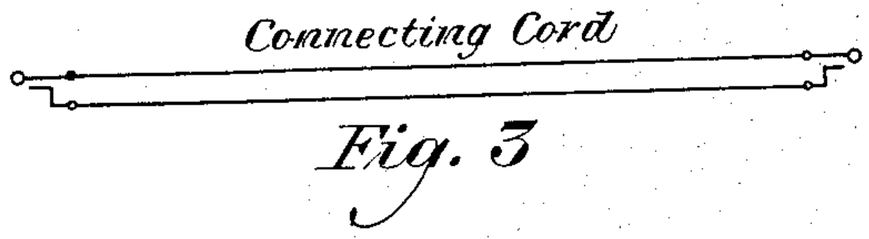

Fig. 3

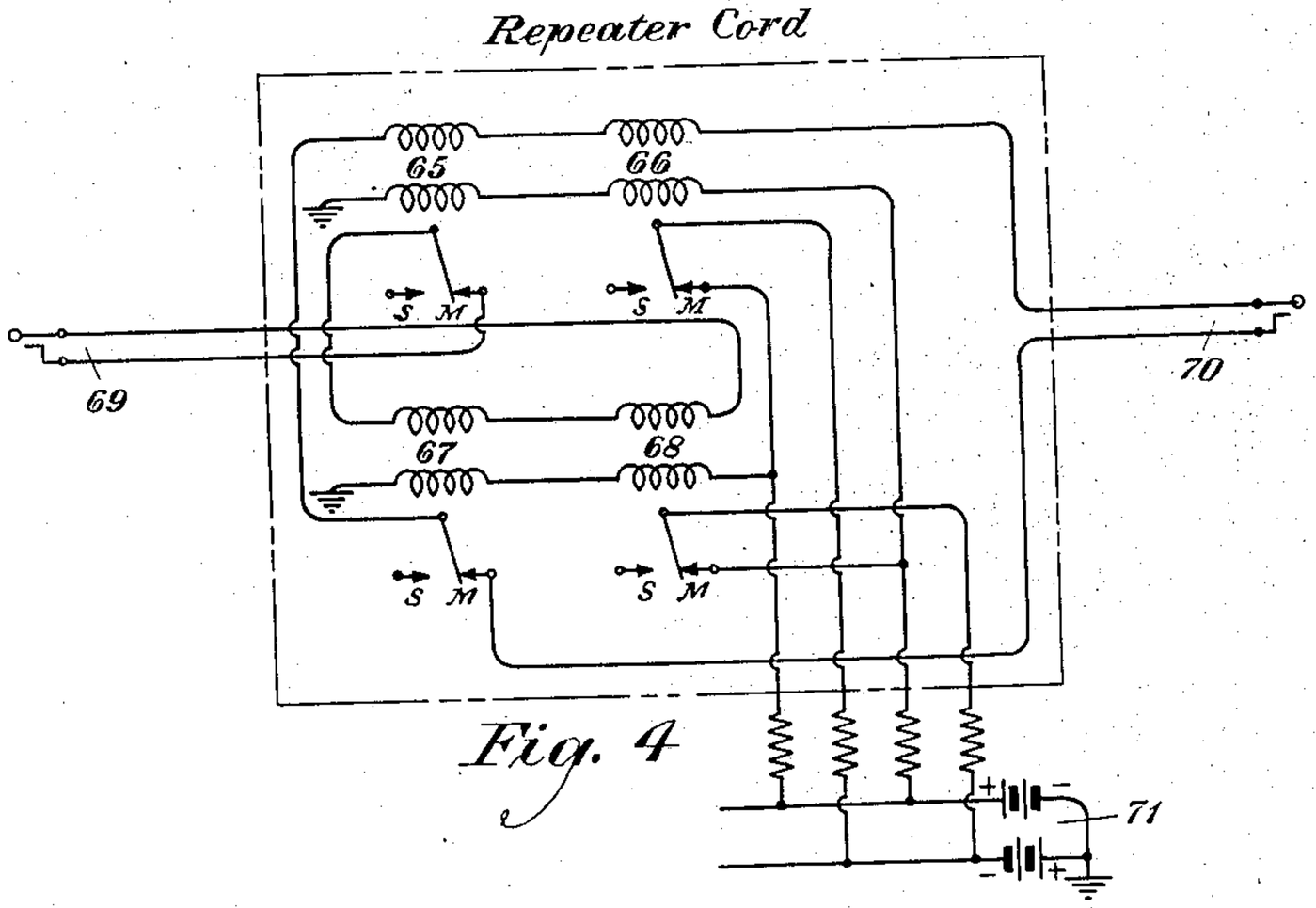

Fig. 4

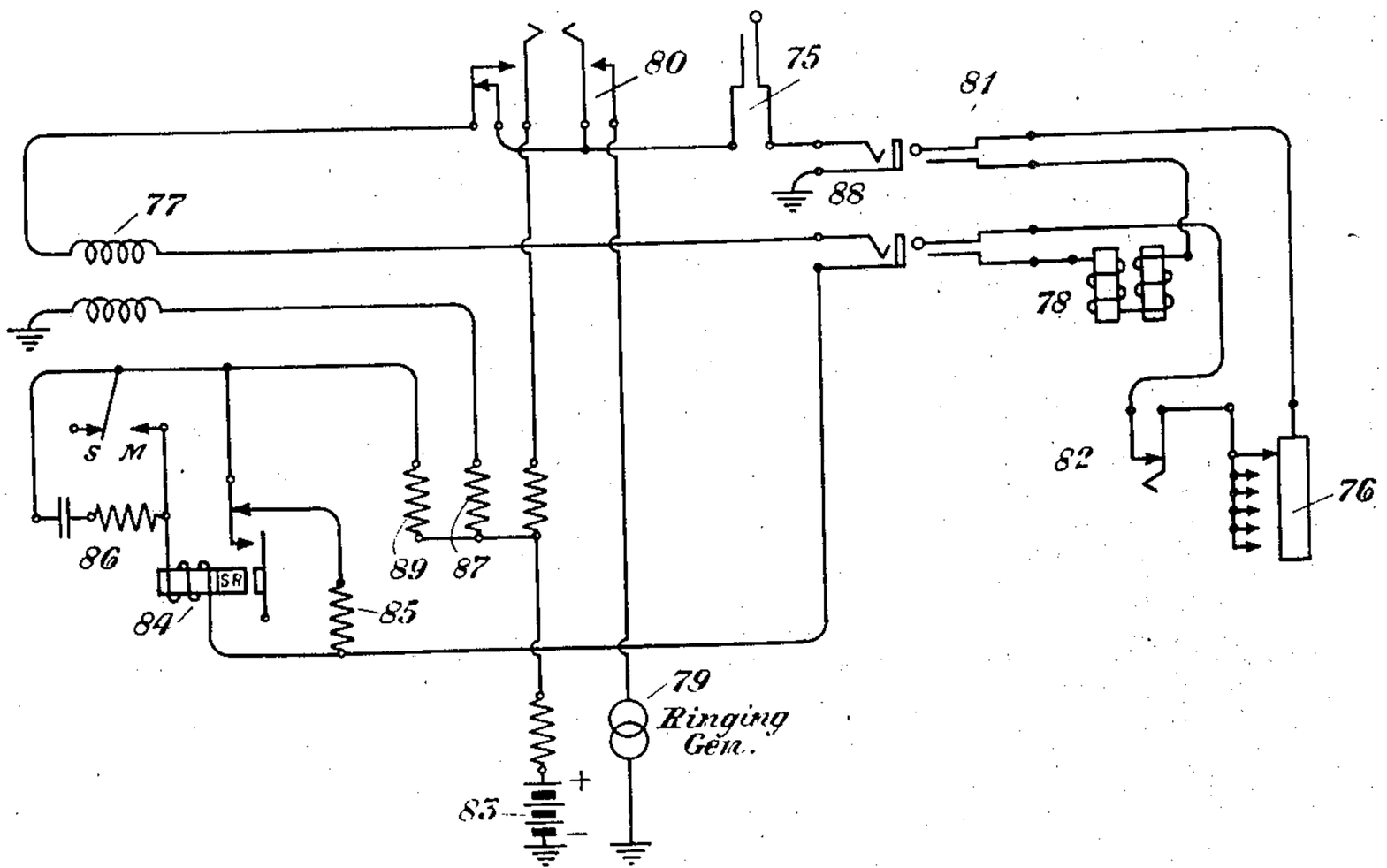

Fig. 5

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TELEGRAPH EXCHANGE SYSTEM

Filed April 3, 1929 4 Sheets-Sheet 4

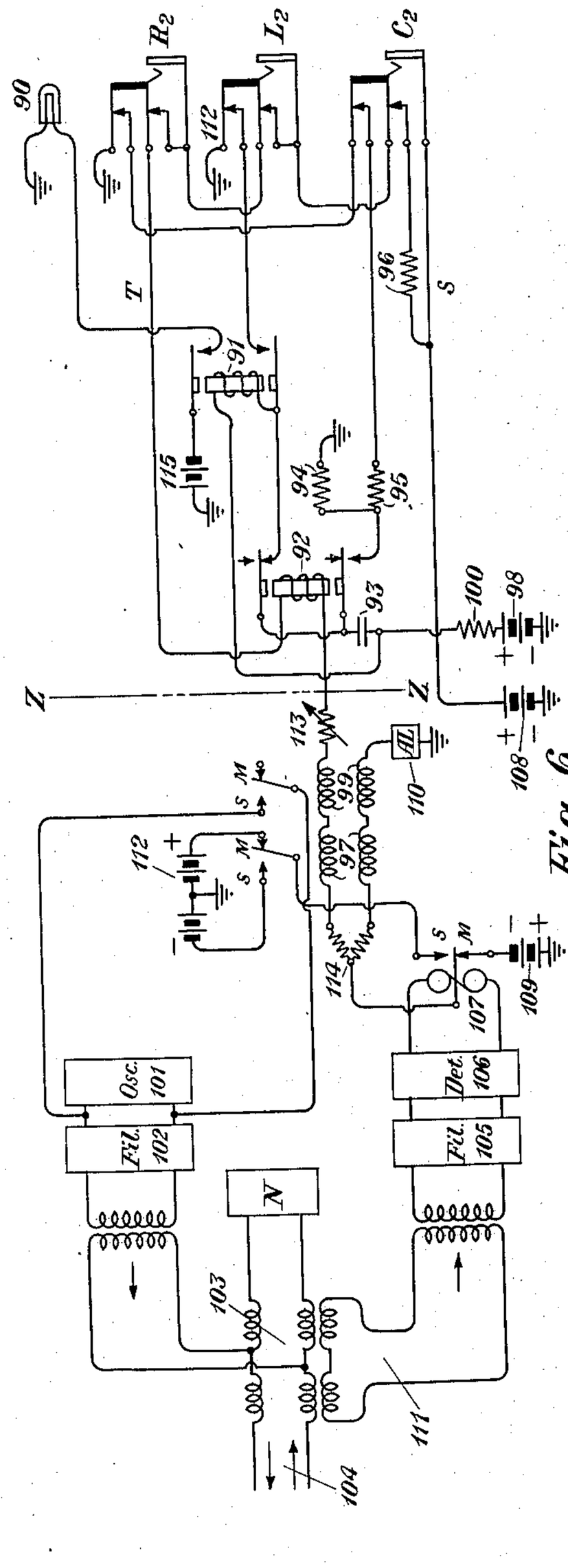

Fig. 6

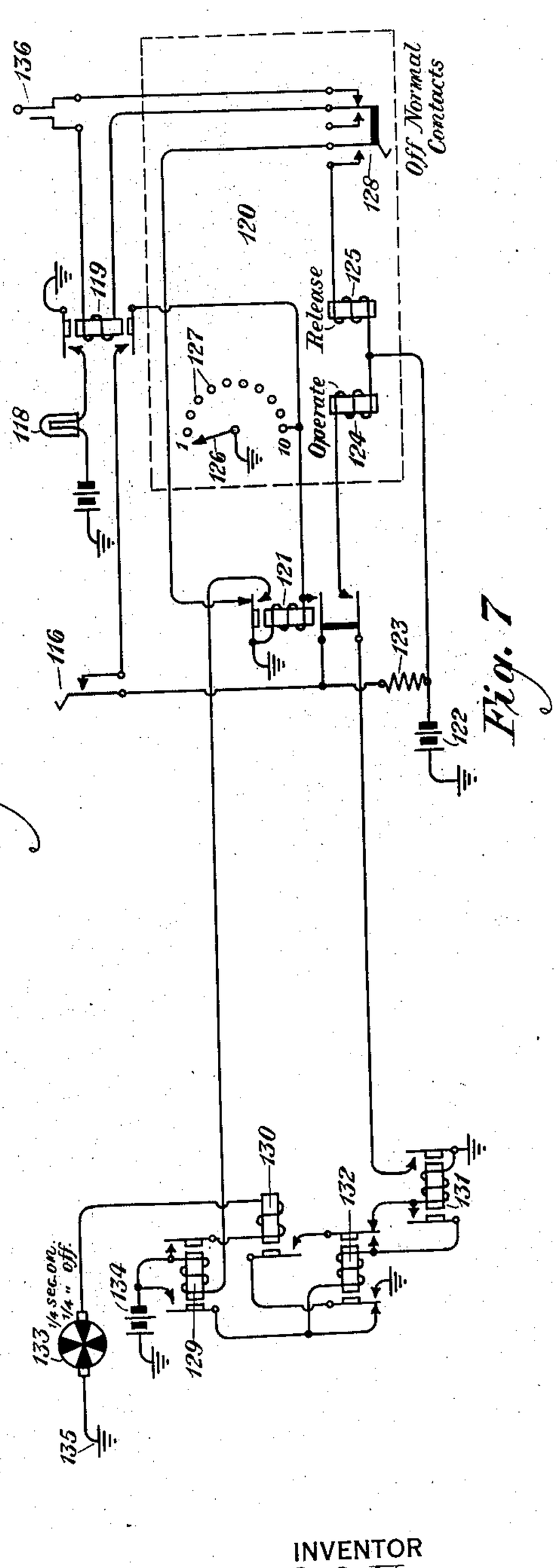

Fig. 7

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UNITED STATES PATENT OFFICE

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TELEGRAPH EXCHANGE SYSTEM

Application filed April 3, 1929. Serial No. 352,136.

This invention relates to switching systems, and more particularly to such systems as applied to telegraph circuits, and discloses an exchange system applicable principally to the use of printing telegraph equipment, by means of which connections may be established quickly and efficiently for communication purposes between any of a plurality of subscribers' telegraph stations, and further by means of which such connections are to remain thus established for more or less temporary intervals in accordance with the wishes of the subscribers.

In short, the invention aims to provide between subscribers' telegraph stations the same type of service that is now provided between telephone stations. At the present time, any telephone user may obtain a connection with any other such user by merely signaling the operator. In a similar manner, the telegraph exchange system disclosed herein provides means whereby any telegraph station served by the exchange system may obtain connection with any other such station by merely signaling the operator at a central office to which the telegraph station is connected.

Accordingly, a primary object of the present invention is to disclose a flexible switching system for quickly establishing and tearing down communication circuits between any of a plurality of subscribers' printing telegraph stations, or between a subscriber's station and an operator's printer set located at a central office.

Another object of the invention is to disclose suitable signaling means associated with such a switching system whereby a subscriber may signal an operator, or vice versa, or whereby an operator may signal a distant operator.

Other objects of the invention will appear in the subsequent detailed disclosure.

The telegraph exchange system, broadly speaking, comprises a group of subscribers' telegraph stations each connected to a given central office over a loop circuit, with other groups of subscribers' stations similarly connected to other central offices. Telegraph trunk circuits extend between the central offices in question, and link circuits are provided at each central office for connecting any subscriber's line with any other such line in the same office or for connecting a subscriber's line to a trunk circuit for connection to a distant station.

It is felt that a telegraph exchange system of the type outlined will satisfy a long-felt need due to the limitations of the present types of telegraph service available to the telegraph user. At the present time, the telegraph user must either transmit his messages through the usual public telegraph office or else must lease a private wire to some distant point for a considerable period of time. The former type of service is, of course, intended for the occasional message, while the latter type of service is intended for the user who has a large amount of daily business with a single distant station.

Since a telegraph user is in general located at some distance from the public telegraph office, delay and possible error is introduced by handling messages in this way. The leased wire, while expeditious, is expensive and provides communication only with a single distant station. Now, it is felt that there are a large number of telegraph users who have not enough business with a given point to render a private wire thereto economical, and who at the same time have business of such a character that the messages must be transmitted expeditiously.

To a telegraph user of this type, the telegraph exchange system disclosed herein would furnish a solution of the problem. By having his office equipped with a printing telegraph sending and receiving set, such a user could be connected directly to a desired distant station for any desired period of time during which he had business to transact. During this period, the user would have in effect a private line to the distant point. His business could, therefore, be transacted expeditiously and yet he need pay for the telegraph service only during the time he actually used the same. During other intervals, the trunk circuits extending between offices would be rendered available to the use of other stations.

Having thus broadly outlined the purpose and scope of the present invention, the detailed operation of the same will now be considered with reference to the drawings, of which:

Figure 1 shows in schematic form the essential elements of a complete telepgraph exchange system embodying the novel features of the present invention. Fig. 2 shows the circuit diagram of a subscriber's loop circuit including the apparatus associated with the loop at the central office as well as at the subscriber's station. Figs. 3 and 4 show link circuits or connecting cords which are used in establishing connections between subscribers' lines, between trunk circuits or between a subscriber's line and a trunk circuit. Fig. 5 shows the circuit diagram of an operator's printer set by means of which the operator may communicate with a subscriber or another operator. Fig. 6 shows the circuit diagram of one end of a trunk circuit used for establishing connections between subscribers having loop circuits connected to different central offices. Fig. 7 shows a special circuit arrangement for transmitting a long break signal of predetermined length over a trunk circuit in order to transmit a disconnect signal to a distant operator.

General features of system

The telegraph exchange system shown in Fig. 1 comprises three central offices A, B and C. Telegraph trunk circuits 1 and 2 connect offices A and B, while trunk circuits 3 and 4 connect offices B and C. Office B is assumed to be situated at an intermediate point between offices A and C, and hence no trunk circuits extend directly from office A to office C. A plurality of subscribers' stations 5, 6 and 7 are connected over individual loop circuits to office A. Similarly, subscribers' stations 8 and 9 are connected to office B, and stations 10 and 11 to office C. Each central office is equipped with an operator's set 13 similar to that shown in Fig. 5, and a disconnect signal circuit 14 similar to that shown in Fig. 7. Each central office is equipped with a plurality of connecting cords 15 and 16 for establishing connections between the subscribers' stations, subscribers' stations and trunk circuits, or between trunk circuits. The repeater cords 16 are used for connecting subscribers' lines which terminate in the same office, or for interconnecting trunks on built-up connections while connecting cords 15 are used for connecting a subscriber's line to a trunk circuit.

Each subscriber's loop circuit and each trunk circuit terminates at the central office in a group of three jacks marked R, L and C on the drawing. Jack R is the "repeater" jack and is intended to receive a plug from a repeater cord 16, while jack C is the "connecting" jack and is intended to receive a plug from a connecting cord 15. Jack L is the "listening" jack and is intended to receive the plug of the operator's set 13 or the disconnect signal circuit 14. The rectangles 12 indicate the signaling and switching apparatus associated with the subscribers' loop circuits at the central office, while rectangles 23 indicate similar apparatus for the trunk circuits.

The manner of establishing a connection between local subscribers' stations is shown for stations 6 and 7, the connection being established by connecting the repeater cord 17 between the repeater jacks of the respective loop circuits. A trunked circuit connection between distant subscribers is indicated as established between stations 11 and 8. At office C, connecting cord 22 extends between the connecting jack for station 11 and the connecting jack of trunk 4, while at office B connecting cord 23 extends from the connecting jack of the trunk to the connecting jack of station 8. A built-up connection between distant stations is shown established between stations 5 and 10. This circuit is completed from station 5, over connecting cord 18, trunk circuit 2, repeater cord 19 at office B, trunk circuit 3 and connecting cord 20 to station 10.

With the exchange system to be described it is possible to establish so-called "conference" connections, i. e., a connection involving more than two subscribers' stations. A connection of this type is indicated for stations 5, 9 and 10, station 9 being associated with the circuit connecting stations 5 and 10 by means of the connecting cord 21 plugged into the connecting jack of trunk 3 at office B. These conference connections may be established between subscribers' lines terminating in the same office as well as on trunked circuit connections.

Local connection

The explanation given above in connection with Fig. 1 furnishes a general picture of the exchange system operation as a whole. The individual types of circuit connections will now be taken up in detail by first considering a local connection, i. e., a connection between two subscribers having loop circuits terminating in the same central office. A connection of the type here contemplated is similar to that shown in Fig. 1 between stations 6 and 7.

Referring to Fig. 2 which shows the subscriber's loop circuit, the equipment to the left of the line x—x is located at the central office, while the equipment to the right of line y—y is located at the subscriber's station. The equipment at the subscriber's station comprises a printing telegraph sending unit 30 and a receiving unit 31, a break key 37, a switch 33 for starting the printer set motor 32 and also for signaling the central

station, a bell 34 whereby the central station may signal the subscriber's station, and a switch 36 the functions of which will be explained later.

At the central station the loop circuit terminates in the jacks R_1, L_1 and C_1, the subscripts 1 being utilized to distinguish the loop circuits from the trunk circuits discussed later, the jacks of the latter circuits being designated by subscripts 2. A line lamp 39 is associated with the jacks whereby the subscriber may signal the central station, and there is an auxiliary signal circuit 40 controlled by the circuit of lamp 39. In addition, there are provided several relays, to be discussed, for operating the signaling circuits.

The repeater cord which is necessary for establishing a connection between local subscribers' lines is shown in Fig. 4. This cord contains a two-way telegraph repeater circuit for repeating signals in either direction between lines to which it is connected by means of plugs 69 and 70. The repeater unit comprises a group of four polarized relays 65 to 68, inclusive, each having line and auxiliary windings interconnected as shown. The auxiliary windings are supplied with current from the power source 71, as indicated. A detailed explanation of the operation of this repeater station will not be given in this application, since a repeater of this type is fully described in the U. S. Patent No. 1,479,430, to J. M. Fell, dated January 1, 1924, which patent is hereby made a part of the present application as if fully included herein.

Fig. 5 shows the printer circuit of the operator's set which is used in communicating with subscribers in establishing connections. The operator's set terminates in a plug and cord 75 so that it may be connected to the jack of a subscriber's line for communication purposes. In series between the tip and sleeve of the plug 75 are the sending contacts 76 of the printer sending unit, the break key 82, and the polar relay 77 which operates the receiving unit of the printer, together with a key 80 which is used for ringing on the subscriber's line, as explained below. The element 78 is the printer selecting magnet which controls the operation of the printer receiving unit including the selection of characters, this printer magnet 78 being in turn controlled by the line relay 77, as explained below.

Having briefly discussed above the various circuit elements involved in establishing a connection between local subscribers' lines, the manner in which this connection is established will now be taken up. Referring again to Fig. 2, assume that the subscriber desires to initiate a call. This is accomplished by operating key 33, which connects the source of power 41 to the printer motor 32 and thus starts the motor. In addition, the operation of key 33 completes a circuit to light line lamp 39 at the central office. This circuit is traced from battery 50 at the central office, through the non-operated contacts of the jacks C_1 to L_1, in series, respectively, through the upper winding of relay 53 and over the S conductor of the loop circuit 60 to the subscriber's station, and thence through the lower operated contacts of key 33, through left and right non-operated contacts of switch 36, through the printing telegraph receiving and sending units 31 and 30, respectively, and break key 37 of printer 57, through left non-operated contacts of key 36, back over the T conductor of loop 60, to the central station, through contacts of jacks M and N and over lead 63 thereat, through the lower back contact and armature of relay 54, upper non-operated contact of jack C_1, upper armature and back contact of relay 54 to ground through the left armature and back contact of relay 52. Current flowing in this circuit operates relay 53 at the central office, which completes a circuit through its front contact and armature to operate relay 52. The operation of relay 52 completes a circuit from battery 64, through the right inner front contact and armature of relay 52, through lamp 39 and relay 45 to ground. Lamp 39 lights over this circuit, and relay 45 operates and completes the auxiliary signal circuit 40 to light pilot lamp 42.

The pilot lamp 42 lights every time a call is initiated on any loop circuit connected to the switchboard, due to the fact that the operating circuits for the lamp 39 individual to all the loop circuits are multipled to relay 45 as indicated by lead 49. Thus, the pilot lamp 42 indicates to the operator every time a call is initiated, while the individual lamp 39 shows the particular loop circuit initiating the call. If desired, the operation of relay 45 may be made to operate a buzzer circuit by merely operating key 44 to connect relay 46 in series with the lamp 42. With this arrangement, when relay 45 operates, lamp 42 will light, and also relay 46 will operate to close the circuit containing battery 48 in series with buzzer 47. The buzzer will thus operate and serve as a warning that a call is waiting on one of the loop circuits.

The operator at the central office answers the call by inserting plug 75 of her set, Fig. 5, in jack L_1 of the subscriber's line. This extinguishes the lamp 39 and connects the operator's printer set to the loop circuit for communication with the subscriber's printer. Upon insertion of plug 75 in jack L_1 a circuit is completed to operate relay 54 to ground through the lower operated contacts of jack L_1. Upon operation of relay 54 a circuit is completed from negative battery 50, through the tip lead of jack L_1 and plug 75, through the operator's printer set, and back through

the sleeve conductor of plug 75 and jack L_1, through the upper winding of relay 53 and out over the S conductor of the loop circuit, through the subscriber's printer set in the manner traced above, and back over the T loop conductor to the central office, through contacts of jacks M and N, and through the lower winding of relay 53, and through the lower front contact and armature and upper armature and front contact of relay 54 to positive battery 51. This current flowing through both windings of relay 53 causes the release of the relay which, it will be noted, is differentially wound. Upon the release of relay 53 relay 52 releases, in turn disconnecting battery 64 from lamp 39, which extinguishes the lamp.

The operator now operates the printer set of Fig. 5 to send the word "operator" or "opr", which is typed up on the receiving unit 31 of the subscriber's printer. The subscriber then answers by operating the sender unit 30 to transmit to the operator's printer set information regarding the called subscriber's line. The operator, having obtained this information, connects plug 70 of a repeater cord (Fig. 4) in the repeater jack R_1 of the calling subscriber's line and connects plug 69 thereof in jack R_1 of the called subscriber's line. Both the calling and called subscribers, of course, have loop circuits similar to Fig. 2. The insertion of plug 69 in jack R_1 of the called subscriber's line operates relay 54 to ground through the operated contacts of the jack. The operation of relay 54 completes a circuit to light lamp 39 of the called subscriber's line. This circuit is traced from positive battery 51 through operated contacts of relay 54 and non-operated contacts of jack C_1, through the lower winding of relay 53 and out over the T conductor of the loop to the subscriber's station, through left non-operated contacts of key switch 36 thereat, through the printer unit 57, through right and left non-operated contacts of key switch 36 to ground 61 through lower non-operated contacts of switch 33. Relay 53 operates over this circuit and completes the circuit to operate relay 52, as explained above, and the operation of relay 52 in turn lights lamp 39.

The operator now removes plug 75 from jack L_1 of the calling subscriber's line and inserts it in jack L_1 of the called subscriber's line and rings on the circuit by operating ringing key 80 of Fig. 5. The operation of key 80 completes a circuit from the ringing generator 79, through the right operated contacts of switch 80, through the sleeve contacts of plug 75 and jack L_1 of the called subscriber's line, through the upper winding of relay 53 and out over the S conductor of the loop to the called subscriber's station and through the ringer 34, condenser 35 and non-operated contacts of switch 36 thereat to ground 61 through switch 33. The ringing current thus rings the bell 34 at the called subscriber's station.

The called subscriber answers by operating switch 33 associated with the printer set thereat to start the printer set motor 32. The operation of key 33 at the called station extinguishes lamp 39 associated with that station, since now current flows from negative battery 50 through non-operated contacts of jack C_1, through the line section of the repeater circuit associated with plug 69 inserted in jack R_1, through the operator's set connected to jack L_1, through the upper winding of relay 53 and over the subscriber's loop circuit, as explained above, back through the lower winding of relay 53 and through operated contacts of relay 54 to positive battery 51. The current in both windings of relay 53 releases the same, as explained, which in turn causes lamp 39 to be extinguished.

The called subscriber now acknowledges the call in some way, as by sending his number on the printer, which is received on the printer sets of both the operator and the calling subscriber. The operator monitors on the connection until the parties are in satisfactory communication, and then disconnects her set by removing plug 75 from jack L_1 of the called subscriber's line.

When the call is completed both subscribers restore switches 33 to their normal positions, as shown in Fig. 2, which stops the printer set motors thereat and also opens the circuit of the S loop conductor at the contacts of switch 33, which prevents the further flow of direct current in the upper winding of relay 53. The current flowing through the lower winding thereof thereupon re-operates the relay which, in turn, causes the lighting of lamp 39 associated with the loop. The operator, upon noting the lighted lamps 39, disconnects the repeater cord from the R_1 jacks of the calling and called subscribers' lines, thus restoring all equipment to normal.

Trunk circuit connection

The establishment of a trunked circuit connection is somewhat different from that outlined above for a local connection. Referring for a moment to Fig. 1, it will be recalled that a trunked circuit connection is one of the type indicated for stations 11 and 8 of Fig. 1. In this case the stations desiring connection have loop circuits terminating in different central offices so that a trunk circuit is required in completing the connection between stations.

The connecting cords used for establishing a connection of this type are shown in Fig. 3, and each cord consists merely in a pair of plugs connected tip to tip and sleeve to sleeve.

The circuit diagram of one termination of

a trunk circuit is shown in Fig. 6. It is only necessary to show the termination of the trunk circuit at one central office, since it is identically terminated at each office between which it extends. Referring to the drawing, the trunk terminates at each office in three jacks R_2, L_2 and C_2. These jacks correspond to the repeater, listening and connecting cord jacks, respectively. As was mentioned above, the subscript 2 is used in this case merely to distinguish the jacks from the corresponding jacks of a subscriber's line (Fig. 2) which have the subscript 1. The equipment shown to the right of the line *z—z* in Fig. 6 is novel to the present invention, whereas that to the left of the line *z—z* comprises standard telegraph equipment which is well known to the art. The trunk circuit shown utilizes alternating carrier current for transmitting the telegraph signals over the trunk circuit, although any other method of signal transmission would be quite satisfactory for the present purpose.

The equipment to the left of the line *z—z* serves to convert the D. C. telegraph pulses into A. C. carrier current pulses for transmission over the telegraph line 104 to the distant end thereof, and also serves to convert the A. C. carrier pulses received from the distant end of the line into D. C. telegraph pulses. Thus, with the printer set connected to jack L_2, R_2 or C_2 the operation of the sender unit will cause corresponding carrier current pulses to be transmitted over line 104. On the other hand, carrier current pulses received over the line will be converted into D. C. pulses suitable for operating the receiving unit of the printer set.

No detailed explanation will be given herein as to the method of operation of the carrier translating equipment as a circuit of this general type is fully discussed and explained in U. S. Patent No. 1,469,259, to B. P. Hamilton, dated October 2, 1923. Specifically, Fig. 1 of the Hamilton patent discloses a circuit arrangement almost identical with that shown to the left of line *z—z* (Fig. 6).

To explain briefly, however, how the circuit operates, assume plug 75 of the operator's printer set 5 to be inserted in jack L_2 of Fig. 6. This will complete a circuit from positive battery 108, through resistance 96, equivalent to the resistance of a subscriber's loop circuit, through non-operated contacts of jack C_2, through the operator's printer set connected to jack L_2, and back through non-operated contacts of jack R_2, through relay 92, resistance 113 and the line windings of relays 99 and 97, the upper arm of impedance bridge 114, and the armature and marking contact of polar relay 107 to ground through negative battery 109. Current flowing in this circuit operates relays 99 and 97 against their marking contacts, as indicated. A second current flows from negative battery 109 through contacts of relay 107, through the lower arm of impedance bridge 114, and the auxiliary windings of relays 97 and 99 to ground through artificial balancing line 110. This current tends to operate relays 97 and 99 against their spacing contacts, but being of only half the magnitude of that flowing in the line windings the armatures of these relays will remain against their marking contacts. If now, a message is transmitted from the operator's printer set the interruption of the sending contacts thereof by interrupting the current in the line windings of relay 97 and 99 will permit the current in the auxiliary windings to move the armatures thereof against their spacing contacts, and thus the armatures of these relays will follow the signals transmitted from the operator's printer set.

Relay 99 is the sending relay which, by alternately closing and opening the short-circuiting path across the output of oscillator 101, controls the transmission of current from the oscillator through band-pass filter 102, through hybrid coil 103, and out over line 104, in accordance with signals transmitted from the operator's printer set.

Carrier current signaling pulses received over line 104 from the distant point flow through hybrid coil 103 into receiving circuit 111, and thence through band-pass filter 105 into detector 106. The rectified current in the detector circuit flows through relay 107 and operates the same in accordance with the signals received. Relay 107 has normally negative battery 109 connected to the marking contact, and positive battery 112 supplied to the marking contact and armature of relay 97 connected to the spacing contact. As relay 107 operates, therefore, in accordance with the received signaling currents, it connects in series with the positive battery 108 through the operator's printer set, alternately negative battery 109 and positive battery 112. Thus, while relay 107 rests on its marking contact current flows through the operator's printer set, and while it rests on its spacing contact no current flows therethrough since positive battery 112, which is equal in magnitude to positive battery 108, opposes the same through the operator's printer set and thus prevents the flow of current therethrough. The line relay 77 of the operator's printer set will, therefore, follow the received signaling pulses and cause the received message to be typed up due to the resulting operation of the selecting magnet 78.

Relays 97 and 99 are not operated by the received signaling pulses since with relay 107 on its marking contact, the flow of current through the line windings of these relays operates the same against their marking contacts, whereas with relay 107 on its spacing contact, no current flows in the line windings of relays 97 and 99 and the reversed current

due to positive battery 112 flowing through the auxiliary windings thereof holds the same operated against their marking contacts.

Relay 97 is a break relay and comes into play when the operator at the local end of the trunk transmits a break signal while local relay 107 is operating in accordance with received signaling pulses. Under these conditions, relay 97 operates in such manner as to maintain relay 99 against its spacing contact during transmission of the break signal, and thus permits the local operator to transmit a clean break signal to the distant point. The manner in which this is accomplished is fully set forth in the patent to Hamilton mentioned above, to which reference is made at this point for a more complete description of the circuit operation.

Returning now to the establishment of a trunked circuit connection between distant subscribers' stations, the call is initiated in the manner described above for a local connection. Referring to Fig. 2, the calling subscriber operates switch 33 to start the printer set motor at the calling station and to signal the central office. The operator at the central office responds by connecting her set to the L_1 jack of the calling subscriber's line and obtains the necessary information in regard to the called station.

When the operator has learned that the call is intended for a station connected to a distant office, she inserts one end of a connecting cord (Fig. 3) in the C_1 jack of the calling subscriber's line, and inserts the other end thereof in the C_2 jack of an idle trunk (Fig. 6) terminating at the desired office. The operator then signals the distant office by operating the break key 82 for about one-half to one second which causes the line lamp 90 at the distant end of the trunk to light.

The operation of the break key interrupts current flowing in the circuit traced from positive battery 108 in the local end of the trunk, jack C_2 and sleeve conductor of the connecting cord, jack C_1, calling subscriber's loop circuit, sleeve conductor of jack L_1, operator's set (Fig. 5), tip conductor of jack L_1, non-operated contacts of jack R_1, jack C_1 and tip conductor of connecting cord, jacks C_2, L_2 and R_2, winding of relay 92 and through the sending relay 99 to ground at negative battery 109. Relay 99 is thus operated against its spacing contact causing transmission of a break signal to the distant end of the trunk.

Since no plug is inserted in jack R_2, L_2 or C_2 at the distant end of the trunk, relay 92 thereat is normally operated over the circuit traced from positive battery 108, through resistance 96, and in series through non-operated contacts of the jacks, the winding of relay 92 and thence through the intermediate equipment to ground through negative battery 109. When, however, the break signal transmitted from the calling end of the trunk arrives at the distant end, it operates relay 107 thereat against its spacing contact. This substitutes positive battery 112 for negative battery 109, and the positive battery 112 opposes the positive battery 108 through the winding of relay 92 and thus causes the release of the relay.

Now, relay 92 controls the circuit for operating relay 91, which in turn controls the lighting of lamp 90. Associated with relay 92 are the condenser 93 and resistance elements 94 and 95. While relay 92 is operated no charge can accumulate on condenser 93 since both terminals thereof are connected to battery 98, one terminal being connected directly thereto through resistance 100, and the other terminal being connected thereto through the winding of relay 91 and the upper front contact and armature of relay 92. When, however, relay 92 releases, as explained above, due to the reception of the break signal, the upper terminal of condenser 93 will be disconnected from battery 98 at the upper contacts of relay 92 and in place thereof will be connected to ground through the armature and lower back contact of the relay and through resistance elements 94 and 95 in parallel. As a result, while relay 92 is released, the condenser 93 will slowly charge up to the potential of battery 98, so that if the break signal is transmitted long enough the condenser will be fully charged to the battery potential when relay 92 is reoperated at the termination of the break signal. The combined resistance of elements 94 and 95 in parallel is such that for the circuit indicated the condenser 93 will be fully charged in about one-half to one second.

After the operator at the calling office has held break key 82 thereat operated for the desired length of time she releases the same, causing relay 99 thereat to move against its marking contact and transmit a marking signal to the distant end of the trunk. The marking signal, upon arriving thereat, operates relay 107 against its marking contact, thus causing a reoperation of relay 92. The operation of relay 92 reconnects the winding of relay 91 across the terminals of condenser 93 so that the condenser discharges through the relay winding and operates the same momentarily. As soon as relay 91 thus operates it completes a locking circuit for itself. This circuit is traced from positive battery 98 through the winding, lower armature and front contact of relay 91 to ground 112 through non-operated contacts of jack L_2. Relay 91, upon operating, connects battery 115 to lamp 90, thus lighting the lamp at the distant end of the trunk. Lamp 90 may, if desired, be wired through an auxiliary signaling circuit similar to that shown at 40 of Fig. 2.

Relay 92 at the calling end of the trunk

will be likewise released during transmission of the break signal, but will not cause the operation of relay 91 to light lamp 90 thereat upon termination of the break signal. The explanation of this difference in operation at the calling and called ends of the trunk is to be found in the different rate at which condensers 93 are charged at the two ends.

It will be noted that resistance 95 normally obtains ground through non-operated contacts of jacks C_2 and R_2 in series. With no plug inserted in jacks R_2 or C_2 the condenser 93 is charged through resistances 94 and 95 in parallel, in which case the condenser will be charged to the full potential of battery 98 in one-half to one second. If, however, a plug is inserted in jack R_2 or C_2 the ground is disconnected from resistance 95, so that condenser 93 must charge through resistance 94 only. Now, resistance 94 is very much larger than resistance 95, and in fact, is so proportioned with respect to the capacity of condenser 93 as to require six to eight seconds for charging the same to the full potential of battery 98.

Returning now to the circuit connection under consideration, it will be recalled that the plug of a connecting cord is inserted in the C_2 jack at the calling end of the trunk, while no plugs are inserted in any of the jacks at the called end. Thus the transmission of a break signal of one-half to one second duration in the manner explained above will permit a full charge to accumulate on condenser 93 at the called end of the trunk, but only a small charge to accumulate on the corresponding condenser at the calling end. As a result upon termination of the break signal, relay 91 will be operated at the called end to light lamp 90 thereat, but will not operate at the calling end due to the small current discharge therethrough from condenser 93.

Incidentally, at this point it is well to bring out the fact that the insertion of a plug in an L_2 jack of the trunk will prevent more than a momentary lighting of lamp 90 at the corresponding end of the trunk, due to the fact that the locking circuit for relay 91 obtains ground at 112 through non-operated contacts of jack L_2. The insertion of a plug in this jack of course disconnects the ground and prevents the relay from locking up.

In a specific design the following constants were used for the elements 93, 94 and 95. Capacity 93 was taken as 2 mf., resistance 94 as 2 megohms and resistance 95 as 100,000 ohms.

Returning now to the establishment of the connection with the called subscriber over the trunk circuit, the operator at the distant end of the trunk, upon noting the lighted lamp 90, inserts plug 75 of her operator's set, similar to Fig. 5, in jack L_2 of the trunk, which removes the ground 112 from relay 91 thereat and extinguishes lamp 90. The distant operator then communicates with the calling operator and obtains the number of the called line. If the called line is idle the distant operator inserts a plug of a connecting cord (Fig. 3) in the C_2 jack of the trunk circuit and inserts the other end of the cord in the C_1 jack of the called subscriber's line and operates the ringing key 80 of her operator's set which, it will be recalled, is still connected in the L_2 jack at the distant end of the trunk. The ringing current in this case flows from the generator 79 (Fig. 5) through the right operated contacts of key 80, through the sleeve circuit of plug 75 and jack L_2 (Fig. 6) and out over the tip conductor of jack C_2 (Fig. 6) and through the tip conductor of the connecting cord (Fig. 3) to the tip terminal of jack C_1 (Fig. 2), through non-operated contacts of jacks R_1 and L_1, the upper winding of relay 53 of the called subscriber's line, out over the S conductor of the loop and through ringer 34 to ground 61 at the called subscriber's line. The ringer 34 thus operates to signal the called subscriber that a call is waiting on the line. It will be noted that while key 80 (Fig. 5) is operated, positive battery 83 is connected through the left operated contacts of key 80 to the tip of plug 75. This battery 83 replaces the positive battery 108 of the trunk circuit during the ringing operation and hence prevents the transmission of a break signal back over the trunk circuit during the ringing interval. Owing to the make-before-break arrangement of the left contacts of key 80, battery 83 is connected to the trunk circuit before battery 108 is disconnected, thus avoiding any possibility of current interruption during operation of the key 80.

Upon establishing connection with the called subscriber's line by inserting a connecting cord between jacks C_2 of the trunk and C_1 of the called line, and before the called subscriber has answered by operating switch 33 at the called station, a circuit is completed to operate relay 53 in the called line. This circuit is traced from positive battery 108 in the trunk circuit, through the sleeve circuit of jack C_2, connecting cord and jack C_1 of the called line, lower winding of relay 53 and over the T loop conductor to ground 61 at the called subscriber's station. The operation of relay 53 in turn operates relay 52 as explained which lights lamp 39 associated with the called line.

In addition, the operation of relay 52 at the time completes a circuit from positive battery 51, right outer front contacts of relay 52, resistance 59, non-operated contacts of jacks L_1 and R_1, tip conductors of jacks C_1, the connecting cord and jack C_2 of the trunk circuit, the operator's set connected to jack L_2, non-operated contact of jack R_2, and windings of relays 92, 99 and 97 to ground through negative battery 109. Current flowing in this circuit maintains relay 99 at the

called end of the trunk operated against its marking contact, and hence prevents transmission of a break signal back over the trunk circuit at this time. Were it not for this feature, a break signal would be transmitted to the calling end of the trunk which would cause a charge to accumulate on condenser 93 thereat as explained and might possibly cause the operation of line lamp 90 thereat upon the subsequent operation of switch 33 at the called station to prevent further transmission of the break signal as explained below. Resistance 59 is given a value about equal to that of the subscriber's loop resistance.

When the called subscriber answers, the operation of switch 33 at the called station connects the loop circuit between batteries 109 and 108 of the trunk circuit, which causes the same current to flow through both windings of the differential relay 53. Relay 53 thereupon releases, in turn releasing relay 52, which extinguishes lamp 39 and opens the circuit traced above for supplying current to the trunk circuit from battery 51 through resistance 59.

The called subscriber now operates his printer to acknowledge receipt of the call, which acknowledgment is typed up on the printers of the operators' sets associated with both ends of the trunk and also on the calling subscriber's printer. The operators monitor on the connection until the calling and called parties are in satisfactory communication, whereupon they disconnect their sets.

During communication the subscribers may break each other in the usual way, but these break signals will in general not operate the lamps 90 associated with the trunks, since as explained, with connecting cords in the C_2 trunk jacks, a break signal of say eight to ten seconds duration is required to insure complete charging of the condensers 93, and the average length of a subscriber's break signal is in general of considerably less duration than eight to ten seconds. If, perchance, the line lamps 90 are operated subsequent to an exceedingly long break signal, it will merely result in the operator's coming in and monitoring on the connection for a short interval.

While the subscribers are thus connected to the trunk, an operator may, if desired, bring in the distant operator by causing a break signal of eight to ten seconds to be transmitted over the trunk which will light the distant line lamp 90 as explained. This long break signal could be transmitted by associating the operator's set with the L_2 jack and holding break key 82 operated continuously for the required interval. Lamp 90 at the calling end would not operate, since the insertion of the plug 75 in the jack L_2 would open the locking circuit for relay 91, as explained. A better method for transmitting such a break signal is provided by the circuit of Fig. 7. The operating details of this circuit will be explained below. At this point it is sufficient to state that the circuit will transmit a break signal of exactly ten seconds duration (or for a different interval if desired) and will operate a signal to inform the operator when the break is completely transmitted. To transmit the break signal, plug 136 (Fig. 7) is inserted in the L_2 trunk jack and key 116 operated momentarily.

When the call is completed, both subscribers restore their switches 33, which relights the respective lamps 39 at the central offices, due to the flow of current through the lower windings of relays 53 only. The operators at both offices, upon noting the lighted lamps, disconnect the connecting cords from the loop and trunk jacks.

Built-up connection

A built-up connection is necessary when there are no trunks extending directly between the central offices to which two distant subscribers desiring communication are connected. In such a case it is necessary to extend the connection through one or more central offices intermediate to those at which the calling and called lines terminate. A built-up connection is shown in Fig. 1 extending between stations 5 and 10.

Assuming station 5 to be the calling station, the procedure in establishing the connection as far as office B is the same as that outlined above for a trunk circuit connection. The operator at office B, upon receiving the signal due to the lighting of line lamp 90 associated with trunk 2 thereat, connects her set to the L_2 jack of the trunk and obtains the necessary information regarding the called station. The operator at office B then proceeds to complete the connection to the called subscriber's station by first inserting one end of a repeater cord (Fig. 4) into the R_2 jack of an idle trunk 3 extending to the called subscriber's office C and then, after waiting for about one second, plugging the other end of the repeater cord into the R_2 jack of trunk 2, as shown by cord 19 (Fig. 1). The reason why a pause of about one second is made before connecting the free end of repeater cord 19 to trunk 2 is to permit a break signal of sufficient duration to be transmitted over trunk 3 to light the line signal 90 associated with the trunk at office C. If desired, of course, both ends of the repeater cord 19 may be plugged up simultaneously and the usual break signal of one second duration transmitted over trunk 3 to operate the line signal at office C by operation of break key 82 associated with the operator's set at office B, which set, it will be recalled, is still connected to the L_2 jack of trunk 2 thereat. The operator at office C, upon noting the lighted line lamp 90, connects her

operator's set (Fig. 5) to the L_2 jack of trunk 3, thus extinguishing the trunk line lamp. The operator at office C then communicates over the circuit with the operator at office A, who still has her set connected to trunk 2 through the subscriber's circuit and connecting cord at office A, and obtains the necessary information regarding the called subscriber's line. The operator at office C thereupon completes the connection by connecting trunk circuit 3 to subscriber's line 10 by means of a connecting cord 20, and rings the called subscriber as explained above for a trunked circuit connection. Meantime the operator at office B disconnects her set as soon as the operators at offices A and C are in satisfactory communication. The operators at offices A and C remain on the line until the called subscriber answers and is in satisfactory communication with the calling subscriber, whereupon the operators at both offices disconnect.

When the call is complete, both subscribers restore the switches 33 associated with their printer sets, which stops the printer set motors and operates the loop signals 39 at offices A and C. The operators at these offices, upon noting the signals, thereupon remove the connecting cords 18 and 20, respectively, from the loop and trunk jacks. Since, however, the repeater cord 19 is still plugged up at office B, it will be necessary for the operator at office A to signal the operator at office B to tear down the connection. This disconnect signal is transmitted by inserting plug 136 of the circuit (Fig. 7) in the L_2 jack of trunk 2 at office A and momentarily operating key 116. The operation of key 116 will cause the circuit of Fig. 7 to transmit a long break signal of eight to ten seconds duration over the trunk circuit, which will light line lamps 90 associated with trunks 2 and 3 at offices B and C in the manner explained above despite the fact that cord 19 is inserted in the R_2 trunk jacks at office B.

The operation of the disconnect signal circuit of Fig. 7 is as follows:

When plug 136 is inserted in the L_2 jack of the trunk, current normally flowing between batteries 108 and 109 in the trunk circuit now flows into the circuit of Fig. 7 over the sleeve conductor, through relay 119 operating the same, through the off-normal contacts 128 of selector switch 120 and back to the trunk over the tip conductor. The operation of relay 119 connects battery to light line lamp 118, and prepares a circuit through the lower contacts of the relay to operate relay 121. When now, the operator momentarily operates the non-locking key 116, a circuit is completed from battery 122 through resistance 123, operated contacts of key 116, lower front contact and armature of relay 119 and through the winding of relay 121 to ground. Relay 121 thereupon operates and immediately locks up to ground through its lower inner armature and front contact. The operation of relay 121 prepares an operating circuit for the "operate" magnet 124 of selector switch 120. This circuit is traced from battery 122 through the winding of magnet 124, lower outer front contact and armature of relay 121 to the right front contact of relay 131. The operation of relay 121 also completes a circuit through its upper front contact and armature to ground, which causes the operation of relay 129. The operation of relay 129 completes a circuit from battery 134 through the right front contact and armature of relay 129, winding of relay 130, to ground 135 through an interrupter 133 adapted to alternately open and close the circuit for approximate half-second intervals.

The function of the chain of relays 129 to 132, inclusive, is to transform the pulses from interrupter 133 which occur at approximately half-second intervals, into pulses occurring at one-second intervals, which pulses are in turn utilized to step the selector switch 120 around one step for each such one-second pulse. Since the selector switch 120 contains only ten steps 127, this would mean that when the selector switch has been stepped completely around step 1 to step 10, about ten seconds will have elapsed. Interrupters of the type indicated at 133, that is, approximately a quarter-second on and a quarter-second off, are available in almost any central office, whereas interrupters which break the circuit at one-second intervals are in general not available. Hence the necessity of the chains of relays 129 and 132.

Returning now to the circuit operation, the operation of relay 129, as explained, also prepares a circuit for operating relay 131. Thus when interrupter 133 completes the circuit to operate relay 130 the first time, relay 131 will immediately operate on the circuit from battery 134, left front contact and armature of relay 129, left back contact and armature of relay 132, armature and front contact of relay 130, right armature and back contact of relay 132 to ground through relay 131. The operation of relay 131 completes a circuit from battery 122 through the winding of magnet 124 to ground at relay 131 which causes the operation of magnet 124 and thus steps the brush arms 126 of the selector switch around one step. As soon as the selector switch is thus stepped off its normal position, the off-normal contacts 128 are released, which opens the circuit between the tip and sleeve of plug 136. This releases relay 119 to extinguish lamp 118, and also by interrupting the flow of current through relay 99 (Fig. 6) transmits a break signal over the trunk circuit.

When now, relay 130 releases at the end of the first pulse of interrupter 133, it opens the operate circuit traced above for relay

131, but a second circuit to maintain relay 131 operated is now traced from ground through the winding of relay 131, left front contact and armature thereof, winding of relay 132, to battery 134 through operated contacts of relay 129. Relay 132 operates over this circuit and prepares a circuit to release relay 131 upon reception of the next pulse from the interrupter. Thus, when the second pulse from interrupter 133 reoperates relay 130, relay 131 releases due to the fact that a path for short-circuiting this relay is now completed through the right front contact and armature of relay 132, front contact and armature of relay 130, left armature and front contact of relay 132 to ground. The alternate ground thus obtained maintains relay 132 operated. Relay 131 thereupon releases, in turn releasing the operate magnet 124 of the selector switch. At the end of the second pulse from interrupter 133, relay 130 releases, in turn opening at its contacts the holding circuit for relay 132, which also releases, thus restoring the chain of relays 130 to 132 to normal. On receipt of the next impulse of interrupter 133, relay 130 will again operate and initiate a repetition of the cycle of operations traced above, which results in stepping the selector switch ahead one more step. It will therefore be seen that for each two impulses from the interrupter 133, the selector switch brush arms 126 will be advanced one step so that the selector switch is rotated one step for each approximately one-second interval.

The selector switch brush arms 126 will thus reach the tenth step in about ten seconds, in which position the winding of relay 121 will be short-circuited causing the release of the relay. The short-circuiting path is of course traced from the lower front contact of relay 121 through step 10 and brush arms 126 of the selector switch to ground. The release of relay 121 in turn opens the circuit to release relay 129 of the impulse circuit. The release of relay 129 in turn disconnects battery from the chain of relays 130 to 132, inclusive, which restores these relays to normal. Since the selector switch is now off normal, the release of relay 121 completes a circuit to operate the release magnet 125 of the selector switch, the operation of which restores the brush arms 126 to their normal position. The operating circuit for the release magnet 125 is traced from battery 122 through the winding of the release magnet, off-normal contacts 128 to ground through the upper back contact and armature of relay 121.

It will be noted that during the entire period that the selector switch is being stepped around, the circuit is opened between the tip and sleeve conductors of plug 136. Lamp 118 thus remains extinguished and a break signal is continuously transmitted over the trunk circuit to the distant end thereof. When the selector switch of Fig. 7 is restored to normal, as explained, relay 119 reoperates and lights lamp 118. This tells the operator at office A that the break signal has been transmitted, whereupon she disconnects plug 136 from the L_2 jack of the trunk. Upon termination of the break signal, relays 107 (Fig. 6) at offices B and C move to their respective marking contacts, which permits each condenser 93 to discharge through relay 91 thereat and operate the line lamps 90 at offices B and C as explained above. On noting the lighted lamps 90 associated with trunks 2 and 3, the operator at office B inserts plug 75 of her set in the L_2 jack of either trunk which extinguishes lamp 90 associated with the trunk in question in the manner explained above. The operator at office B then challenges on the circuit by sending "office B" or the like on her printer. Upon receiving no response to this challenge, the operator disconnects cord 19 from trunks 2 and 3 and momentarily inserts a plug in the L_2 jack of the other trunk circuit to extinguish line lamp 90 associated therewith. The operator at office C upon noting lighted lamp 90 also connects plug 75 of her set to the L_2 jack of trunk 3 thereat to extinguish the lamp and challenge in a similar manner. Upon receiving no response, she disconnects.

Conference connections

As was mentioned above, it is possible with the exchange system disclosed herein to establish connections which are common to more than two subscribers' stations. Such connections are termed "conference connections." A connection of this type is indicated in Fig. 1 associating stations 5, 9 and 10.

Conference connections may be established which involve local stations, only, i. e., three or more stations having their loop circuits terminating at a given central office. Conference connections may be established which involve local as well as distant stations. In such a case connections are extended over trunk circuits from the distant stations to the office at which the local stations terminate and the plurality of stations are interconnected in a common communication circuit at such office. Finally, conference connections may be established involving distant stations only. For this case individual trunk circuit connections are extended from a plurality of stations to an intermediate office distant from all of the stations, and the various lines are interconnected at such intermediate office.

Conference connections of the first type, i. e. involving local stations only, may be established by means of repeater cords (Fig. 4), using the N jacks as well as the R_1 jacks of the loop circuit (Fig. 2). That is, for a connection involving three local stations, one repeater cord would be connected between

the R_1 jacks associated with two of the loop circuits, and a second repeater cord would be connected from the N jack of one of such interconnected loops and the R_1 jack of the third loop. It will be obvious from this example that this procedure could be extended to include a larger number of stations.

Connections of the second type which involve both local and distant stations may be established using a connecting cord to connect a local station and a trunk circuit by means of the C_1 and C_2 jacks, respectively; the trunk circuit could then be connected to a second trunk circuit using a repeater cord between the R_2 jack of the first trunk and the L_2 jack of the second trunk; the second trunk could then be connected to a third trunk and so on by means of repeater cords extending from the R_2 jack of one trunk to the L_2 jack of the succeeding trunk in the chain; and finally, additional local stations could be added to that already connected by means of repeater cords extending from the R_1 jack of one local station to the N jack of the next local station, and so on.

Connections of the third type involving distant stations only could, of course, be established as indicated above by means of repeater cords each extending from the R_2 jack of one trunk to the L_2 jack of a second trunk.

The insertion of repeater cords in the L_2 jack associated with certain of the trunks would, of course, disconnect the line lamp 90 from such trunks, but a disconnect signal could still be received on other trunks involved in the connection which had no plug inserted in the L_2 jack thereof.

Operating details

If, after a connection has been established with a subscriber's line (Fig. 2), the subscriber desires to signal the operator, this may be accomplished by repeatedly operating and restoring the key switch 36. It will be recalled that after a connection is established, line current flows through both windings of relay 53 at the central office and the relay is thus released. When, however, key 36 is operated, it opens at the upper left contacts of the key the S conductor of the loop and connects the T conductor of the loop to ground 62 through right and left operated contacts of key switch 36. This permits current to flow through the lower winding only of relay 53 at the central office and thus operates relay 52 thereat to light line lamp 39. In this way, by repeatedly operating switch 36, a flashing of the line lamp 39 at the central office may be accomplished to signal the operator thereat.

A further function of switch 36 is to permit the printer unit 57 at the subscriber's station to be operated on local test to see if the printer is operating properly. When switch 36 is operated, battery 38 in series with a suitable resistance is connected in series with printer unit 57, so that the operation of the sending contacts 30 will cause a message to be typed up on the receiving unit 31, and thus a test can be made to determine if the printer is in satisfactory operating condition.

It will be noted that the operation of switch 36 does not prevent the central office from operating the ringer 34 to signal the subscriber's station. With switch 36 in its normal position, the ringer 34 obtains ground at 61, as explained above, through condenser 35. With switch 36 operated, the ringer obtains ground at 62 through condenser 35 and the operated contacts of the switch, so that the operator at the central office, by applying ringing current to the S loop conductor may operate the ringer in any event.

Jack N, in addition to its use in establishing conference connections, as noted above, also provides means whereby printer for monitoring purposes may be associated with the loop circuit at the central office.

In case of trouble to the circuit equipment to the left of line *x*—*x*, the loop circuit may be transferred to spare circuit equipment by patching with a connecting cord similar to Fig. 3 from jack M of the loop circuit in question to jack N of the spare circuit equipment, at the same time inserting a wooden plug, or the like, in jack M of the spare circuit. With such an arrangement, a circuit would be traced from the sleeve conductor of jack N associated with the spare circuit, over the sleeve conductor of connecting cord and through the sleeve conductor of jack M of the original circuit, and over the loop circuit 60 and back through the tip conductor of jack M of the original circuit, the tip conductor of the connecting cord to tip conductor of jack N of the spare circuit, through lower operated contacts of jack M of the spare circuit (due to the insertion of a wooden plug therein) back through the upper operated contacts of jack N of the spare circuit to the upper winding of relay 53 of the spare circuit. The circuit of Fig. 2 as thus patched would operate in the same manner as the circuit shown in the drawing with the exception that the spare equipment to the left of lines *x*—*x* would replace the similar equipment normally connected to the loop circuit.

The condenser 55 in series with a suitable resistance is connected between the left armature and back contact of relay 52 to prevent possible "buzzing" of relays 52 and 53 when the subscriber operates switch 33 to initiate a call. When switch 33 is operated, current flows from battery 50 through upper winding of relay 53, over the loop circuit and back through non-operated contacts of relay 54 to ground through left armature and back contact of relay 52, as explained above. This current operates relay 53 which, in turn, com-

pletes a circuit to operate relay 52, as explained.

The operation of relay 52 maintains relay 53 operated thereafter by replacing the ground obtained through the left armature and back contact of relay 52, with positive battery 51 supplied through the left front contact and armature of relay 52. It will be seen, however, that during the operation of relay 52, the current through the upper winding of relay 53 is momentarily interrupted which might possibly cause relay 53 to fall off and thus release relay 52 before the operation of relay 52 is complete. This would cause the cycle of operations described to start all over again, with the result that relays 52 and 53 would "buzz" continuously thereafter.

To prevent this possible effect, the condenser 55, in series with a suitable resistance, is connected as shown. With relay 52 released, no charge would accumulate on condenser 55. When, now, switch 33 is operated, relay 53 would be energized through its upper winding, as explained, and cause the operation of relay 52. In this instance, however, as the left armature of relay 52 moves off of its back contact, current from battery 50 continues to flow through the upper winding of relay 53 to charge up condenser 55. This flow of current maintains relay 53 operated until the left armature of relay 52 is operated against its front contact, whereupon the positive battery 51 maintains relay 53 operated thereafter. The resistance in series with condenser 55 merely serves to limit this charging current and thus minimizes arcing at the left armature and back contact of relay 52.

The variable resistance 56 is connected in series in the S conductor of the loop circuit in order to adjust the loop resistance to a constant value for all loops. The resistance 72 is inserted in the T conductor, as shown, in order to prevent excessive currents from flowing over this conductor to ground at 61 after the subscriber has switched off by restoring switch 33 but before the operator has disconnected her operator's set repeater cord or trunk circuit from the L_1, R_1 or C_1 jack of the loop circuit, since, for any of these conditions, battery is connected to the T loop conductor at the central office.

With reference to Fig. 6, resistance 96 associated with the C_2 jack is connected in the current supply circuit when the trunk is disconnected and also when an operator's set is connected to the L_2 jack or a repeater cord to the R_2 jack. Under such circumstances, resistance 96 which is equivalent to the resistance of a subscriber's loop maintains the direct signaling current at its proper value. When a loop is connected to the trunk circuit, the insertion of a connecting cord plug in the C_2 jack replaces resistance 96 by the loop circuit.

It is necessary to use the repeater cord for connecting one trunk circuit to another in order to properly close through the D. C. signaling circuits associated with trunks. If two trunks were connected by means of a connecting cord, negative battery 109 in one trunk would oppose negative battery 109 in the other trunk so that spacing signals would normally be transmitted to the distant ends of both trunks.

The operator's printer set indicated schematically in Fig. 5 is of the recently developed, mechanically selected type in which the selection of characters during the actual printing operation is accomplished by mechanical means controlled through the signal magnet 78 operating in accordance with the received signal pulse rather than by means of a group of selecting relays, as is the case of certain well-known types of printers.

The circuit is so arranged that with magnet 78 operated, it prevents rotation of the receiving cams associated with the printer mechanism. During reception of signals, the magnet 78, as will be explained, releases in accordance with the received signaling pulses, and the release thereof, according to the initial or "start" pulse for each character transmitted, permits rotation of the receiving cams once. If, during abnormal conditions, the magnet 78 is released continuously, it will permit continuous rotation of the receiving cams. It is undesirable, of course, owing to wear and tear on the apparatus, to have the receiving cams rotating continuously while the printer set is not in use. For this reason, it is necessary to provide means whereby the magnet 78 is operated continuously while the operator's circuit is disconnected from the line, as well as to have it operated continuously while connected to a line and no signals are being received. The slow release relay 84 controls a circuit for maintaining the magnet 78 operated while plug 75 is disconnected from a subscriber's line or a trunk circuit, as will now be explained.

When the plug 75 is inserted in the jack of a subscriber's line or of a trunk circuit, the current supplied therefrom, in flowing through the line winding of relay 77, will operate the same against its marking contact. The operation of the polar line relay 77 against its marking contact will complete a circuit to operate magnet 78 traced from battery 83 through resistance 89, armature and M contact of relay 77, winding of slow release relay 84 and through the winding of magnet 78 to ground at 88. Magnet 78 thus remains operated while no singals are being received and prevents rotation of the receiving cams associated therewith. The slow release relay 84 also operates over the circuit traced above and opens a second operating circuit for magnet 78 traced from battery 83, through resistance 89, back con-

tacts of relay 84, through resistance 85 and through magnet 78 to ground at 88.

During reception of signals, the polar line relay 77 is operated against its spacing contact for each interruption in the line current, in turn, opening at its contacts the operating circuit traced above for magnet 78. Magnet 78 thus follows the operations of polar line relay 77 and causes the messages to be typed up in accordance with the signals received. Relay 84, being slow to release, does not follow the rapid current interruptions through its winding but remains operated continuously while signals are being received and thus prevents closure of the second operating circuit for magnet 78 which was traced above. As the result of this feature, magnet 78 is under absolute control of polar line relay 77 while the operator's set is connected to a subscriber's line or trunk circuit.

Upon disconnection of the operator's set from the line, however, the polar relay 77 is operated continuously against its spacing contact due to current supplied to its auxiliary winding from battery 83 and through resistance 87 to ground. This interrupts the circuit traced above from battery 83 through the winding of relay 84 and magnet 78 to ground, with the result that magnet 78 releases, immediately to be followed, after a short interval, by the release of relay 84. Upon the release of relay 84, the second operating circuit for magnet 78 traced above through resistance 89, back contacts of relay 84 and through resistance 85 to ground through the winding of magnet 78 which causes the reoperation of the magnet and thus prevents rotation of the receiving cams. Relay 84 remains thus released during the entire interval that the operator's set is disconnected from a line with the result that the receiving cams are prevented from rotating during such interval. Since, upon disconnection of the operator's set from the line circuit, magnet 78 releases momentarily during the interval between such disconnection and the falling off of relay 84, the receiving cams will continue to rotate during such interval. No difficulty results from this fact, however, beyond the possible printing of a single false character.

The circuit comprising the resistance 86 in series with a capacity connected between the marking contact and the armature of polar relay 77 is merely a "spark killer" for minimizing arcing at the contacts of relay 77 during operation.

The plug and jack arrangement 81 provides a flexible system in case of trouble to the operator's printer set, in which case a substitute printer set may be associated with the plug 75 by merely plugging the same into the jack.

What is claimed is:

1. A telegraph exchange system comprising in combination, a plurality of central offices, loop circuits extending from each office to a plurality of subscribers' telegraph stations individual to such office, telegraph trunk circuits interconnecting said offices, link circuits at each office for interconnecting the loop circuits terminating thereat, or for connecting a loop circuit to a trunk circuit for communication purposes, operators' telegraph sets at the central offices with means independent of said link circuits for operatively associating the same with a loop or trunk circuit.

2. A telegraph exchange system comprising in combination, a plurality of central offices, loop circuits extending from each office to a plurality of subscribers' telegraph stations individual to such office, telegraph trunk circuits interconnecting said offices, a plurality of two-conductor link circuits at each office for interconnecting the loop circuits terminating thereat or for connecting a loop circuit to a trunk circuit for communication purposes, operators' telegraph sets at the central offices with means independent of said link circuits for operatively associating the same with a loop or trunk circuit, a single line signal individual to each loop circuit at the corresponding office whereby a subscriber's station may at any time signal the central office, means whereby a central office may signal any subscriber's station connected thereto, and means whereby an operator at one central office may signal over a trunk circuit an operator at the distant office.

3. A telegraph exchange system comprising in combination, a plurality of central offices with loop circuits extending from each office to a plurality of subscribers' telegraph stations individual to such office, telegraph trunk circuits interconnecting said offices, link circuits at each office containing two-way telegraph repeater elements for interconnecting the loop circuits thereat, other link circuits at each office for directly connecting a loop circuit to a trunk circuit for communication purposes, means for signaling the central office from a subscriber's station, means for signaling any subscriber's station from the corresponding central office, and means for signaling a distant office over a trunk circuit from a given office.

4. A telegraph exchange system comprising in combination, a plurality of central offices with loop circuits extending from each such office to a plurality of subscribers' telegraph stations individual to such office, telegraph trunk circuits interconnecting said offices, link circuits at each office containing two-way telegraph repeater elements for interconnecting the loop circuits thereat, other link circuits at each office for directly connecting a loop circuit to a trunk circuit for

communication purposes, means for signaling the central office from a subscriber's station, means for signaling any subscriber's station from the corresponding central office, and means for signaling a distant office over a trunk circuit from a given office, means associated with the loop circuits at each office adapted to supply telegraph signaling current to the corresponding subscribers' stations, said means being further adapted to supply similar current to any said two-way repeater element when connected between loops, means whereby a trunk circuit supplies such signaling current to a loop circuit upon connecting the same therewith, and operators' telegraph sets at each office with means for associating the same with a loop or trunk circuit whereby such circuit supplies signaling current to said operator's set.

5. A telegraph exchange system comprising in combination, a central office having a plurality of subscribers' stations each equipped with a printing telegraph set individually connected thereto over loop circuits, telegraph trunk circuits extending from said office to other similar offices, link circuits at said office for interconnecting said loop circuits or for connecting trunk and loop circuits for communication purposes, operators' printing telegraph sets at said office with means for operatively associating the same with loop or trunk circuits, a line signal associated with each loop at the central station, switching means at each subscriber's station operable to light the corresponding line signal and to operatively associate the printer set at said station with the loop circuit, means responsive to the association of an operator's set with said loop for extinguishing said line signal, additional switching means at said subscriber's station for flashing said line signal thereafter, means responsive to the restoration of said switching means for reoperating said signal, and means responsive to the disassociation of said operator's set from said loop for extinguishing the same.

6. In a telegraph exchange system as set forth in claim 5, slow acting means associated with each operator's printer set adapted to render such set inoperable while disassociated from a loop or trunk circuit but adapted to place such set under control of the telegraph line current when so associated.

7. A telegraph exchange system comprising in combination, a central office with loop circuits extending therefrom to a plurality of subscribers' stations each equipped with a printing telegraph set, telegraph trunk circuits extending from said office to other similar offices, link circuits at said office for interconnecting said loops or said loops and trunks for communication purposes, operators' printer sets at said office with means for operatively associating the same with any said loop or trunk, signaling means associated with said loops at said stations responsive to ringing current, means at said office to apply such current to any said loop to call the corresponding station, switching means thereat to extinguish said signal and to operatively associate the printer set thereat with said loop, line signals individual to said loops at said office responsive to the operation of said station switching means whereby any station may initiate a call, means responsive to the association of a link or operator's circuit with said loop for extinguishing said line signal, additional means at said station for flashing said line signal thereafter, and means responsive to the subsequent restoration of said station switching means before said link or operator's set is disconnected for relighting said line signal to obtain a disconnect, means responsive to such disconnection for extinguishing said signal, and means whereby an operator at said office may signal a distant operator over a trunk circuit.

8. A telegraph exchange system comprising in combination, a central office with loop circuits individually connecting the same to a plurality of subscribers' stations, telegraph trunk circuits extending from said office to other similar offices, link circuits containing two-way telegraph repeater elements for interconnecting said loop circuits at said office, other link circuits thereat for directly connecting a loop to a trunk circuit, a printing telegraph set at each said station responsive to switching means thereat for operatively associating said printer set with said loop, means at said office responsive to such association for supplying line current over said loop to said printer set, operators' printer sets at said office with means for associating the same with a loop or trunk, means responsive to such association with a loop or trunk circuit for supplying line current from said loop or trunk to the operator's set thus connected, and means responsive to the connection of a trunk to a loop circuit as aforesaid adapted to supply line current from said trunk over said loop to said subscriber's printer set, means whereby any said station may signal said office and vice versa, and means whereby an operator at said office may signal a distant operator over a trunk circuit.

9. A telegraph exchange system comprising a plurality of central offices, pluralities of subscribers' telegraph stations individual to said offices and individually connected thereto over loop circuits, telegraph trunk circuits interconnecting said offices, link circuits at each office for interconnecting the loop circuits thereat with each link circuit containing a two-way telegraph repeater element, means responsive to such interconnection of a link circuit adapted to supply line current to the loop circuits and repeater element thus associated, other link circuits at each office for directly connecting a trunk cir-

cuit to a loop circuit thereat whereby line current for the loop circuit is supplied from telegraph means associated with the trunk circuit, operators' telegraph sets at each office, means for associating any said set with a loop or trunk circuit whereby signaling current for the same is supplied from the loop or trunk thus connected, means whereby any subscriber's station may signal the corresponding central office, means whereby an operator may signal a subscriber's station, and means individual to said trunks whereby an operator at one office may signal a distant office, said means responding to signaling current of one length when said trunk is idle at the distant office, and responding to signaling current of a different length when said trunk is associated with a link circuit thereat.

10. In a telegraph exchange system in combination, a plurality of central offices, loop circuits extending from each office to a plurality of subscribers' telegraph stations individual to said office, telegraph trunk circuits interconnecting said offices, link circuits thereat for interconnecting said loops or said loops and trunk, operators' telegraph sets at each office with means independent of said link circuits for operatively associating the same with a loop or trunk circuit, means independent of said link circuits for supplying telegraph line current to said loops, trunks and operators' sets, and signaling means independent of said link circuits whereby a subscriber may signal the central office and vice versa, and whereby any operator at one office may signal over a trunk circuit an operator at a distant office.

11. In a telegraph exchange system a plurality of subscribers' stations each equipped with telegraph sending and receiving means, loop circuits individually connecting said stations to a central office with each loop terminating in a plurality of jacks thereat, link circuits at the central office for interconnecting said loops, each link comprising a two-way telegraph repeater connected between plugs, an operator's telegraph set at said office terminating in a plug, means individual to said loops and adapted upon association of a link circuit with a first loop jack of said plurality for supplying line current to the loops and repeater element thus connected, said means being further responsive to the association of said operator's set with a second loop jack of said plurality for supplying line current to the loop and operator's set, telegraph trunk circuits terminating in jacks at said office, additional link circuits thereat for directly associating a trunk circuit with a third loop jack whereby line current for the loop is supplied from telegraph means individual to said trunk.

12. In combination a signal transmission circuit extending between two points, means at each point for transmitting signaling current over said circuit to the distant point, signaling means at each point responsive to said signaling current received from the distant point, said signaling means comprising at each point a line relay, means responsive to the operation of said line relay in one sense by said signaling current for charging a condenser from a direct potential source through a high resistance, whereby a predetermined time interval is required to charge said condenser fully, means responsive to the operation thereafter of said line relay in the opposite sense, to discharge said condenser through a second relay to operate the same provided said condenser is charged approximately to the full potential of said source, a locking circuit for said second relay completed upon operation thereof, a line signal responsive to the operation of said second relay, means at the point in question for extinguishing said line signal.

13. In a telegraph exchange system in combination, a telegraph trunk circuit extending between two central offices, signaling means associated therewith whereby an operator at either office may signal the distant office, said means comprising at each office means for transmitting a break signal over said trunk, a normally operated line relay responsive to such a break signal transmitted over said circuit from the distant office, a circuit completed upon release of said line relay during reception of said break signal for charging a condenser from a direct potential source through a high resistance whereby a certain time interval is required for charging said condenser, means responsive to the reoperation of said line relay upon termination of said break signal for discharging said condenser through a second relay to operate the same provided said condenser had accumulated approximately a full charge, a locking circuit for said second relay completed upon operation thereof, a line signal responsive to the operation of said second relay, means at the called office for extinguishing said line signal.

14. In a telegraph exchange system comprising a plurality of central offices, pluralities of subscribers' telegraph stations individual to said offices and individually connected thereto over loop circuits, telegraph trunk circuits interconnecting said offices, operators' telegraph sets at each office, and link circuits thereat for interconnecting said loops and said loops and trunks, means individual to said trunks whereby an operator at one office may signal the distant office, said means comprising for each trunk at each office a normally operated line relay releasing upon reception of a telegraph break signal transmitted from the distant office, means responsive to the release thereof for charging a condenser from a direct potential source through a high resistance whereby a certain

time interval is required for charging said condenser fully, means responsive to the reoperation of said line relay upon termination of said break signal for discharging said condenser to operate a second relay provided said condenser has accumulated approximately full charge, a locking circuit for said second relay completed upon operation thereof, a line signal responsive to the operation of said second relay, means for associating any said operator's set with said trunk circuit at the calling office for transmitting said break signal to the distant office to operate said line signal thereat, means whereby such association prevents operation of the signaling means associated with said trunk at the calling office, means whereby the connection of an operator's set to said trunk at the called office extinguishes said line signal thereat, means whereby the association of a link circuit with said trunk at the called office increases said condenser charging resistance whereby an appreciably longer break signal than that first mentioned is required to reoperate said line signal with said link circuit thus connected.

15. In a telegraph exchange system as set forth in claim 14, a device for transmitting said appreciably longer break signal to reoperate said trunk line with a link circuit connected to said trunk, said device comprising a pair of normally closed contacts with means for serially connecting the same in said trunk circuit at the calling office, automatic tuning and switching means responsive to manually operable start means for thereafter opening said serially connected contacts a predetermined time interval for transmitting a break signal to reoperate said distant line signal, and means associated with said device to indicate the reclosure of said contacts upon termination of said break signal.

16. In combination, a printing telegraph receiving set, a line relay adapted to be energized in accordance with telegraph line current, slow acting means responding to the continuous energization of said line relay or the intermittent energization thereof in accordance with telegraph signals for placing said printer receiving unit under the exclusive control of said line relay for operation in accordance therewith, said slow acting means responding differently to a sustained deenergization of said line relay for rendering said receiving unit inert during the period of said sustained deenergization.

17. In combination with a printing telegraph set including driving motors and receiving cams wherein during operation of the driving motors thereof the rotation of the receiving cams is controlled by electromagnetic means adapted while energized continuously to prevent rotation of said cams, but permitting such rotation while deenergized continuously or intermittently in accordance with telegraph signaling currents, means responsive to the association of said printer set with a normally closed telegraph line for energizing said electromagnetic means in accordance with said line current, but responding to a sustained interruption of said line current or to the disassociation of said printer from such a line, to energize said electromagnetic means continuously from a local current source for preventing rotation of said cams during such a period.

18. In combination with a printing telegraph set including driving motors and receiving cams wherein during operation of the driving motors thereof, the rotation of the receiving cams is controlled by electromagnetic means adapted while energized continuously to prevent rotation of said cams, but permitting such rotation while deenergized continuously or intermittently in accordance with telegraph signaling currents, means responsive to the association of said printer set with a normally closed telegraph line for energizing said electromagnetic means in accordance with said line current, but responding to a sustained interruption of said line current or to the disassociation of said printer from such a line, to energize said electromagnetic means continuously from a local current source for preventing rotation of said cams during such a period, said means comprising a line relay responsive to said line current, a slow release relay responsive to said line relay and operable continuously thereby during the continuous or intermittent energization of said line relay in accordance with telegraph signaling currents, means responsive to the operation of said slow release relay for placing said electromagnetic means under exclusive control of said line relay, means responsive to the release of said slow release relay during a sustained release of said line relay consequent upon a sustained interruption to said line current or the disassociation of said printer from said line, for energizing said electromagnetic means from a separate current source to prevent rotation of said cams during continuance of such condition.

19. In combination with a printing telegraph set including receiving cams wherein during operation thereof, the rotation of the receiving cams is controlled by electromagnetic means, means responsive to the association of said printer set with a normally closed telegraph line for energizing said means in accordance with said line current for rotating said cams in accordance with telegraph signaling currents, and means responsive to the disassociation of said printer set from said line for energizing said means from a local current source whereby the rotation of said cams is prevented during such disassociation.

20. In combination with a printing telegraph set including receiving cams wherein

during operation thereof, the rotation of the receiving cams is controlled by electromagnetic means, means responsive to the association of said printer set with a normally closed telegraph line for energizing said means in accordance with said line current for rotating said cams in accordance with telegraph signaling currents, and means responsive to the disassociating of said printer set from said line for energizing said means from a local current source whereby the rotation of said cams is prevented during such disassociation, said means comprising a line relay responsive to said line current, a slow release relay controlled thereby and operable continuously during the sustained or intermittent operation of said line relay in accordance with telegraph signaling currents, means with said slow release relay thus operated for placing said electromagnetic means under control of said line relay, means responsive to the release of said slow release relay during continued release of said line relay for energizing said electromagnetic means from said local current source as aforesaid.

21. A telegraph exchange system comprising in combination, a central office, a plurality of subscribers' telegraph stations individually connected thereto over loop circuits, operators' telegraph sets at said office with means for associating the same with any loop circuit for communication purposes, means at said office for interconnecting any two or more of said stations in a common communication circuit, and means whereby any such station may flash the operator while thus connected.

22. A telegraph exchange system comprising in combination, a central office, a plurality of subscribers' telegraph stations individually connected thereto over loop circuits, operators' telegraph sets at said office with means for associating the same with any loop circuit for communication purposes, means at said office for interconnecting any two or more of said stations in a common communication circuit, means whereby an operator may signal any of said stations, means whereby any station may signal the operator to initiate a call, obtain a disconnect, or flash the operator during a connection to said station.

23. A telegraph exchange system comprising in combination, a pluralty of central offices, loop circuits extending from each office to a plurality of subscribers' telegraph stations individual to such office, telegraph trunk circuits interconnecting said offices, operators' telegraph sets at each office with means for associating the same with a loop or trunk circuit for communication purposes, means for establishing individual connections over said trunk circuits between a given office and one or more stations associated with distant offices, and means at said given office for interconnecting two or more such distant stations in a common communication circuit.

24. A telegraph exchange system comprising in combination, a plurality of central offices, loop circuits extending from each office to a plurality of subscribers' telegraph stations individual to such office, telegraph trunk circuits interconnecting said offices, operators' telegraph sets at each office with means for associating the same with a loop or trunk circuit for communication purposes, means for establishing individual connections over said trunk circuits between a given office and one or more stations associated with distant offices, means at said given office for interconnecting two or more such distant stations in a common communication circuit, means whereby any station thus connected may flash its local operator, and means whereby any such local operator may signal said given office over the trunk circuit.

25. A telegraph exchange system comprising in combination, a plurality of central offices, loop circuits extending from each office to a plurality of subscribers' telegraph stations individual to such office, telegraph trunk circuits interconnecting said offices, operators' telegraph sets at each office with means for associating the same with a loop or trunk circuit for communication purposes, means for establishing individual connections over said trunk circuits between a given office and one or more stations associated with distant offices, means at said given office for interconnecting two or more such distant stations in a common communication circuit, and means at said given office for interconnecting one or more such distant stations and one or more stations local to said given office in a common communication circuit.

26. A telegraph exchange system comprising in combination, a plurality of central offices, loop circuits extending from each office to a plurality of subscribers' telegraph stations individual to such office, telegraph trunk circuits interconnecting said offices, operators' telegraph sets at each office with means for associating the same with a loop or trunk circuit for communication purposes, means at each office for interconnecting two or more subscribers' loops terminating thereat in a common communication circuit, means including said trunk circuits for extending connections from a given office through intermediate offices to a distant subscriber's station, means for interconnecting at said given office two or more such distant station connections in a common communication circuit, said means first and last mentioned being further adapted to interconnect at said given office one or more said distant stations and one or more stations local to said office in a common communication circuit.

27. In a telegraph system as set forth in claim 26, means whereby an operator at any

said office may signal any said station associated therewith, means whereby an operator at one office may signal over a trunk circuit an operator at a distant office, and means whereby any subscriber's station may signal the corresponding central office to initiate a call, obtain a disconnect or flash the operator while a connection to said station is established.

28. A telegraph exchange system comprising in combination, a plurality of central offices, loop circuits extending from each office to a plurality of subscribers' telegraph stations individual to such office, telegraph trunk circuits interconnecting said offices, operators' telegraph sets at each office with means for associating the same with a loop or trunk circuit for communication purposes, link circuits at each office containing two-way telegraph repeater elements for interconnecting the loops circuits thereat, other link circuits at each office for directly connecting a loop circuit to a trunk circuit for communication purposes, said link and trunk circuits being adapted to extend a connection from a subscriber's station associated with one office through one of more intermediate offices to a subscriber's station associated with a distant office.

29. In a telegraph exchange system in combination, a central office, loop circuits extending therefrom to a plurality of subscribers' telegraph stations, telegraph trunk circuits extending therefrom to other similar offices, link circuits at said office for interconnecting said loops or said loops and trunks, operators' telegraph sets thereat with means for associating the same with a loop or trunk, and means individual to said loops for signaling said office from any station, said means comprising at said office a differentially wound relay having one winding in each loop conductor, a line signal responsive thereto, switching means at said station operable to energize one winding of said relay to light said line signal, means responsive to the association of a link or operator's set with said loop for energizing both windings of said relay to release the same and extinguish said line signal, additional means whereby said station may thereafter energize one winding only of said relay intermittently to flash said line signal, means responsive to the subsequent restoration of said switching means at said station to permanently reoperate said line signal through the energization of one said relay winding, and means responsive to the disassociation of said link or operator's circuit from said loop for deenergizing both windings of said relay to extinguish said line signal.

30. In a telegraph exchange system in combination, a central office having a loop circuit extending therefrom to a subscriber's station equipped with a printing telegraph set, link means at said office for associating one operator's printer set or a second subscriber's station with said station, signaling means responsive to ringing current normally associated with said loop at said station, means at said office to apply ringing current to operate said signaling means, switching means at said station operable to disassociate said signaling means from said loop, to start the printer set motors thereat, to operatively associate said printer set with said loop, and to normally operate a line signal associated with said loop at said office for initiating a call, means responsive to the association of said link means with said loop for extinguishing said line signal, additional switching means at said station operable to reoperate said line signal, to reassociate said signaling means with said loop circuit whereby said office may call said station, and to connect said printer unit in a local testing circuit, said additional switching means having as one object the flashing of the operator under such conditions, means responsive to the restoration of said switching means first mentioned with said link means connected for reoperating said line signal, and means responsive to the disconnection of said link means thereafter for extinguishing said line signal.

31. A telegraph exchange system comprising in combination a plurality of central offices, lines extending from each office to a plurality of subscribers' telegraph stations individual to such office, telegraph trunk circuits interconnecting said offices, link circuits thereat for interconnecting said loops or said loops and trunks, operators' telegraph sets at each office with means for associating the same with a loop or trunk circuit, means whereby an operator at one office may signal over a trunk circuit an operator at a distant office, said means responding to a telegraph break signal of a certain length to operate a line signal associated with said trunk at the distant office, means responsive to the association of an operator's circuit with said trunk at the distant office to extinguish said line signal, means responsive to the association of a link circuit with said trunk at the distant office to change said signaling means whereby an appreciably longer break signal than that first mentioned is thereafter required to reoperate said line signal, and automatic tuning and switching means at said calling office for transmitting over said trunk a break signal of the required length to reoperate said line signal.

32. In a telegraph exchange system in combination, a central office having a loop circuit extending therefrom to a subscriber's telegraph station, link circuits at said office for connecting said station with other such stations, operators' telegraph sets at said office with means for associating the same with said loop, signaling means whereby said station

may signal said office to initiate a call, obtain a disconnect or flash the operator during a connection to said station, said means including a differentially wound line relay having one winding in each loop conductor, and a second relay responsive thereto and in turn controlling said line relay, a condenser and resistance in series so associated with the contacts of said second relay as to prevent a continuous intervibration being set up between said line and second relays.

33. A telegraph exchange system comprising in combination a plurality of central offices with lines extending from each office to a plurality of subscribers' telegraph stations individual thereto, telegraph trunk circuits interconnecting said offices, with each loop and trunk terminating at a given office in a plurality of jacks individual thereto, link circuits at said offices containing two-way telegraph repeater elements for interconnecting said loops or said trunks utilizing therefor a first of the jacks associated with each of the loops or trunks thus connected, additional link circuits at said offices for directly connecting a loop circuit to a trunk circuit utilizing therefor second jacks individual to the loop and trunk thus connected, operators' telegraph sets at said offices terminating in plug circuits for associating the same with any loop or trunk circuits by means of third jacks individual to such loops, and trunks, and line current and signaling means suitably controlled through contacts on said jacks.

In testimony whereof, I have signed my name to this specification this 1st day of April, 1929.

GILBERT S. VERNAM.