Nov. 29, 1938. F. S. KINKEAD 2,138,580

PRINTING TELEGRAPH SYSTEM

Filed July 11, 1936 3 Sheets-Sheet 1

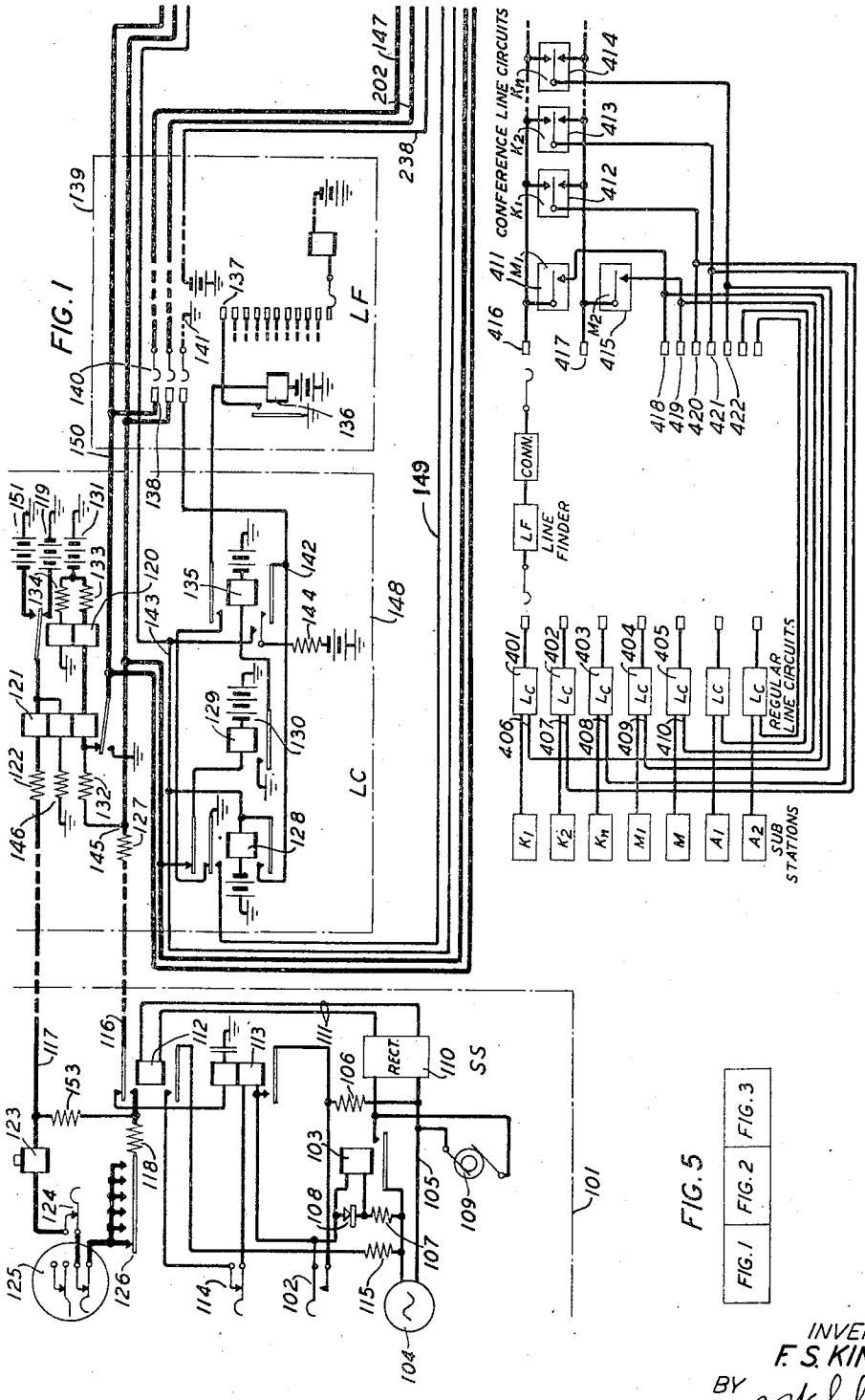

FIG. 5

FIG. 1	FIG. 2	FIG. 3

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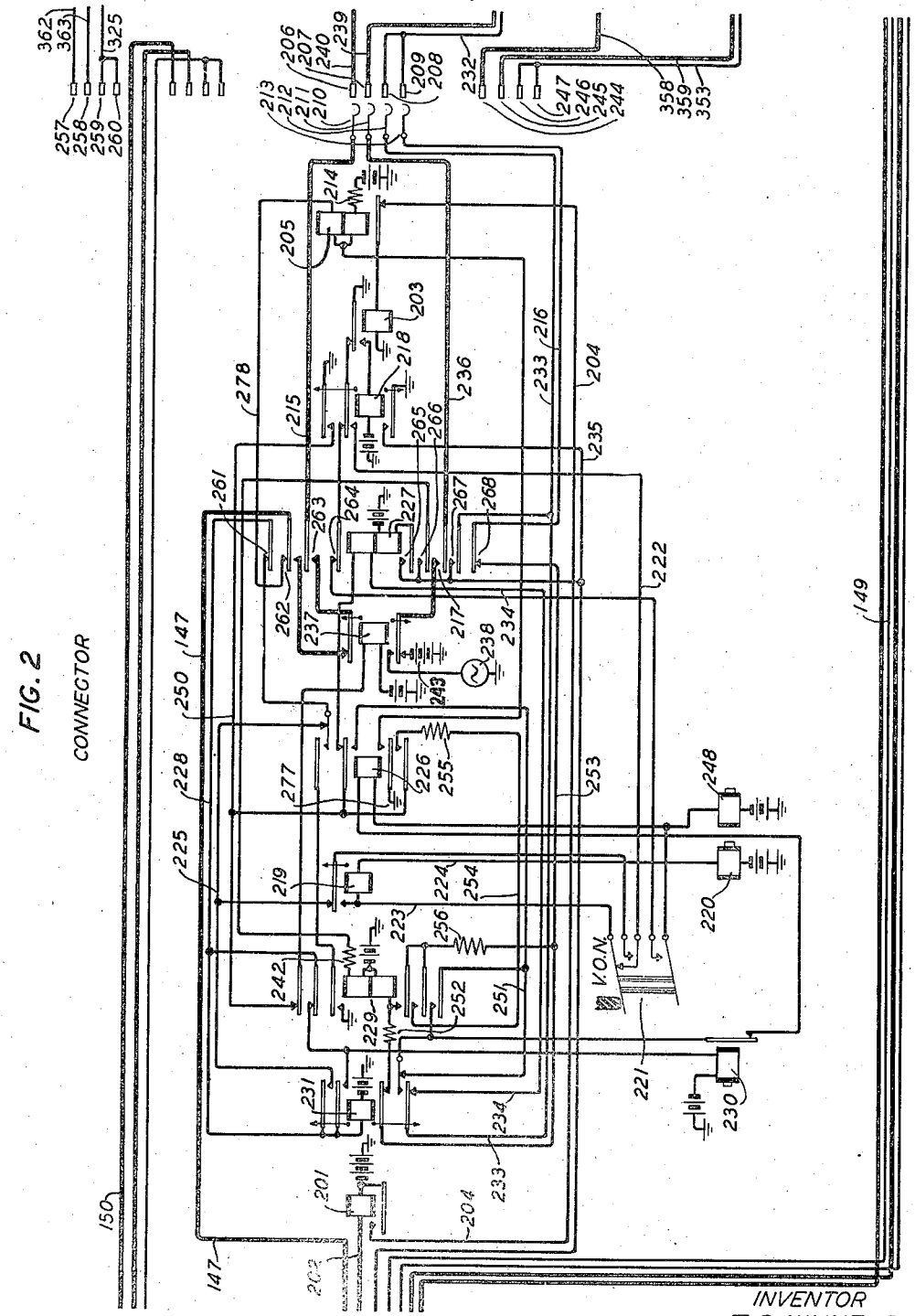

FIG. 2

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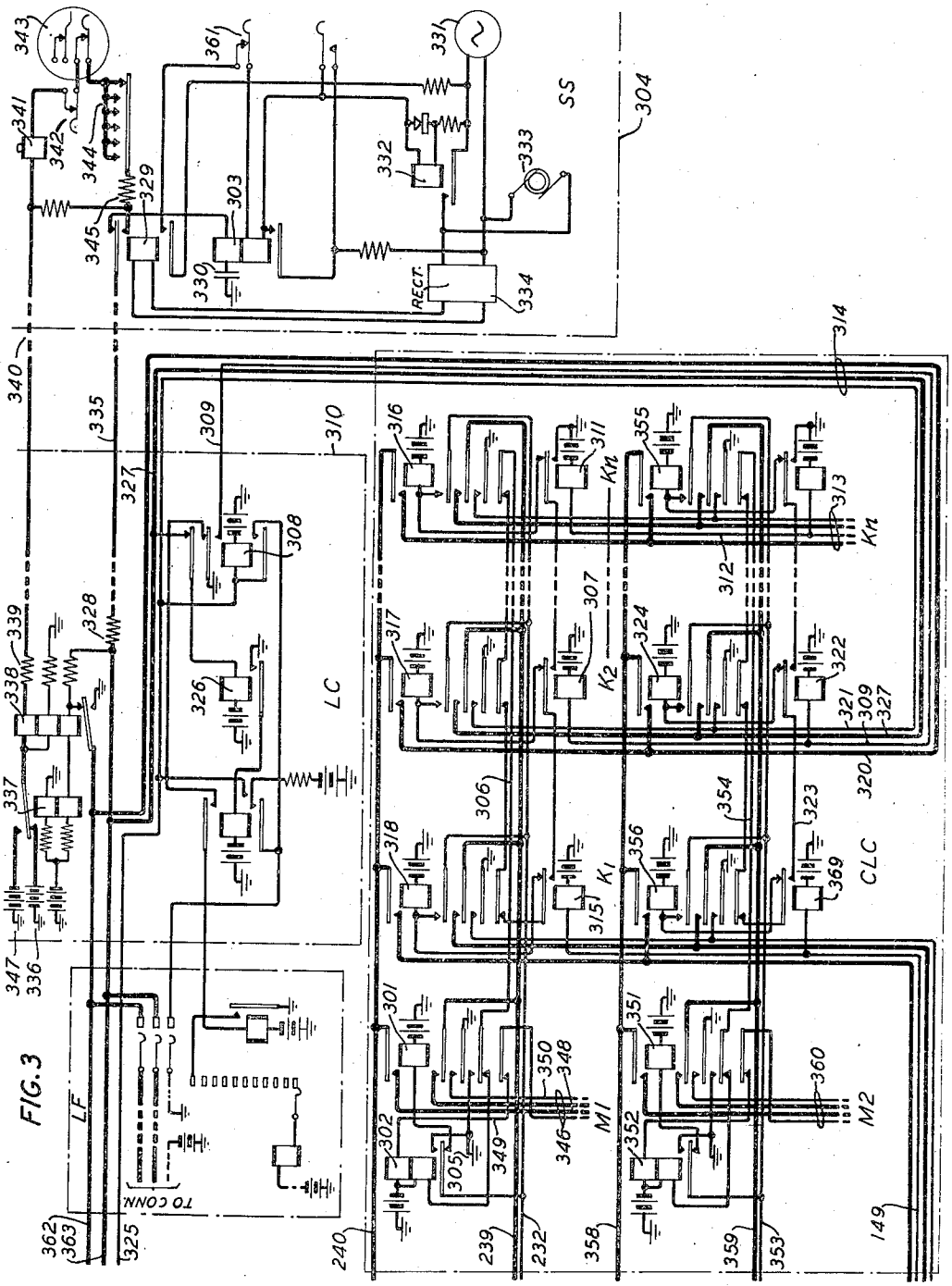

FIG. 3

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Patented Nov. 29, 1938 2,138,580

UNITED STATES PATENT OFFICE

2,138,580

PRINTING TELEGRAPH SYSTEM

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Application July 11, 1936, Serial No. 90,082

5 Claims. (Cl. 178—2)

This invention relates to a printing telegraph system and more particularly to a telegraph system wherein automatic switches are employed for the establishment of channels of telegraph communication.

The invention has for its main object to effect the repeating of signals in each of the line circuits in a printing telegraph private branch exchange system which utilizes automatically and directively operable switches at a central office for establishing telegraphic connections between subscribers' stations.

Another object is to effect transmission in both directions in a circuit established between any one subscriber's station and a plurality of the other, or called, stations and to effect in a circuit so established, transmission in both directions between any two or more of the plurality of called stations for conference purposes.

Heretofore in printing telegraph private branch exchange systems wherein were employed automatically operated line-finder and hunting connector switches, the transmitted signals were repeated over a plurality of line circuit groups to receive a broadcast message, by a repeater connected in the connector switch circuit. In such systems two or more subscribers' stations connected in a predetermined group, may be connected to a set of terminals in the multiple contact bank of the hunting connector switch, which set may be directively selected in a manner similar to a set used for establishing a connection between individual subscriber's stations. A circuit so established, that is to include a predetermined group of subscribers' stations is arranged to permit transmission in one direction only, in other words, from the subscriber's station originating the call to the plurality of subscribers' stations, grouped to receive the call. This type of circuit is usually known as a broadcast circuit wherein the receiving station cannot transmit, although such stations may transmit over other circuits provided for originating calls. In having a single repeater for a predetermined group of subscribers' stations, it was necessary that the subscribers' line circuit have equivalent resistance values, regardless of the length of the circuit. The resistance values of all line circuits arranged in a predetermined, or broadcast group, were made equal at the time the system was installed and line circuits of this predetermined value of resistance may be added to or removed from the broadcast circuit without necessarily adjusting the networks that were originally installed.

According to the present invention, a plurality of subscribers' line circuits may be connected in a predetermined group to a set of terminals on the hunting connector switch for establishing a conference circuit. The conference circuit differs from a broadcast circuit in that it, as its name implies, provides for transmission in both directions between the originating station and any one of the stations in the predetermined group and between stations in the predetermined group. This arrangement also provides for separate repeaters in the subscriber's line circuit whereby no compensation in the resistance network individual to the line circuit is required to accommodate for the addition or removal of line circuits in a predetermined group.

One feature of the present invention provides supervision and remote control that is not affected by ground potential differences.

Another feature resides in the introduction of a special repeater in each line circuit whereby grouping of station line circuits for conference connections may be had without necessitating additional repeating relays and without impairing transmission.

Still another feature is the provision of a connector switch circuit arranged to hunt the first idle station in one or more predetermined groups, the one or more groups being connected to a single set of terminals in the multiple contact bank of the hunting connector switch.

The invention will be understood from the following description when read in connection with the accompanying drawings:

Fig. 1 of which, represents at the left a teletypewriter subscriber's station circuit SS which connects over a line with a dial office line circuit LC, each arranged according to this invention. The line circuit LC is shown connecting with a typical dial office line-finder LF, which is represented in an abbreviated schematic form:

Fig. 2 shows a dial office connector circuit arranged, according to this invention and adapted to cooperate with the circuits of Fig. 1;

Fig. 3 shows a conference line circuit CLC arranged according to this invention and interconnected with the line circuit LC of Fig. 1 and with the line circuit LC of Fig. 3, which cooperates with the line-finder LF and the teletypewriter subscriber's station circuit SS of Fig. 3;

Fig. 4 is a single line layout illustrating in an abbreviated skeleton form the general circuit arrangement of the invention;

Fig. 5 is a block diagram which shows the order

in which the circuits of the invention are to be interconnected.

The operation of the invention will now be described in detail. Let it be assumed that the subscriber of station 101 desires to establish a teletypewriter connection with the stations of the conference line circuit CLC, the circuit arrangements of which are shown by Fig. 3. In this arrangement are represented two groups consisting of master stations M_1 and M_2, with each of which is associated the group comprising subsidiary stations $K_1, K_2, \ldots K_n$. Station K_1 is identical with station 101, and station K_2 with station 304. All circuits for these stations are shown in detail. For the other stations only the apparatus of the conference line circuit is shown. As will appear from the hereinafter given description, the invention provides that the calling station will dial the number of the conference line associated with station M_1. The connection will then be completed if station M_1 and at least one of the stations $K_1, K_2, \ldots K_n$ are not busy. If (*a*) station M_1 is busy or (*b*) all of the stations $K_1, K_2, \ldots K_n$ are busy then the hunting connector of Fig. 3 will endeavor to establish connection with the conference terminals of station M_2. If now M_2 and at least one of the stations $K_1, K_2, \ldots K_n$ are not busy, the connection will then be completed to the conference group of station M_2. If, however, (*a*) station M_2 is also busy or (*b*) all of the stations $K_1, K_2, \ldots K_n$ are busy then a busy indication will be returned to the calling station 101, as will be hereinafter described.

To initiate the call, start switch 102 is operated which operates the motor control relay 103 in a circuit traced from the source of alternating current power 104, over conductor 105, through resistance 106, contacts of switch 102, winding of relay 103 and resistance 107 to the said current source 104. To facilitate the operation of relay 103, a rectifier 108, which may conveniently be of the usual copper-oxide type, is connected in shunt with the winding of relay 103. With this arrangement, one-half of the alternating current wave through said winding is effectively annulled so that the operating current for relay 103 is thereby made unidirectional. Relay 103 in operating closes an obvious circuit from alternating current source 104 to the teletypewriter motor 109, which is started and to the rectifier 110, which is represented conventionally by a box and may be of any well-known type. The output of rectifier 110 is delivered over conductors 111 to the winding of relay 112 which operates and closes a circuit for operating relay 113, which is traced from current on conductor 105, through resistance 106, operated contacts of key 102, lower winding of relay 113, contacts of stop key 114, lower contacts of relay 112 and resistance 115 to current source 104. Relay 113 in operating short-circuits the contacts of start key 102, thereby maintaining the operating circuits for relays 103 and 113 hereinbefore traced, after key 102 is restored to its normal position. Relay 112 in operating transfers with its upper armature line conductor 116 from its normal connection with the upper winding of relay 113 to a connection with the right terminal of resistance 118. Relay 120 is normally operated to its front contacts due to a flow of current from positive ground through the upper winding of relay 120 and resistance 134 to negative grounded battery 131. When relay 112 operated as before described a circuit was closed for operating high resistance relay 129, which is traced from negative battery 130, through the winding of relay 129, upper outer back contacts of relay 128, resistance 127, over line conductor 116, through upper operated front contacts of relay 112, resistance 118, normally closed contacts 126 of the sending distributor pulsing contacts of dial 125, contacts of break key 124, winding of printer magnet 123, over line conductor 117, through resistance 122, uppermost winding of relay 121 and operated contacts of relay 120 to positive grounded battery 119. Relay 121 also operates in this circuit at this time but it has no immediate function. Relay 129 in operating closes an obvious circuit for operating relay 135, which in turn operates relay 136 in a circuit which is traced from ground through the inner, upper, back contacts of relay 128, upper contacts of relay 135 and winding of relay 136 to grounded battery. Relay 136 in operating places a ground on commutator contact 137, thereby indicating that the terminals 138 of the calling line are located on the tenth level of the line-finder 139, which functions to cause the brushes 140 to establish contact with terminals of terminal set 138. Details of the line-finder are well known in the telephone art and are omitted since a complete description would not add to an understanding of this invention. When the lower or sleeve brush of brush set 140 contacts the lowermost terminal of terminal set 138, ground 141 is connected to conductor 142 through the winding of a relay, not shown, in the line-finder circuit which operates the cut-off relay 128 in a circuit traced from battery through the winding of relay 128, over conductor 143, through lower operated contacts of relay 135 to the ground on conductor 142. In multiple with the winding of relay 128, through the lower contacts of relay 135, is resistance 144, which is used to reduce the resistance of the operating circuit of the before mentioned line-finder relay, not shown, the winding of which is connected to ground 141. Cut-off relay 128 in operating, locks through its lower contacts to ground on conductor 142, and with its uppermost contacts releases relay 129, which releases relay 135. Relay 135 in releasing disconnects with its lower contacts resistance 144, and with its upper contacts opens the circuit of relay 136, which releases, disconnecting ground from commutator contact 137.

When brushes of set 140 established contact with terminals of set 138 a circuit was closed for operating relay 201 which may be traced from negative battery through the winding of relay 201, over conductor 202, middle brush of set 140 and middle terminal of set 138 to junction 145, from which the circuit is the same as that followed for relay 121. As soon as the circuit for relay 201 is established the current through the winding of line magnet 123 of the circuit of station 101 which was previously flowing from the source connected to the high resistance winding of relay 129 only, is increased so that this magnet now operates, and connects current in well-known manner to the last segment of the receiving distributor, not shown, thereby causing the associated distributor arm to stop revolving, which is an indication to the operator at station 101 that the circuit is ready to receive dial impulses. When relay 201 operated as before described, a circuit was closed for operating the pulsing relay 203, which may be traced from grounded battery through the contacts of relay 201, over conductor 204, through contacts of relay 205, and winding of relay 203 to ground. Let it be assumed now to facilitate this descrip-

tion that the directory number of the conference line with which a connection is desired is, for instance 91, and that the corresponding terminals on the connector bank are 206, 207, 208 and 209. On the first break of the dial 125, the circuit hereinbefore traced through the windings of relays 120 and 121 is opened. Relay 121 releases due to the biasing action of the current in its middle winding, the circuit of which may be traced from positive battery 119 through operated contacts of relay 120, middle winding of relay 121, and resistance 146 to ground. Relay 120 remains operated due to the current through its upper winding and relay 201 remains operated due to the shunt path through the bridging resistance 153. Relay 121 in releasing connects ground through its back contacts to conductor 150, thereby closing a circuit for operating relay 205, which may be traced from grounded battery through resistance 214, upper and lower windings of relay 205 in series, over conductor 278, through back contacts 262 of relay 227, over conductor 147, through tip brush of set 140 and tip terminal of set 138 to said ground on conductor 150. Relay 205 in operating releases relay 203. When relay 203 operated it operated relay 218 through an obvious circuit. Relay 218 is slow to release and holds over the dial pulses. Consequently a circuit is now closed to operate slow-release relay 219 and vertical magnet 220, which is traced from grounded battery through the windings of vertical magnet 220 and relay 219, normally closed contacts of vertical off-normal combination 221, over conductor 222, through operated upper inner make contacts of relays 218 to ground on back contacts of relay 203. On the next closure of the contacts of dial 125 relay 121 reoperates in turn causing the release of relay 205, the reoperation of relay 203, and the deenergization of vertical magnet 220, relay 219 being of the slow-release type remains operated at this time. The connector switch, in the well-known manner, now takes one vertical step, causing the VON springs 221 to operate, transferring pulsing conductor 222 from conductor 223 to a path extending through the armature, front contact and winding of relay 219 to conductor 224. Immediately after, on the second opening of dial 125, vertical magnet 220 is reenergized and the switch takes its second vertical step, the pulsing circuit now being completed through the front contacts of relay 219, which being slow releasing, remains operated during successive pulses of the dial. In this way the switch is stepped upward until the ninth level is reached, which corresponds to the tens digit, of the assumed number, 91. When the dial closes after the ninth pulse, relay 219 releases and pulsing lead 222 is now transferred by the back contacts of relay 219 to conductor 225. This conductor is extended through the upper, outer normally closed contacts of relay 226, contacts 261 of relay 227 to conductor 228. From conductor 228 the circuit is completed through the middle upper contacts of relay 229 and the winding of rotary magnet 230 to grounded battery. Another multiple circuit from conductor 228 is completed through the winding of relay 231 to grounded battery. The connector is now ready for rotary stepping. After the units digit 1 of the assumed number 91 is dialed, rotary magnet 230 causes the switch to rotate horizontally one step, and brushes 210, 211, 212 and 213 contact with terminals 206, 207, 208 and 209, respectively. If the conference line connected to terminals 206, 207, 208 and 209 is not busy, battery potential will be present on sleeve conductor 232, which will operate the cut-through relay 227 in a circuit which will now be described. After the last rotary pulse, which in this case is assumed to be that due to the units digit 1 of the number 91 relay 203 and 218 operate due to the closing of the line circuit and therefore relay 231 releases and rotary magnet 230 is deenergized. The release of relay 231 accordingly closes a circuit from battery through the winding of relay 301, back contacts of relay 302, over conductor 232, through terminal 208 and connector brush 212, over conductor 233, lower outermost back contacts of relay 231, over conductor 234, through upper winding of relay 227, upper inner back contacts of relay 226, to ground on the upper, outermost operated contacts of relay 218. Relay 227 partly operates; it first closes a locking circuit for itself from battery through its lower winding, contacts 265, over conductor 235 to ground on the lower operated contacts of relay 218, and then completely operates on this lower winding. In the circuit hereinbefore traced for operating relay 227 through its upper winding, relay 301 also operated and connected ground 305 with its lower, next to outermost armature and front contact to conductor 306. For this description it is assumed that station 304, which corresponds to conference station K_2 is not busy. Relay 307 is accordingly not operated, since there is no ground on conductor 309 due to the non-operation of the cut-off relay 308 of the regular line circuit 310 of station 304. When cut-off relay 128 of the regular line circuit 148 of station 101 operated, ground was connected to conductor 149 by the upper front contacts of relay 128, thereby operating relay 315 of the conference line circuit associated with the regular line circuit of station 101. The aforesaid ground on the conductor 306 is now extended through the lower outermost contacts of relay 316, through similar contacts of intermediate relays similar to relays 316 and 317, which intermediate relays are not shown, through lower outermost contacts of relays 317 and 318, armature and front contact of relay 315 operated as aforesaid, armature and back contact of relay 307 and winding of relay 317 to battery. Relay 317 operates and (1) locks through its lower innermost contacts to ground on sleeve conductor 232, (2) connects with its upper armature and contact tip conductor 240 to tip conductor 320, (3) connects with its lower, next to innermost armature and contacts, ring conductor 239 to ring conductor 327, (4) connects ground to conductor 321 with its lower next to outermost armature and contact thereby operating cut-off relay 308, which in operating connects ground with its upper inner front contacts to conductor 309, thereby operating relays 307 and 322. Relay 322 in operating transfers conductor 323 from its connection with the winding of relay 324 to a similar connection with the first succeeding non-operated relay similar to relay 324, thereby making the conference line circuit associated with said succeeding relay available to a call through the line associated with the conference station M_2. The aforesaid ground on conductor 321 is extended over sleeve conductor 325 to the sleeve terminal 259 of the regular non-conference connector terminals of station 304 thereby making this set of terminals test busy. With its upper outer armature and contact cut-off relay 308 also disconnects the winding of relay 326, thereby pre-

venting its operation from station 304 over the tip and ring conductors 340 and 335.

Relay 227 in operating as before described connects ring conductor 236 through its contacts 217 to the lower armature of relay 237, which operated previously, when relay 218 operated, in a circuit from ground on the upper outer armature and contact of relay 218 through upper outermost armature and contact of relay 229 and winding of relay 237 to battery. When relay 237 operates a circuit is closed from alternating ringing current source 238, through lower front armature and contact of relay 237, closed contacts 217 of relay 227, over ring conductor 236, through connector brush 211 and associated terminal 207, over ring conductor 239 through lower, next to innermost armature and contact of relay 317, over conductor 327, through resistance 328, over line conductor 335 through upper armature and back contact of relay 329, upper winding of relay 303 and condenser 330 to ground. Relay 303 which is designed to operate on alternating current, now operates and locks on current from the alternating current supply 331. The apparatus of the circuit of station 304 now functions in the same manner as did that of station circuit 101, when relay 113 operated in response to the operation of start key 102. Relay 332 operates and closes a circuit for starting teletypewriter motor 333 and for energizing the rectifier 334. Rectifier 334 supplies current for operating relay 329, which transfers line conductor 335 from the upper winding of relay 303 to the circuit of the teletypewriter of station 304.

Cut-through relay 227 in operating also closes a circuit for operating relay 229 which is traced from battery through the upper winding of relay 229, resistance 242, lower closed contacts 266 of relay 227, to ground on conductor 235. Relay 229 in operating opens, with its upper, outermost contacts the operating circuit of relay 237, which releases disconnecting the ringing current source 238 and connecting negative battery 243 to the ring conductor. Current from positive battery 336 now flows through the operated contacts of repeater relay 337, top winding of repeater relay 338, resistance 339, over line conductor 340, through winding of teletypewriter printer magnet 341, contacts of break key 342, dial 343, and distributor 344, resistance 345 and thence through the upper armature and front contact of relay 329 and the circuit path over the ring conductor hereinbefore traced in connection with the operation of relay 303, to the aforesaid negative battery 243. Printer magnet 341 is energized and its subsequent operation depends on the signal impulses that are transmitted from station 101. The circuit details for accomplishing this are well known and are not shown here. Repeater relay 338 is also operated due to the current in its top winding, which predominates over the normal flow of current from positive battery 336 through its middle or biasing winding.

Relay 227 in operating also performs various additional functions. With its contacts 261 it opens the operating circuit of relay 231, thereby causing the release of this relay after a connection has been established. Transfer contacts 262 transfer tip conductor 147 from the upper winding of relay 205 to tip conductor 215 by way of upper armature and contact of relay 237 and closed contacts 263 of relay 227. Contacts 264 open the release circuit for the connector switch. Contacts 268 disconnect the hunting lead 216 so as to prevent the operation of relay 229 after the circuit is cut through, and contacts 267 connect direct ground from conductor 235 to sleeve conductor 233 thereby holding relay 301 operated and making terminal 208 test busy to other hunting connectors.

The circuit between the calling station 101 and the called station 304 is now complete and with the motors at both stations operating teletypewriter communication in either direction may now begin. In accordance with common practice, station 101 may signal station 304 by operating the upper case "S" key, thereby ringing the teletypewriter bell at station 304. When relay 301 operated as before described it completed connection over leads 346 to a line circuit similar to line circuit 310. Lead 349, however, is disconnected by the lower outermost armature and contact of relay 301 to prevent the operation of relay 302, when the cut-off relay (not shown), the winding of which is connected to lead 350, operates, due to the ground on the lower middle armature of relay 301.

The said line circuit associated with relay 301 is connected to the circuit of station M_1, not shown, similar to station 304, which station is accordingly also now ready for teletypewriter communication in either direction.

The operation of the invention will now be described, assuming that the calling station 101 transmits a message to be received by the station 304 and the station M_1 connected over leads 346. When the sending distributor of station 101 transmits spacing and marking impulses repeater relay 121 is actuated correspondingly due to the opening and closing of the circuit through its top and bottom windings. When a spacing impulse is transmitted, relay 121 releases and connects ground to conductor 150. This ground impulse is now transmitted through the tip terminal 138 and associated tip brush 140 of the line-finder 139, over tip conductor 147, through upper operated contacts 262 of relay 227, upper break contacts of relay 237, upper operated contacts 263 of relay 227, through connector brush 210 and associated terminal 206, over conductor 240, through upper operated contacts of relay 317, over conductor 320 to the armature of repeater relay 338, which relay is operated, as aforesaid, due to the operation of relay 329. The normal flow of current through the bottom windings of relays 338 and 337 is now increased. Relay 338 continues to hold, but relay 337 releases due to the neutralizing effect of the increased current in its bottom winding. The release of relay 337 disconnects positive battery 336 from the tip conductor 340 and connects negative battery 347 thereto. Negative battery 347 meeting negative battery 243 over the ring conductor reduces the current through the winding of the teletypewriter printer magnet 341 to zero, which accordingly releases delivering a spacing impulse to the teletypewriter apparatus. When the sending apparatus of station 101 transmits a marking impulse relay 121 reoperates due to the reestablishment of normal current through its top and bottom windings and disconnects ground from conductor 150 which reduces the current through the lower winding of relay 337, allowing relay 337 to operate on the normal current through its upper winding and transmit a marking impulse from positive batery 336 to the station 304. In this manner the teletypewriter message is transmitted from station 101 to station 304. The marking and spacing impulses delivered over the tip conductor 150 also pass

through the upper operated contacts of relay 301, to the tip conductor 348 which connects with the armature of a repeater relay similar to relay 338, which repeater relay is in the regular line circuit associated with conference station M_1. This causes a repeater relay, similar to relay 337, to operate and deliver spacing and marking impulses to its associated station (not shown), negative battery 243 functioning over conductor 239, through lower innermost armature and contact of relay 301 and conductor 348.

The operation of the invention has been discussed for the transmission of a message from station 101 to the station 304 and the conference station M_1. A description will now be given for transmission from the called station 304 to station 101. When spacing and marking impulses are delivered from station 304 relay 338 functions in the same manner as did relay 121, ground pulses being delivered to conductor 320 and thence over the tip conductor path, hereinbefore traced, to the armature of relay 121. These ground pulses hold supervisory relay 201 through resistance 132 and cause relay 120 to deliver spacing and marking impulses to station 101, causing the apparatus thereat to print the transmitted message. Simultaneously the ground pulses from relay 38 are also delivered through the top contacts of relay 301 over conductor 348 to the M_1 station (not shown) at which station the message from station 304 is also recorded. In like manner, the station M_1 may also transmit a message which is recorded at stations 101 and 304. Accordingly the three connected stations can freely intercommunicate with each other as desired.

In the description before given it was assumed that the conference group associated with conference station M_1 was not busy, that is, that the station M_1 with at least one of the associated stations $K_1, K_2, \ldots K_n$ was not busy. It will now be assumed that a busy condition is encountered, and in accordance with the operation of the invention that the brushes 210, 211, 212 and 213 of the hunting connector of Fig. 2 now automatically pass over the terminals 206, 207, 208 and 209 and connect with terminals 244, 245, 246 and 247 connected to the conference station M_2 and the conference stations $K_1, K_2, \ldots K_n$. It is assumed that station M_2 and at least one of the associated stations $K_1, K_2, \ldots K_n$ are not busy. For descriptive purposes let it be assumed that the non-busy station is K_2, as in the before given description.

In reference to the M_1 station a busy condition is established if ground is found on sleeve terminal 208. This may be due (1) to ground connected by another connector similar to the connector of Fig. 2 or (2) to ground connected to conductor 232 by the operation of relay 302. Relay 302 may be operated through its upper winding from ground on conductor 349, connected through the lower outermost contacts of relay 301 to ground on the operated contacts of the associated cut-off relay of the regular line circuit of station M_1, which cut-off relay was previously operated due to a connection established through the regular line circuit or the regular connector terminals. Relay 302 may also be operated due to a circuit closed from battery through its lower winding, lower, next to outermost back contacts of relay 301, over conductor 306, through lower outermost contacts of relay 316, similar contacts of intermediate relays between relays 316 and 317, lower outermost contacts of relays 317 and 318 and operated front contacts of relays 315 and 307 to ground on the operated contacts of relay 311. Relay 302 in operating also disconnects the winding of relay 301.

When brush 212 encounters the grounded sleeve terminal 208 a circuit is closed for operating relay 226 which may be traced from battery through the winding of release magnet 248, winding of relay 226, break contacts of rotary magnet 230, (which is now deenergized due to the absence of ground on pulsing lead 232 following the dialing of the units digit 1 of the assumed number 91), lower outermost front contacts of relay 231 before this relay releases, over conductor 233 to the aforesaid ground on the sleeve terminal 208. When the slow-to-release relay 231 finally releases, relay 226 locks up through a circuit traced from ground on the upper outer contacts of relay 218, over conductor 250, through upper, inner operated front contacts of relay 226, over conductor 251, thence through the lower, middle, normally closed contacts of relay 231 to battery over the operating path originally traced. When relay 231 releases it also closes a circuit to operate relay 229, which is traced from battery through the lower winding of relay 229, through resistance 252, lower innermost break contacts of relay 231, over conductor 253, through lower outermost contacts 268 of relay 227 to the ground on the hunting terminal 209 which is connected to the sleeve terminal 208. Relay 229 in operating also locks up under control of relay 226 in a circuit traced from battery through the lower winding of relay 229 and its lower innermost and middle contacts in series, over conductor 254, through resistance 255 and lower outer contacts of relay 226 to ground on conductor 250. When relay 229 operates as before described it closes a circuit for operating relay 231 which is traced from battery through the winding of relay 231 over conductor 228, through upper contacts 261 of relay 227, upper outer, operated front contacts of relay 226, to ground on the upper innermost contacts of relay 229. When relay 231 operates as aforesaid it connects the winding of rotary magnet 230 in multiple with its own winding by means of its upper, inner make contacts. This causes rotary magnet 230 to rotate the brushes 210, 211, 212 and 213 one step until they contact the next terminals 244, 245, 246 and 247, corresponding to the number following the assumed number 91, that is, 92. The operation of rotary magnet 230 opens the operating circuit of relay 226, which releases, thereby opening the circuit of rotary magnet 230, before traced. When magnet 230 releases the winding of relay 226 is connected from battery on the winding of release magnet 248 to sleeve terminal 246, over the same circuit which was traced when brush 212 made contact with sleeve terminal 208. In this case, however, by assumption the conference station M_2 is not busy, that is, there is battery potential on sleeve terminal 246 and consequently relay 226 does not reoperate. Since the number 92 is the second or last number in the group, the hunting terminal 247 is left unconnected. Consequently, the locking circuit which was formerly established for relay 229 through its lower innermost contacts, resistance 256, lower outermost contacts 268 of relay 227 to ground on hunting terminal 209 is now no longer maintained and accordingly relay 229 releases. The connector circuit now functions as before described when connection was established with terminals 206, 207, 208 and 209. In this case relay 227 operates through its upper winding over conductor

353 in series with the winding of relay 351, which also operates. Relay 351 with its lower, next to outermost front contacts connects ground to conductor 354 which is extended through lower outermost contacts of relay 355, of intermediate relays not shown, of relays 324 and 356, operated front contacts of relay 357, back contacts of relay 322 to battery through the winding of relay 324. Relay 324 operates and functions with respect to conductors 314 in the same manner as did relay 317 when connection was established to the terminals of the conference station M_1 and relay 351 in operating as aforesaid functions with conductors 360 as did relay 301 with the conductors 346. Station 101 is now connected through for conference communication, over tip and ring conductors 358 and 359 to the lines of conference station M_2, not shown, and of station 304.

The operation of the invention will now be discussed for the busy condition, that is, when stations M_1 and M_2 are both busy, or all stations $K_1, K_2, \ldots K_n$ are busy. When the brushes 210, 211, 212 and 213 in the hereinbefore given description, encountered the busy terminals 206, 207, 208 and 209, they were automatically stepped to the next and last terminals of the conference group, that is, to terminals 244, 245, 246 and 247. By assumption, these latter terminals were assumed to be not busy and the operation of the invention in completing the connection was then discussed. These terminals 244, 245, 246 and 247 are now assumed to be busy.

Referring to the previously given description, when sleeve brush 212 found battery potential on sleeve terminal 246, relay 227 operated when relay 231 released after the removal of the pulsing ground from conductor 225. With busy ground on terminal 246 relay 226 operates in the same manner as it operated from busy ground on sleeve terminal 208, and locks up to ground on the conductor 250. When hunting brush 213 contacts the terminal 247, no circuit is closed since terminal 247 is not connected. Consequently, in this case relay 229 does not operate, when relay 231 releases. Accordingly, relay 231 and consequently rotary magnet 230 are not operated, relay 226 remaining locked up. Relay 226 in operating connects ground 257 with its lower inner contacts to the junction point of the upper and lower windings of relay 205. Relay 205, however, does not operate, since the current in the windings acts differentially. A circuit closed through the upper winding of relay 205 may be traced from battery 131, through resistance 133, bottom windings of relays 120 and 121, operated contacts of relay 121, over tip conductor 150, through line-finder tip terminal 138 and tip brush 140, over conductor 147, through upper back contacts 262 of relay 227, through upper winding of relay 205 to the ground connected to the junction of its two windings. This current flow causes the magnetic action of the lower winding of repeater relay 120 to predominate over that of the upper winding so that relay 120 operates to its back contacts, causing negative battery 151 to meet negative battery 131 over the line of station 101, thereby reducing the current flow in said line to such an extent that teletypewriter printer magnet 123 releases and causes the sending distributor to run open, which will be an indication to the calling station 101 that a busy condition exists.

The operation of the invention whereby a disconnect signal is given to the calling station 101 and all apparatus is restored to normal when the conference communication between the stations is completed will now be discussed. When the stop key 361 at station 304 is operated the circuit through the lower winding of relay 303 is opened and this relay releases, releasing in turn relay 332, which opens the circuit of teletypewriter motor 333, which stops. The release of relay 332 also deenergizes rectifier 334 which thereby effects the release of relay 329. All apparatus at station 304 is now restored to normal. When relay 329 releases the circuit through station 304 is opened which causes repeater relay 338 to release thereby transmitting a ground impulse over the tip conductor through to the armature of repeater relay 121. Relay 120 now releases, as explained in connection with the transmission of a busy signal, and the motor of station 101 runs open indicating that a station of the conference connection has disconnected. The aforesaid ground impulse over the tip conductor will in similar manner cause the motor of the station associated with the conference station M_1 also to run open, if the stop key at this station has not been previously operated. The operator at the calling station 101 will now operate the stop key 114 stopping the motor 109 and restoring all apparatus at station 101 to normal. When the circuit of station 101 is opened by the release of relay 112, relay 121 releases and also supervisory relay 201 of the connector circuit. The release of relay 201 opens the operating circuit of relay 203 which releases, in turn releasing relay 218 which removes ground from conductor 235 causing the release of the line-finder 139 and the associated cut-off relay 128. Relay 218 in releasing also removes the locking ground from the winding of cut-through relay 227 which also releases. The release of relay 227 closes a circuit for operating release magnet 248, which is traced from battery through the winding of magnet 248, lower operated contacts of VON combination 221, upper break contacts 264 of relay 227, and back contacts of relay 218 and 203 to ground. This causes the connector switch with its VON contacts 221 to be restored to normal. The release of relay 218 as aforesaid also removed ground from the sleeve conductor 233. This releases relays 351, 324 and 308, and also the cut-off relay (not shown) in the line circuit connected with relay 351 over conductors 360. All apparatus is now ready for another call.

The operation of the invention has been discussed for the establishment of a conference connection wherein the connector of Fig. 2 made connection with conference terminals 206, 207, 208, 209 or 244, 245, 246, 247. It is to be understood, however, that a connection may also be established on a non-conference basis. Assuming that the operator of station 101 desires a non-conference connection with station 304, the number corresponding to the connector terminals 257, 258, 259, 260 are dialed with the dial 125. The apparatus of Figs. 1 and 2 operates as before described. If the called line is busy, ground on the sleeve conductor 325 will cause a busy indication to be returned. If the called line is not busy, the connection with station 304 will be established over conductors 362, 363 and 325. Ground connected to sleeve conductor 325 will operate the cut-off relay 308, which functions in the same manner as when operated over conductor 321. Ringing current will be connected to ring conductor 363 which will operate relay 303 and cause the apparatus of station 304 to function as before. Stations 101 and 304 can now communicate with each other. From station 101 the spac-

ing and marking impulses are transmitted by relay 121 over the tip conductors of Figs. 1 and 2 as before, through tip brush 210 and associated connector terminal 257, over conductor 362 to the armature of repeater relay 338. Relay 337 now repeats the received impulses and actuates the teletypewriter apparatus of station 304. In like manner spacing and marking impulses are transmitted from station 304 to station 101, relay 120 repeating the received impulses.

In the previous description the establishment of connections between stations M_1, M_2, K_1, K_2 . . . K_n was discussed. Referring to Fig. 4 it is seen that the regular line circuits of these stations, 401, 402, 403, 404 and 405 are connected over conductors 406, 407, 408, 409 and 410 with corresponding conference line circuits 411, 412, 413, 414 and 415, respectively. All of the aforementioned stations, accordingly, may call or be called in conference over conference connector terminals 416 and 417. The same stations may establish non-conference connections over connector terminals 418, 419, 420, 421 and 422. In addition to the conference stations there may be other stations such as A_1 and A_2, the line circuits of which are not cross-connected to corresponding apparatus of a conference line circuit. Any one of these latter stations may originate a conference connection over terminals 416 and 417, but it cannot be called for a conference connection by any other station.

The description of the operation of the invention as before given serves to illustrate an important feature of the invention, whereby it is feasible to connect together for conference communication different teletypewriter stations, as desired, without the necessity of using compensating resistances in series with the line conductors. In other words it is entirely practical to cross connect for a conference group, any number of lines within the current carrying capacity of the apparatus, without consideration being given to the respective resistance of the individual lines. This result is due to the use of individual repeaters in the line circuit of each line.

Another advantageous feature which is evident from a consideration of the operating description before given is that supervision and remote control of the various stations is unaffected by ground potential differences.

What is claimed is:

1. In a telegraph exchange system, a plurality of subscribers' stations, each arranged to originate and receive calls and certain of said plurality of subscribers' stations arranged in a plurality of groups for conference purposes, a source of signals at each of said stations, a main station, line circuits for respectively connecting said plurality of subscribers' stations to said main station, means at said main station for connecting in response to signals from one of said sources the line circuit of the calling subscriber's station to one or more other of said line circuits respectively extending to the called subscribers' stations, and a signal repeater device in each of said line circuits for repeating signals received from the source at any one of the interconnected subscribers' stations for further transmission.

2. In a telegraph exchange system, a plurality of subscribers' stations, certain of said plurality of subscribers' stations arranged in a plurality of groups, a main station, circuits for respectively connecting said plurality of stations to said main station, a source of signals at each of said subscribers' stations, means in each of said circuits responsive to the source of signals at the subscriber's station connected to the particular circuit, for repeating the signals from said source, automatic switching means at said main station responsive to said repeated signals for connecting said subscriber's station to any one of the other subscribers' stations individually or to two or more of the other subscribers' stations collectively in one or another of said groups, and means whereby said repeating means is adapted for repeating signals over its associated circuit in either direction depending on the direction of transmission.

3. In a telegraph exchange system, a plurality of subscribers' stations, a certain of said plurality of subscribers' stations arranged in groups, a connection initiating device and an impulse sender at each of said stations, printing telegraph equipment comprising a transmitting and a receiving unit at each of said subscribers' stations, a source of power at each of said subscribers' stations for driving said equipment, a main station, a source of current at said main station for operating said equipment in response to the operation of any one of said impulse senders and any one of said transmitting units, a normally deenergized circuit connecting each of said subscribers' stations with said main station, automatically operated switching mechanism at said main station responsive first to said connection initiating device and then to said impulse sender, a terminal in said mechanism, means whereby said terminal may be selected by said impulse sender at a calling one of said subscribers' stations for establishing a connection between said calling subscriber's station and any one of said groups of subscribers' stations for conference purposes, means whereby said source of power at said calling subscriber's station is effective to drive its associated printing telegraph equipment in response to the operation of said connection initiating device at the calling subscriber's station and said sources of power at said connected stations being effective to drive their associated printing telegraph equipment upon the establishment of the completed connection, and a repeating device in each of said normally deenergized circuits for repeating impulses of current transmitted by said transmitting unit at the transmitting station to each of the receiving units at the subscribers' stations in any one group that is connected for conference purposes.

4. In a telegraph exchange system, a plurality of subscribers' stations, a certain of said plurality of subscribers' stations arranged in groups, a connection initiating device and an impulse sender at each of said stations, printing telegraph equipment comprising a transmitting and a receiving unit at each of said subscribers' stations, a source of power at each of said subscribers' stations for driving said equipment, a main station, a source of current at said main station for operating said equipment in response to the operation of any one of said impulse senders and any one of said transmitting units, a normally deenergized circuit connecting each of said subscribers' stations with said main station, automatically operated switching mechanism at said main station responsive first to said connection initiating device and then to said impulse sender, a terminal in said mechanism, means whereby said terminal may be selected by said impulse sender at a calling one of said subscribers' stations for establishing a connection between said calling subscriber's station and the idle subscribers' stations in any one of said groups of subscribers' stations for conference

purposes, and a repeating device in each of said normally deenergized circuits for repeating impulses of current transmitted by said transmitting unit at the transmitting station to each of the receiving units at the subscribers' stations in any one group that is connected for conference purposes.

5. In a telegraph exchange system, a plurality of subscribers' stations, a main station, printing telegraph equipment and a source of power therefor at each of said subscribers' stations, said source being normally disconnected from its associated equipment, a normally opened line circuit connecting each of said subscribers' stations to said main station, said line circuit having varying impedance values, a signal repeating means in each of said line circuits, switching means at each of said subscribers' stations for closing its associated line circuit, pulsing means in each of said subscribers' stations for transmitting an intermittent current over its associated line circuit, automatically operated means at said main station responsive first to said switching means and then to said pulsing means for interconnecting one of said subscribers' stations with more than one of the other subscribers' stations for the establishment of a multiple, or conference, connection prepared for communication in both directions as soon as the connection is completed, relay means responsive to said switching means for operatively connecting the power source at any one of said subscribers' stations originating a call, and other relay means responsive when said automatically operated means completes a connection between said calling stations and more than one of the other subscribers' stations, for operatively connecting the power sources at said more than one of the other subscribers' stations.

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