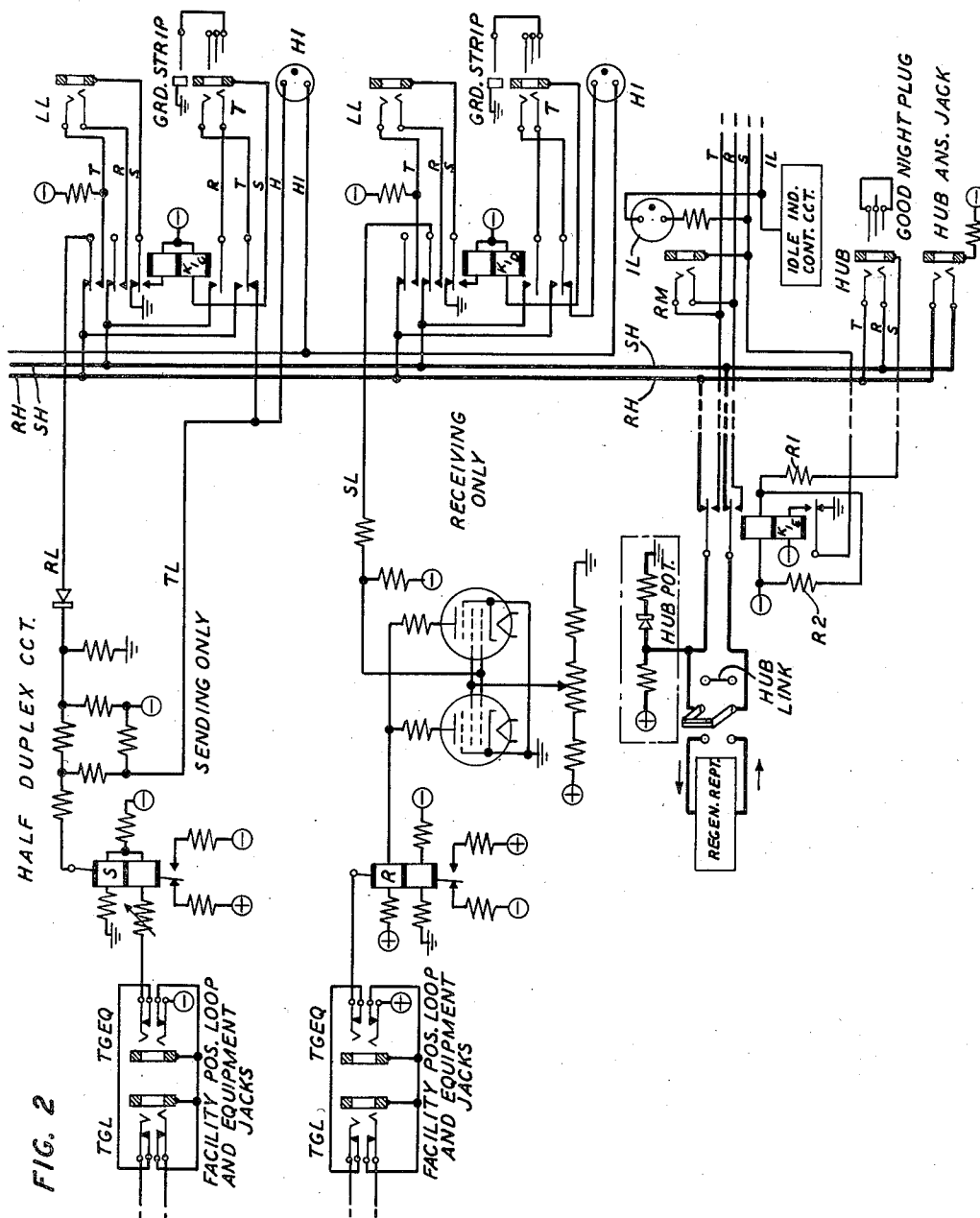


K. E. FITCH ET AL
TELEGRAPH SERVICE BOARD CIRCUITS

8 Sheets-Sheet 2

Filed Oct. 26, 1953



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TELEGRAPH SERVICE BOARD CIRCUITS

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8 Sheets-Sheet 3

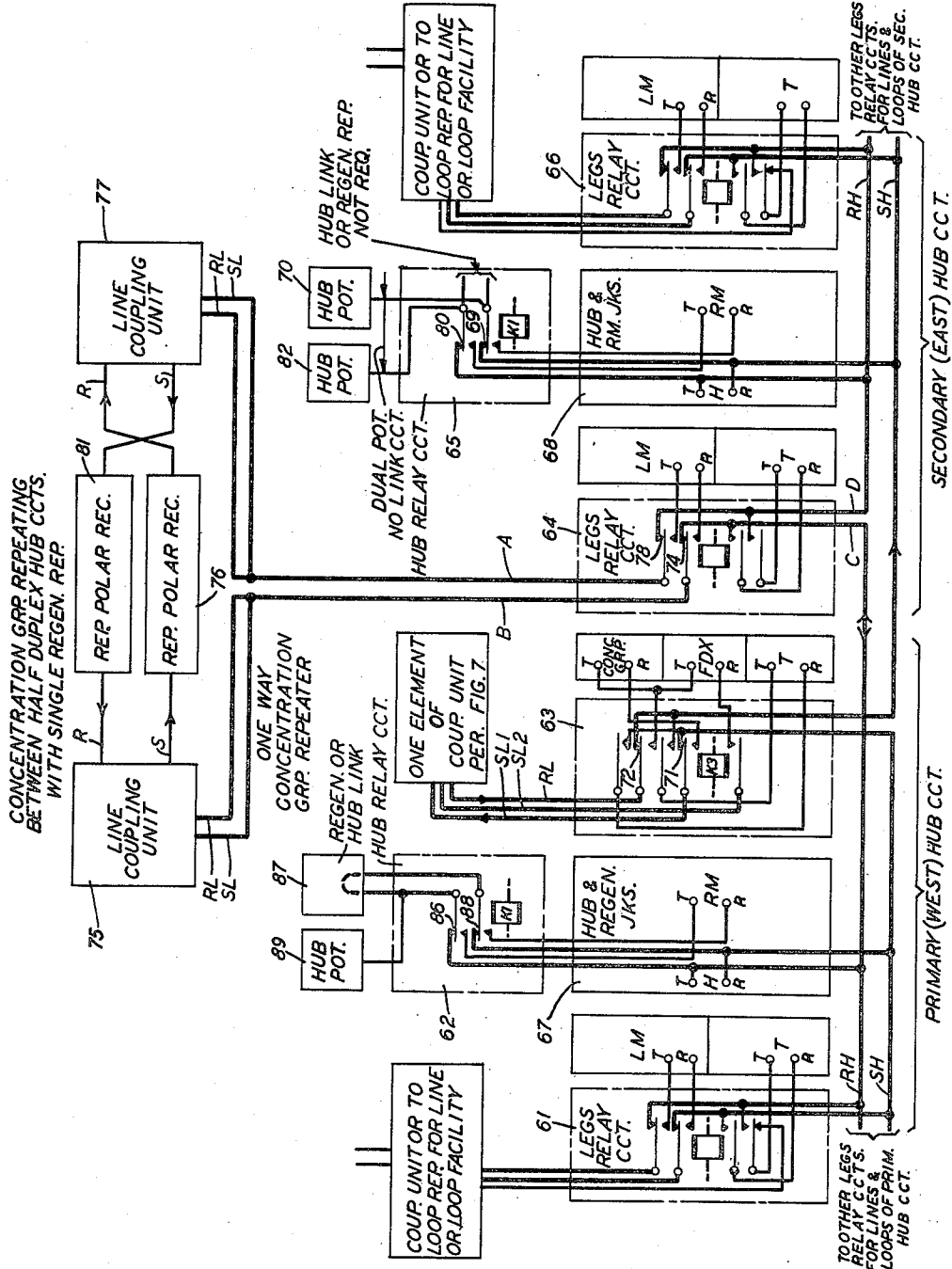


FIG. 3

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8 Sheets-Sheet 4

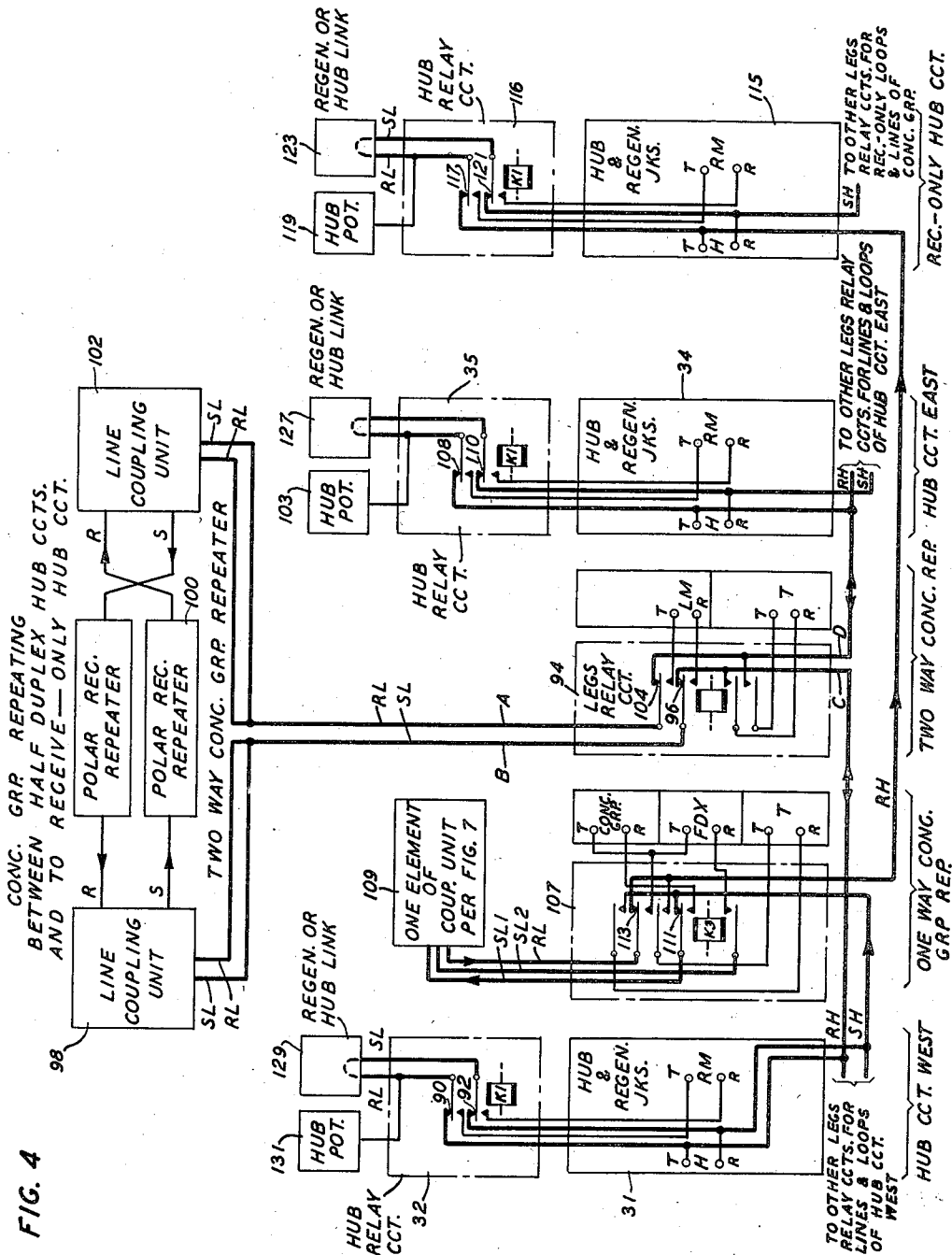


FIG. 4

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8 Sheets-Sheet 5

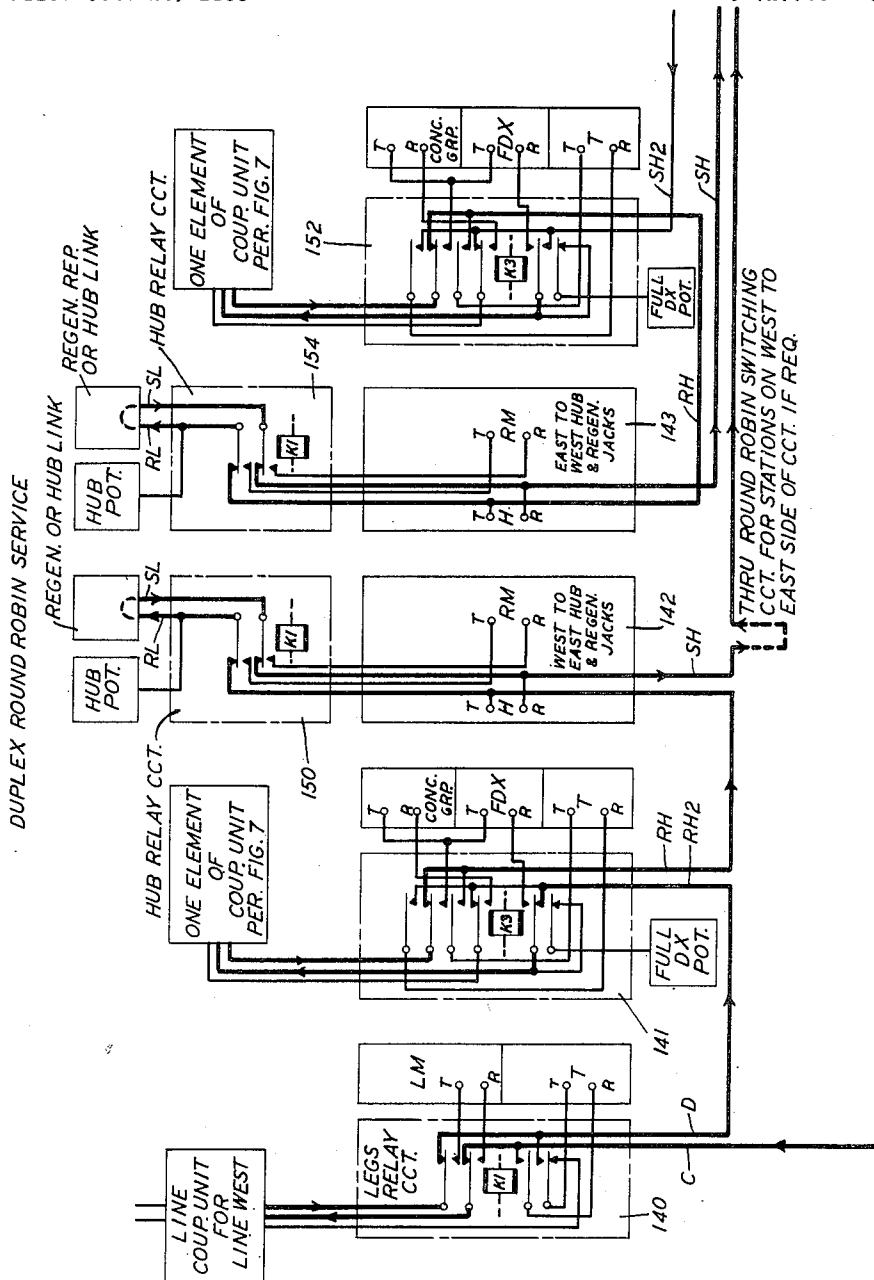


FIG. 5

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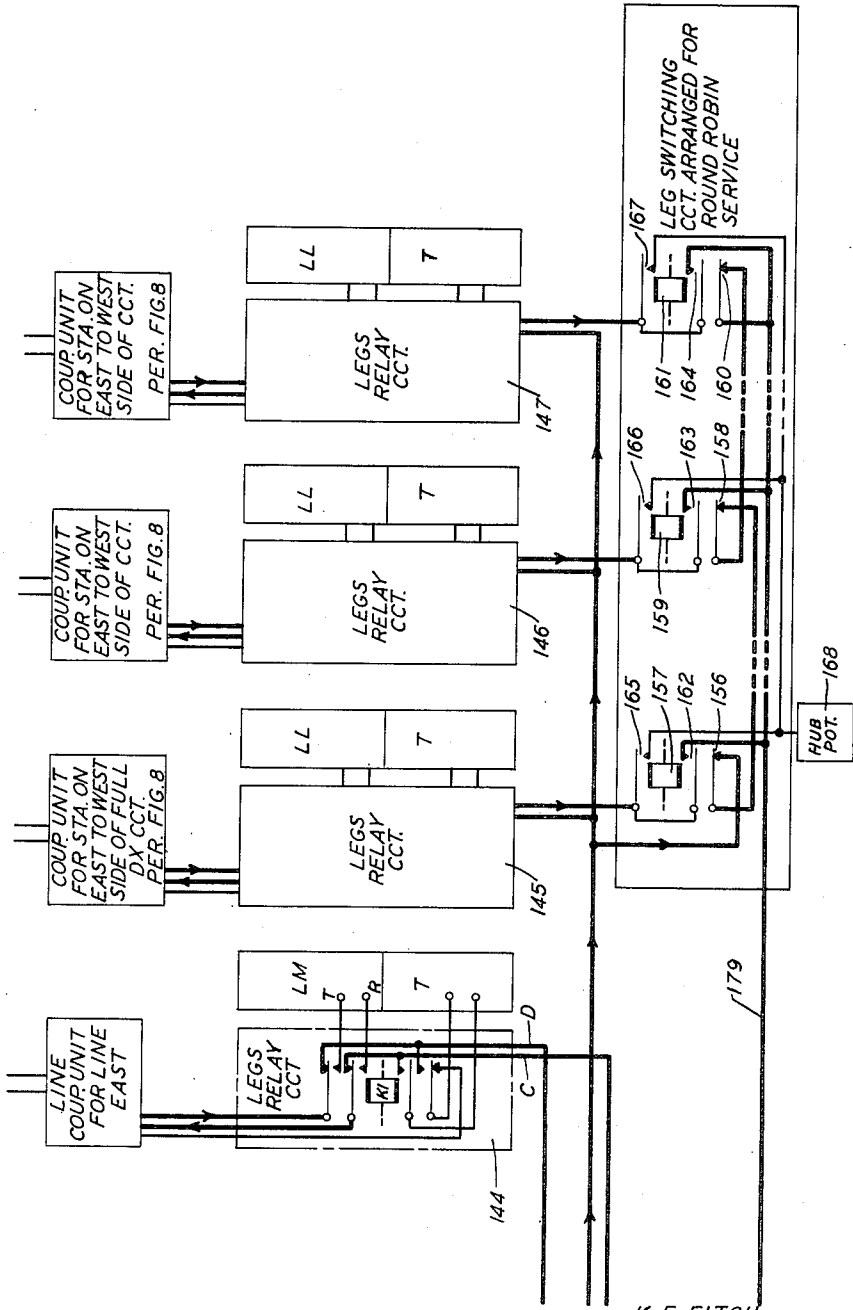
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FIG. 6

DUPLEX ROUND ROBIN SERVICE



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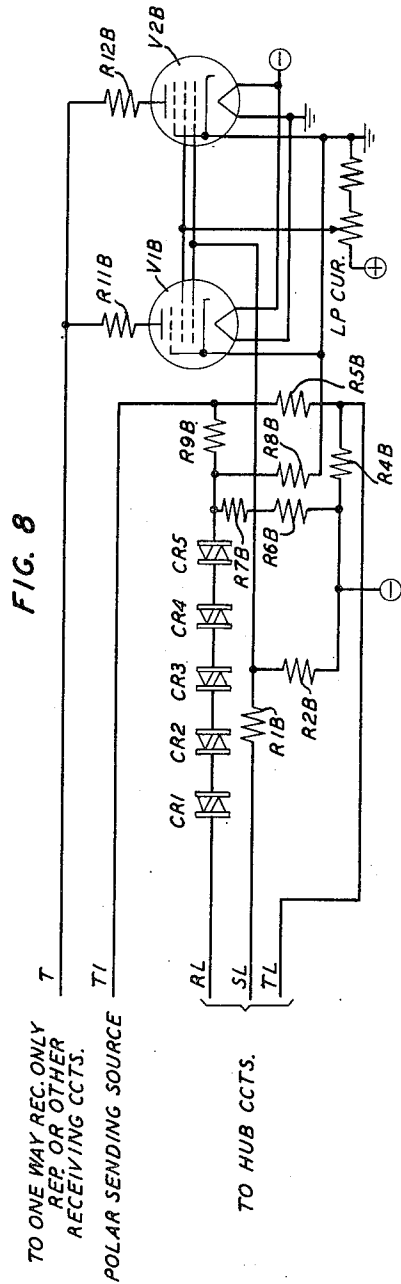
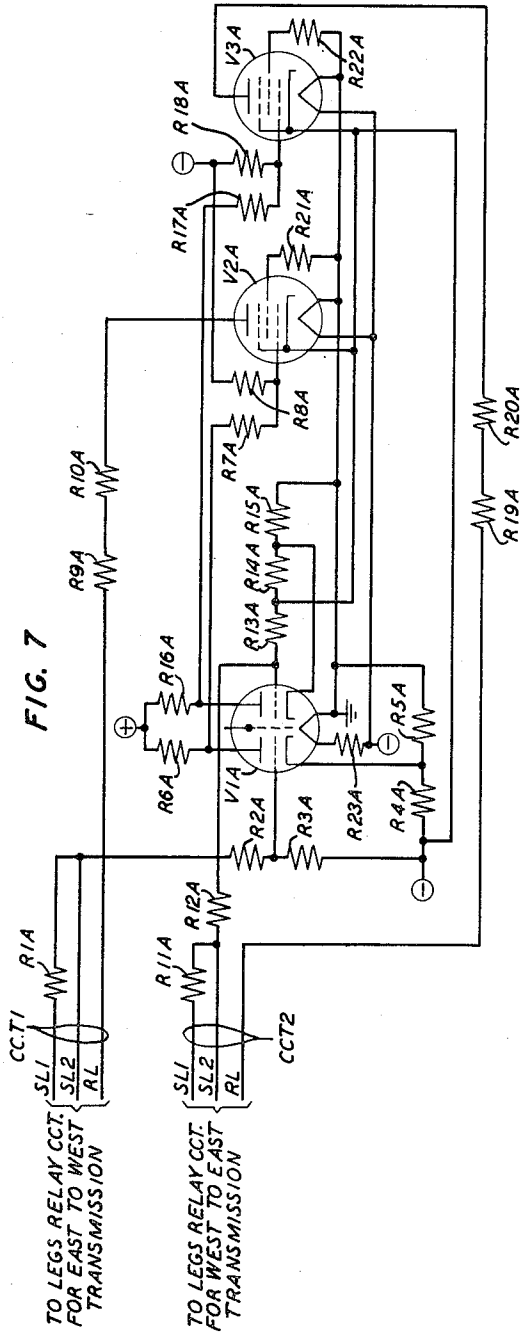
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TELEGRAPH SERVICE BOARD CIRCUITS

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8 Sheets-Sheet 8

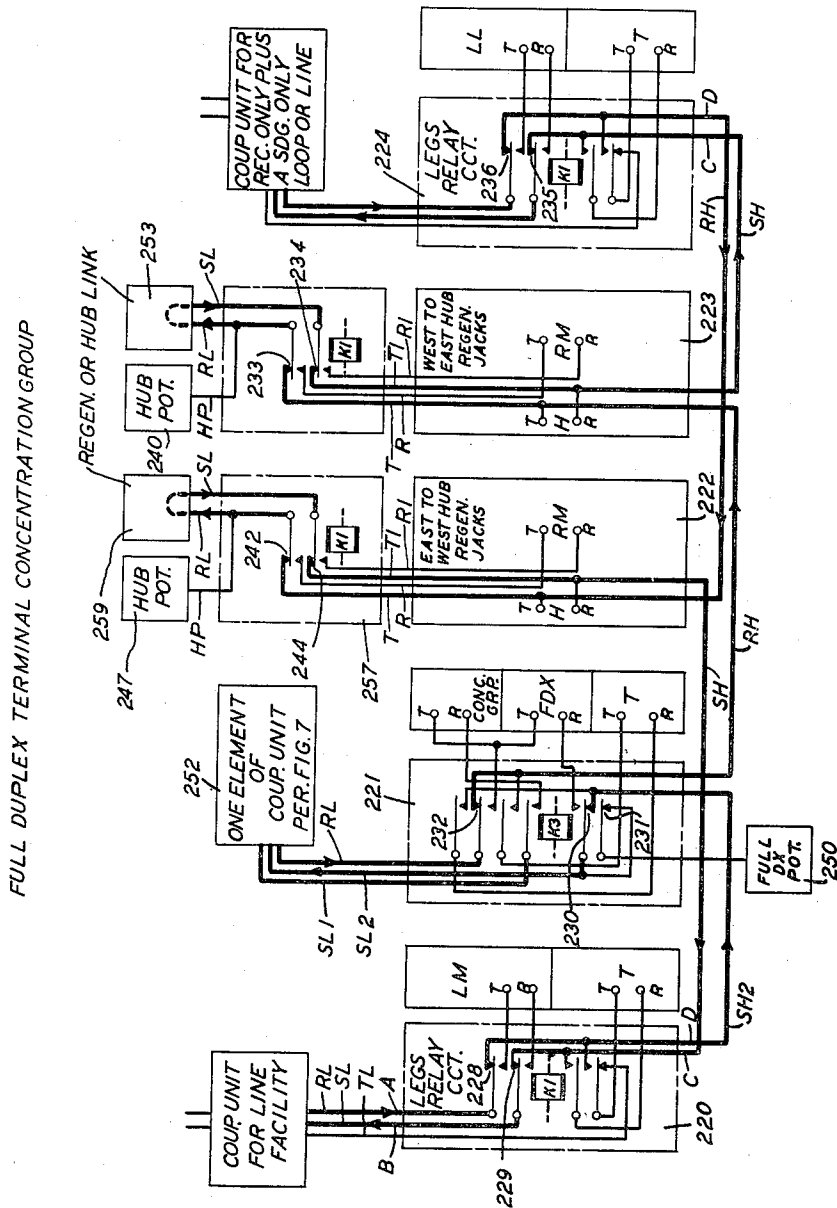


FIG. 9

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TELEGRAPH SERVICE BOARD CIRCUITS

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Application October 26, 1953, Serial No. 388,342

12 Claims. (Cl. 178—73)

This invention relates to hub telegraph systems and more particularly to the switching arrangements for telegraph service boards in hub telegraph systems wherein private telegraph subscriber loops are interconnected into hub concentration groups at a telegraph service board and concentration groups in different cities are interconnected by telegraph lines extending between the cities. In such systems arranged for half-duplex service any subscriber loop in the network may transmit to all of the other subscriber loops in the network simultaneously. Such communication in hub systems is carried on through what is known in the art as hub repeater circuits and hub coupling unit circuits. The hub circuit broadly may be considered as an electrical point to which the loop and line elements of each concentration group are connected in a manner somewhat resembling the spokes of a wheel connected to the hub of the wheel. The subscriber loops, it is to be understood, extend from subscriber stations relatively near a particular telegraph service board through the concentration group to the hub of a concentration group. Concentration groups at service boards in different cities are then interconnected by means of telegraph lines which join the hubs of the various concentration groups together into a single intercommunicating unit. The service is termed half duplex as only one loop may transmit effectively at any one time to all facilities interconnected in the network. Full-duplex operation may be carried on through dual hubs at each service board involved.

Private line networks thus interconnected through such hub concentration groups at a telegraph service board are interconnected on a semipermanent basis, that is to say, the components of the network may remain undisturbed for protracted periods, such as for days or weeks or longer, as contrasted with the type of operation in teletypewriter exchange switchboards, which operation resembles telephone exchange operation in that the interconnections generally are of relatively short duration.

An object of the invention is the improvement of arrangements for associating hub telegraph circuit elements, such as hub telegraph lines and hub telegraph subscriber loops, in the concentration groups of private telegraph networks on a semipermanent basis, in order to facilitate additions to, subtractions from, and substitutions of hub telegraph line and hub telegraph subscriber loop facilities in, concentration groups at a telegraph service board.

Private line telegraph systems in one large well-known communication plant are now administered in what is known in the art as a telegraph service board. Each telegraph line and each subscriber telegraph loop in the board is equipped with an individual hub type telegraph repeater and each telegraph line and loop is equipped also with an individual coupling unit, formerly known as a control circuit, the function of which is to prevent "reflection" of signals transmitted over the telegraph

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line toward a hub back to its point of origin. One end of each telegraph line and loop is arranged to be interconnected through an individual jack circuit, one for each line and one for each loop forming part of a concentration group to the hub. When the lines and loops are so equipped, the administration of the circuits may be performed by attendants at telegraph switchboards known in the art as telegraph service boards, since the addition, subtraction, or substitution of lines and loops does not require compensatory adjustment of the other facilities in a concentration group. In private line networks, since the circuits comprising them are interconnected on a semipermanent basis, there is relatively little switching performed and the circuits are designed to take advantage of this fact. By this is meant that line calling, recalling, disconnect and ringing facilities, trunk circuits, operator cord circuits and so forth are not provided, because of the relatively little switching which is required. The network may be established by the use of complementary facilities. For instance, information necessary to the establishment of all of the concentration groups interconnected into networks at Chicago and New York, for instance, may be passed over a single telegraph line between service board attendants at Chicago and New York and the same is true for the interconnection of concentration groups in other cities.

Telegraph service boards are divided into two classes according to the number of lines and loops which must be interconnected in a given office: When the number of interconnections is large, a multiposition board having multiple appearances of certain important line and repeater facilities is used. Where the number of required interconnections is relatively small, one, or a few, non-multiple positions are used. An example of a multiposition telegraph service board is described in Patent 2,349,586 granted to Bonorden-Koos-Kreck-Large-Marshall, May 23, 1944. An example of a single position telegraph service board is disclosed in Patent 2,542,208 granted to M. R. Purvis, February 20, 1951. The circuits of the telegraph service board described in Patent 2,349,586 employ electromagnetic devices, such as polar relays, to perform both the telegraph communication function, that is, telegraph transmitting and telegraph receiving, as well as the function of preventing the "reflection" of signals. In the circuits disclosed in Patent 2,542,208, electromagnetic relays are employed in the telegraph repeaters but space discharge devices are employed to prevent reflection. The circuits of the present telegraph service board resemble the circuits of Patent 2,349,586 in function but employ space discharge devices to prevent reflection and to perform certain telegraph repeating functions.

The invention may be understood from reference to the associated drawings in which preferred embodiments of the invention are presently incorporated. It is to be understood, however, that the invention may be incorporated in other embodiments which will be suggested to those skilled in the art from a consideration of the following.

In the drawings:

Fig. 1 and Fig. 2 taken together with Fig. 1 positioned above Fig. 2 disclose a typical half-duplex concentration group;

Fig. 1A discloses a leg patching cord;

Fig. 1B discloses a facility patching cord circuit;

Fig. 3 discloses a concentration group repeating between half-duplex hub circuits with a single regenerative repeater;

Fig. 4 discloses a concentration group repeating between half-duplex hub circuits and to a receive-only hub circuit;

Figs. 5 and 6 taken together with Fig. 5 at the left of Fig. 6 disclose a duplex round robin arrangement;

Fig. 7 shows a coupling unit circuit for full duplex coupling or one-way hub to hub repeating;

Fig. 8 shows a coupling unit circuit for interconnecting hub circuits and one-way send and receive circuits; and

Fig. 9 discloses a typical full-duplex terminal concentration group.

Refer now to Fig. 1 and Fig. 2 together, with Fig. 1 above Fig. 2. Before describing the operation of the circuit in detail it will be first described generally.

Fig. 1 shows at the upper left a telegraph line connected through telegraph line and equipment jacks TGL and TGEQ which are located at a position in the switchboard, known as the facilities position, through a polar relay telegraph line repeater and a line coupling unit having a duplex-control circuit, to prevent reflection of the signals transmitted toward the hub back from the hub to their point of origin. The coupling unit is connected through contacts of a cut-off relay K1A, in a legs relay circuit, one of which is individual with each line and each loop, to the receiving hub RH and the sending hub SH, when cut-off relay K1A in the legs relay circuit is in the normal condition as indicated. When relay K1A is operated, in a manner to be described, the coupling unit is disconnected from the SH and RH hub leads and the sending and receiving legs of the coupling unit are extended through contacts of relay K1A to the leg multiple jack LM.

The jack LM and its associated idle indicator lamp IL are multiplied through corresponding jacks and lamps at each of the other service positions in the telegraph service board as indicated by the conductors extending therefrom to the right of the figure. This is to permit the line to be appropriated for use in other concentration groups at other positions when released from the present concentration group with which it is normally associated.

A testing jack T is also associated with this circuit and its tip, ring and sleeve conductors extend to the bottom winding and to individual armatures on the bottom of cut-off relay K1A in the legs relay circuit. When relay K1A is operated, in a manner to be described, the tip and ring conductors of the jack are connected to the receiving and sending hub leads, respectively, for testing to permit a spare telegraph line facility to be connected to the hub leads as a substitute.

Fig. 1 comprises also a circuit, shown in the lower portion of the figure, which extends toward the left to a subscriber's loop comprising a teletypewriter transmitter and receiver, not shown, on the subscriber's premises. The loop is connected also through telegraph line and telegraph equipment jacks TGL and TGEQ at the facilities position and then through an electronic loop repeater, including a coupling unit feature, and the contacts of a cut-off relay K1B, in an individual legs relay circuit, to the receiving and sending hub RH and SH. The individual legs relay circuit associated with the loop circuit comprises also a single non-multiplied loop jack LL and a test jack T, corresponding generally to the jacks associated with the line circuit.

Fig. 2 shows at its top a one-way sending-only hub facility which extends toward the left to a subscriber telegraph station, not shown, having a telegraph sender only. The circuit is interconnected through telegraph loop and telegraph equipment jacks TGL and TGEQ at the facilities position, a one-way polar relay sending repeater, a one-way sending-only coupling unit and cut-off relay K1C, in an individual legs relay circuit, to the receiving hub RH. This portion of the circuit also has an individual loop jack LL and an individual testing jack T.

Fig. 2 shows also in its middle portion a one-way receiving-only hub facility, which extends toward the left to a subscriber station, not shown, having a telegraph receiver only. The circuit is interconnected through telegraph loop and telegraph equipment jacks TGL and

TGEQ to a one-way polar relay receiving repeater, a receiving-only coupling unit and cut-off relay K1D, in an individual legs relay circuit, to the sending hub. This portion of the circuit also has an individual loop jack LL and an individual testing jack T.

Fig. 2 shows also in its lower portion a regenerative repeater and hub potentiometer connected through an individual legs relay circuit to the hub and to a jack circuit comprising a multiple jack and an idle indicating lamp. The receiving and sending hubs RH and SH extend through the contacts of the cut-off relay K1E in the individual hub relay circuit which corresponds generally to the legs relay circuit associated with the line and loop facilities, to the hub potentiometer and to the regenerative repeater, when required, or alternatively to a strap called the hub link interconnecting the two hubs.

It is to be understood that the arrangement shown in Figs. 1 and 2 is one of a number of typical arrangements and does not include all of the circuits which may be interconnected into a particular concentration group at the telegraph service board. Other typical concentration group arrangements are shown in Figs. 3, 4, 5, 6 and 9. A particular concentration group might include, for instance, three or four or more telegraph lines, such as the one indicated in Fig. 1. The concentration group might include also four or five or more telegraph subscriber loop circuits, such as shown in Fig. 1, and several receiving-only subscriber loop circuits as well as several sending-only subscriber loop circuits such as shown in Fig. 2.

The number of facilities, that is, lines and loops, that may be interconnected through a single hub is limited due to two factors, namely, leakage through the receiving legs, which are interconnected in parallel to the hub point, and the capacitance of the cabling used in interconnecting the various facilities to the hub. The leakage is a function of the maximum ambient temperature and the capacitance is a function of the lengths and number of legs. In some cases the leakage will be the limiting factor and in other cases the total capacitance of the interconnecting cables will be the limiting factor.

If the number of legs required to be interconnected into a single concentration group, at a particular service board, exceeds the limit, it becomes necessary to divide them among two or more hubs and the hubs may be interconnected by what is known in the art as a two-way concentration group repeater and a one-way hub to hub repeater, as in the arrangement per Fig. 3 to be described hereinafter. The two-way concentration group repeater may comprise, for instance, two electronic coupling units connected back to back through telegraph repeating relays.

A number of components of the present system are disclosed in the following United States patents and patent applications which are hereby made part of the present disclosure as though fully set forth herein:

Telegraph line electronic coupling units are disclosed in Patent 2,528,120 granted to J. R. Davey October 31, 1950 and in Patent 2,636,942 granted to J. R. Davey April 28, 1953. Electronic subscriber loop repeaters are disclosed in Patent 2,594,993 granted to W. T. Rea April 29, 1952 and in patent application of J. R. Davey Serial No. 173,442 filed July 12, 1950, now Patent No. 2,649,504 granted August 18, 1953. Full-duplex electronic hub-type coupling arrangements are disclosed in Patent 2,607,852 granted to W. T. Rea August 19, 1952 and in patent application Serial No. 232,799 of J. T. Neiswinter filed June 12, 1951. The idle line indicator circuit is disclosed in patent application Serial No. 237,506 of B. Ostendorf, Jr. filed July 19, 1951, now Patent No. 2,657,336 granted October 27, 1953.

Attention is particularly directed to the bottom portion of Fig. 2 which discloses the means by which the hub potentiometer and the regenerative repeater, or alternatively the hub link between the sending and receiving hubs, are interconnected to the hubs. The hub potentiometer is connected through the top break contact of the hub

cut-off relay K1E in an individual legs relay circuit to the receiving hub, when relay K1E is in the normal released condition as indicated on the drawing. The top and bottom terminals of the regenerative repeater, or alternatively the top and bottom terminals of the hub link, are connected through a double-pole double-throw switch, depending upon the position of the switch, through the top pair of back contacts of the hub cut-off relay K1E to the receiving and sending hub. It will be observed that the hub potentiometer is always connected to the receiving hub when relay K1E is released. When the incoming signals do not require regeneration, by which is meant retiming and reshaping of the signals to conform to standard signals, and relay K1E is in the normal unoperated position and the double-pole double-throw switch is actuated to engage the terminations of the hub link, the receiving hub and the sending hub are interconnected, so that electrically they constitute a single point. When the signals are required to be regenerated, the double-pole double-throw switch is actuated so as to interpose the regenerative repeater between the receiving hub and the sending hub.

The hub relay circuit includes also a regenerative multiple jack RM. The tip and ring conductors of jack RM are connected to the pair of top make contacts of relay K1E. When the relay is operated, in a manner to be described, the hub potentiometer and the regenerative repeater, or the hub link, depending upon the position of the double-pole double-throw switch, are connected to the regenerative multiple jack RM. It will be observed that jack RM and its associated idle indicating lamp are multiplied through the various positions of the telegraph board as indicated by the conductors shown extending to the right. This affords means for interconnecting a regenerative repeater and its associated hub potentiometer which have been disconnected from a particular concentration group, in a manner to be described, into another concentration group. The hub relay circuit includes also a hub jack, the tip and ring circuit of which are connected to the receiving hub RH and the sending hub SH. The sleeve of the jack is connected through a resistor R1 and the upper winding of relay K1E in parallel with resistor R2 to battery. The hub jack affords means for operating relay K1E, in a manner to be described, to disconnect the hub potentiometer and the regenerative repeater or hub link. The hub circuit includes also a hub answering jack, the tip and ring circuits of which are connected to the receiving hub RH and sending hub SH, respectively. The hub answering jack affords means for communicating through the hub through telegraph or teletypewriter cord circuits such, for instance, as are disclosed in the patent granted to M. R. Purvis mentioned in the foregoing.

The manner in which telegraph communication signals are transmitted through the hub circuit per Fig. 1 and Fig. 2 will now be described. It will be assumed that the telegraph line circuit shown at the top left of Fig. 1 extends to a telegraph service board in a distant city where it is interconnected into a hub circuit concentration group thereat. It will be assumed also that a number of telegraph subscribers' loop circuits are interconnected to the same distant concentration group and that one of these subscribers transmits telegraph signals from his subscriber station. The signals will pass from his loop circuit through the hub associated with the concentration group at the distant office and through a distant telegraph line repeater and through the top conductor of the line and equipment jacks TGL and TGEQ at the facility position and the winding of polar telegraph repeater receiving relay R to operate relay R in the line repeater. The signals will be propagated through the top or receiving conductor of the coupling unit associated with the line repeater through the top break contacts of relay K1A in the legs relay circuit to the receiving hub. It has been explained that the hub potentiometer is connected through relay K1E to the receiving

hub. As marking and spacing signals are received on the hub, the hub will assume, in accordance with the received signals, either a characteristic marking potential, such as plus 60 volts, for instance, or a characteristic spacing potential, such as minus 30 volts, for instance. Assuming that the regenerative repeater is not employed, these signals will pass through the hub link strap rather than the regenerative repeater in the hub circuit and appear on the sending hub. They will pass simultaneously through the sending legs of each one of the facilities interconnected into the hub including all of the telegraph lines and all of the telegraph loops, including the receiving-only loops. They will not be propagated over sending-only loops since these circuits are arranged only for transmission toward the receiving hub. The signals will be prevented from passing through the sending leg associated with the particular receiving leg from which the signals are being transmitted toward the hub. This function will be performed by the coupling unit of the line telegraph repeater. The manner in which this circuit functions is described in detail in Patent 2,528,120 mentioned in the foregoing.

If one of the subscriber's loops, connected to the concentration group, shown in Figs. 1 and 2, transmits, after transmission from the telegraph line circuit described in the foregoing has terminated, the signals originating at the local subscriber station will pass through the connected telegraph loop circuit and the loop and equipment jacks TLG and TGEQ at the facility position to the electronic loop repeater. The signals will pass through the receiving leg of the electronic loop repeater and the top back contact of relay K1B in the individual legs relay circuit to the receiving hub RH. The signals received from the loop will be impressed on the hub potentiometer. The signals will produce the characteristic positive 60-volt mark and negative 30-volt space potentials, for instance, on the receiving hub. The signals will pass through either the regenerative repeater or the hub link connected to the contacts of hub relay K1E to the sending hub and will pass out over the sending legs of all facilities connected to the sending hub to the distant concentration groups and to the local subscriber stations, except the sending-only station which is not connected to the sending leg.

The signals received from the local subscriber loop circuit, which is assumed to be transmitting toward the hub, will be prevented from passing back to their source of origin by arrangements in the electronic subscriber loop repeater described in Patent 2,594,993, for instance.

If more than one facility connected into the concentration group attempts to transmit simultaneously, every time more than one spacing signal element appears on the receiving hub a potential characteristic of a plural space condition, such as minus 60 volts, for instance, is produced on the receiving hub. In response to this, as described in the patents identified in the foregoing, the sending legs of all line and loop repeaters will be placed in such condition that spacing signals produced on the hub by the simultaneous sending will be transmitted to every facility connected to the hub except the sending-only facilities. The reception of the mutilated signals will serve as an indication of the attempted simultaneous sending.

The primary functions of a concentration group, such as is typified by Fig. 1 and Fig. 2, are as follows:

1. To give access to line facilities, regenerative repeaters or loop repeaters;
2. To provide an idle indicating lamp, associated with the leg multiple jack of a line facility, spare loop repeater or regenerative repeater which lamp can be lighted to indicate that the circuit is not in use;
3. To provide a test jack by means of which substitution of spare facilities for assigned facilities may be made and through which test jack it is possible to monitor on line-facilities which extend through the

service board and are connected to a teletypewriter exchange switchboard;

4. To afford access through a nonmultiple loop jack to a loop repeater which has been released from its normal assignment; and

5. To provide a common hub jack and hub jack relay circuit which will afford access to the hub leads of a concentration group for test purposes and which will provide means for the addition of a leg to a concentration group on a patched basis and which provides also for replacement of an assigned regenerative repeater or hub link with a spare or released regenerative repeater or hub link.

Each line facility, spare loop repeater, or regenerative repeater terminates at the service board in a leg multiple jack circuit. These jacks are designated LM for each line facility and each spare loop repeater and RM for the regenerative repeater and appear at each position in the telegraph service board.

The tip and ring conductors of these jacks, when connected to the relay in the associated legs relay circuit, are open when the relay is released. When the relay is operated, the tip and ring conductors are connected to the receiving and sending legs of the associated repeater which is disconnected from the hub through the operation of the relay and the repeater may be patched out and employed as a spare repeater in another concentration group.

When the relay in a line repeater circuit, such as relay K1A, is released, the sleeve conductor of the jack, such as jack LM, is connected directly to ground, in the case of a line facility which is normally interconnected to a concentration group. When this relay, such as K1A, is operated, in a manner to be described, which is the condition prevailing when the facility is released from a concentration group or when it is idle, the sleeve conductor of the jack LM connects to a source of negative potential through the top winding of relay K1A which has a resistance of small magnitude. From the sleeve of the jack LM a circuit is also extended through resistor R6, which is of relatively large magnitude, and the idle indicator lamp IL, which may be, for instance, a neon lamp, to the idle indicator control circuit. The idle indicator control circuit is operated momentarily from time to time by the operator at the service board positions when idle lines extending to distant cities are required to be added to concentration groups. At such times as the idle indicator control circuit is actuated, positive potential is supplied through the idle indicator circuit to the lamp lead and the lamp is illuminated for a measured interval to indicate that the circuit is idle. The operation of the idle indicator circuit is disclosed in detail in the Patent 2,657,336 further identified in the foregoing. Connection of plug L of the leg patching cord per Fig. 1A to the jack LM will establish a low resistance circuit from ground through the winding of relay K2 in Fig. 1A, sleeve of plug L, and sleeve of jack LM to the junction between high magnitude resistor R6 and the source of negative potential supplied through the winding of relay K1A in Fig. 1. This will extinguish the idle indicator lamp IL. The extinguishing of the lamp indicates that the idle circuit has been appropriated for use and is no longer idle.

When the cut-off relay, such as relay K1A, is released, ground potential is applied through the top innermost back contact of the relay and high magnitude resistor R6 to the idle indicator lamp IL. Under such circumstances when the idle indicator control circuit is operated, in a manner described in the idle indicator Patent 2,657,336 further identified in the foregoing, the positive potential supply from the idle indicator circuit is insufficient to illuminate the lamp and since the associated circuit is at this time not available for other service it is thereby shown as being busy.

In the foregoing it was mentioned that spare loop re-

peaters and regenerative repeaters terminate in the service board in a leg multiple circuit. In the arrangement per Fig. 1, the loop repeater shown is assumed to be connected to a subscriber loop circuit. There may be spare loop repeaters in the service board and these will also be connected through multiple jack circuits having associated idle indicator lamp circuits multiplied throughout the various positions of the board. They will be identified as spare loops by appropriate designations. They will be also connected to the idle indicator circuit and, upon actuation of this circuit, if they are not at the time appropriated for use in some concentration group, they will be indicated as being idle and available for such service.

Attention has been called to the fact that the regenerative repeater in Fig. 2 is equipped with an individual legs relay circuit and multiple jack appearances, each having associated therewith an idle indicator lamp, so that the regenerative repeater, when not connected into a concentration group, will be indicated as idle upon the actuation of the idle indicator circuit and may be patched into a concentration group requiring a regenerative repeater.

Loop repeaters, which are assigned normally to a particular concentration group, are terminated on a non-multiple basis in a loop leg jack such as jack LL in Fig. 1. It will be observed that the terminals of jack LL are not extended toward the right as are the terminals of jack LM and jack RM and that there is no idle indicator lamp associated with jack LL. The jack LL will, therefore, appear at only one position in the service board, the position at which the concentration group of which it forms a part has its appearance and is being administered. The tip, ring and sleeve conductors of jack LL are connected to the contacts of a relay, such as relay K1B, in the associated legs relay circuit. When the associated subscriber loop is connected into the hub of the concentration group, relay K1B is released. The sleeve conductor of the jack LL is connected to ground through a back contact of relay K1B. The tip and ring leads of the jack LL are connected to open front contacts on the relay. When the cut-off relay is operated, the sleeve conductor of the jack is connected to a source of negative potential, such as negative 48 volts, through a low resistance winding on the relay and the tip and ring conductors are connected to the receiving and sending legs, respectively, of the loop facility. This permits the loop facility to be patched out as a spare. In this case, the Release Plug, such as that shown in the lower right in Fig. 1, is connected to a ground strip GRD Strip and to a jack T, and a circuit may be traced from ground on the ground strip through the release plug, sleeve of jack T and bottom winding of a cut-off relay such as relay K1B to battery, operating the relay and holding it in the operated position as long as the patch remains up.

A concentration test jack T is associated with every assigned line or loop repeater.

The leg patching cord Fig. 1A is used to patch spare lines, loops or regenerative repeaters to a hub concentration group. In patching a spare line or loop repeater to a concentration group in making a substitution the plug L of the leg patching cord is connected to one of the leg multiple jacks LM or to the loop leg jack LL of the spare line or spare loop which is to be connected into the concentration and the plug C of the leg patching cord is connected to the test jack T of the line or loop in the concentration group which is to be disconnected from the concentration group and replaced by the spare line or loop, which spare line or loop is thereby substituted for the disconnected line or loop. The tip and ring conductors of the leg multiple jack are connected through the tip and ring conductors of the plug L of the patching cord and through the tip and ring conductors of the plug C of the leg patching cord to the tip and ring

conductors of the test jack T of the facility which is to be replaced.

A spare line or loop repeater when patched to the jack T replaces the assigned facility. At this time the assigned facility is released from the concentration group by the operation of the cut-off relay, such as relay K1A in the case of a line, or relay K1B in the case of a loop substitution. Operation of the cut-off relay is controlled from ground through resistor R8 and R10 in parallel in the leg patching cord Fig. 1A, through the sleeve of plug C, the sleeve of the jack T to which it is connected and the bottom winding of the cut-off relay, such as relay K1A or K1B, to battery.

When it is necessary to release the assigned facility, without replacing it with a spare, the release plug shown in the upper right in Fig. 1 is connected to the T jack and to the ground strip. This establishes a circuit from ground, connected to the grounded strip, through the release plug, to the sleeve of Jack T and the bottom winding of the cut-off relay, such as relay K1A or K1B, to battery operating the cut-off relay in the legs relay circuit. This disconnects the associated facility from the concentration group.

Refer now to the leg patching cord circuit per Fig. 1A. In Fig. 1A jack H2 provides access to the communication conductors for other patching cords or for monitoring through the concentration group by means of a telegraph or teletypewriter cord circuit such as disclosed, for instance, in Patent 2,542,208 mentioned in the foregoing. Trouble indicator jack T2 in Fig. 1A provides for connecting a hit indicator cord circuit to the patching cord so that observations of trouble may be made on signals received through patched facilities. Relay K1F in Fig. 1A has a winding in series in the tip transmission lead of the leg patching cord of Fig. 1A and the armature of relay K1F operates to its lower position in response to spacing pulses passing through the patching cord. When the armature is operated to its lower position, negative 130 volts, for instance, is connected through resistor R14 to the tip of jack T2 for a spacing condition and when the armature engages its upper contact in response to a mark, resistors R13 and R14 are connected in series between negative battery and ground, impressing a voltage of negative 50 volts, for instance, on the tip of jack T2. Relay K2 operates when cord L is connected to a regenerative multiple jack RM but remains released when this cord is connected to a leg multiple jack LM or a loop leg jack LL. In order to effect this the magnitude of the resistance in the sleeve circuit of the regenerative jack RM is made smaller than the corresponding resistance in the other two jack circuits. In its unoperated condition the armature of relay K2 connects a 200-ohm ground, for instance, to the sleeve of cord C and in the operated condition the armature causes the sleeve of cord C to have a potential of approximately positive 100 volts, for instance. This positive potential provides for operation of relay K1E in the regenerative repeater circuit which releases the regenerative repeater or hub link when a spare regenerative repeater or hub link is patched to jack hub.

These patches may include substitutions and additions of regenerative repeaters or spare hub link circuits. The patching facilities may also be used for building up concentration groups on a temporary basis.

In tracing the line and loop circuits, in the foregoing, each line and loop was shown to extend through a telegraph line jack or telegraph loop jack and a telegraph equipment jack at the facility position. These jacks permit testing repeaters, adjusting loop currents and patching spare repeaters to line or loop conductors as required. The patches are made by means of the facility patching cord circuit per Fig. 1B and occasionally by loose patch cords.

The concentration group is equipped with means for indicating hits on the facilities connected into the con-

centration group. These indications are obtained by means of lead TL which extends from the coupling unit to lamp HI. A circuit may be traced, for instance, from lead TL of the coupling unit associated with the line repeater, through the hit indicator lamp HI and contacts of key HIT, and a potentiometer comprising resistors R2 and R3 to a source of negative potential. Corresponding hit indicator lamp circuits are associated with all lines and all loops. The key HIT is connected in parallel to all of the lamps HI. On signals incoming from the facility, negative potential, 125 volts, for instance, is impressed on the lamp for a spacing signal and negative 50 volts, for instance, for a marking signal. When the hit indicator key HIT is closed to observe hits, negative battery, negative 24 volts, for instance, is connected to the opposite side of the lamp. When hit indications are not to be observed, negative 87 volts, for instance, may be supplied through the hit indicator key HIT to the lamp, preventing the lamp HI from lighting. The negative potential changes are under control of relay HT and key PC.

The hub jack shown in the lower portion of Fig. 2 connects to a hub relay circuit comprising relay K1E and provides access to a concentration group to permit the addition of line or loop facilities or the substitution of regenerative repeaters on a patched basis. It also provides for the connection of communication circuits, such as the telegraph cord circuit described in Patent 2,542,208 further identified in the foregoing, for monitoring and communicating purposes.

The concentration group may be made inoperative by connecting a "Good Night" plug to the hub jack. This interconnects the tip and sleeve conductors of the hub jack to apply a source of negative 24-volt potential, for instance, from the sleeve circuit to the tip conductor. This causes a spacing signal to be sent outward over each facility of the group to notify each distant office or station that the circuit is inoperative. The hub answering jack shown at the bottom of Fig. 2 is provided to permit the service board attendant to answer incoming calls from stations connected to the hub.

Attention is now particularly called to an important feature of the invention, namely to the legs relay circuit shown in the present Figs. 1 and 2, which may be contrasted with the legs relay circuit per Fig. 3 or Fig. 7 of the multiposition service board for use in large cities, of the prior art, disclosed in Patent 2,349,586 further identified in the foregoing. In the present switchboard the legs relay circuit associated with each facility connected into a concentration group employs a single relay, whereas in the prior art four relays were required for each such circuit. These circuits are the most numerous employed in private wire hub service.

Figs. 3, 4, 5, 6 and 9 show typical concentration group arrangements which may be employed in the telegraph service board of the present invention. These various typical concentration groups employ a number of coupling units and repeaters, well known in the art, the basic operation of which, without the switching arrangements of the present invention, have been described in the patents and patent applications identified in the foregoing. In addition they include also coupling units which have been modified to make them more adaptable in the flexible service afforded by the present switchboard. The modified units will, therefore, be described in detail preliminary to the description of the concentration groups per Figs. 3, 4, 5, 6 and 9 in which the modified units are employed.

Refer now to Fig. 7 which shows a coupling unit circuit arranged for full-duplex coupling or for one-way service between two or more hubs comprising a concentration group at a switchboard. The circuit of Fig. 7, since it may be employed in either a full-duplex circuit or in interconnecting two hubs in a single concentration group, is arranged on the input side to accept signals

which may be, for instance, negative 10 volts for marking and negative 60 volts for spacing at a full-duplex potentiometer or alternatively may accept, for instance, positive 60 volts for marking and negative 30 volts for spacing at a hub potentiometer. The output side of the coupling unit connects to a hub potentiometer and produces the usual positive 60-volt marking and negative 30-volt spacing hub signaling conditions, for instance. The coupling unit per Fig. 7 consists essentially of two one-way coupling circuits, each capable of performing these functions.

First the manner in which the circuit of Fig. 7 functions in full-duplex operation will be described.

As explained in the description of Figs. 1 and 2 all line facilities appearing in the service board have a line coupling unit serving as a connecting link between the terminal repeater and the concentration jacks. When the line coupling unit is connected through the concentration jacks directly to a hub potentiometer the line circuit operates half duplex with double space by-pass action. To operate a line full duplex, the line coupling unit is connected through the concentration jacks to a full-duplex potentiometer which provides voltages of negative 10-volt marking and negative 60-volt spacing, for instance, on the RL lead of the coupling unit and allows spaces to freely pass outward by way of the SL lead of the coupling unit. In order to have the regular voltages of positive 60-volt mark and negative 30-volt space, for instance, appear on a full-duplex hub, the coupling unit per Fig. 7 is used as a connecting link between the full-duplex potentiometer and the regular hub potentiometer.

The negative 10-volt mark and negative 60-volt space signals, for instance, at a full-duplex potentiometer, are connected to the coupling unit per Fig. 7 through lead SL2. For the east-to-west half of the unit, lead SL2 connects to the control grid of the left half of tube V1A by means of the voltage divider comprising resistors R2A and R3A terminating in negative 130 volts. The left half of tube V1A is thus arranged to conduct for mark and cut off for space. The plate voltage swings of the left-hand section of tube V1A are coupled to the control grid of tube V2A by means of a voltage divider comprising resistors R7A and R8A which terminates in negative 330 volts bias supply voltage, for instance. Tube V2A is thus caused to conduct for space and cut off for mark. The plate of tube V2A connects through resistors R10A and R9A to the RL lead. The RL lead is connected to a hub potentiometer which furnishes a marking voltage of positive 60 volts, for instance. When tube V2A conducts during a space, a current of 30 milliamperes, for instance, is drawn from the hub potentiometer lowering the hub potentiometer to negative 30 volts, for instance. Resistor R21A provides the proper screen voltage for tube V2A. Resistor R23A serves to drop the filament supply voltage to the proper operating value for tube V1A. The west-to-east half of the unit utilizes tube V3A and the right-hand half of tube V1A. The operation is the same as for the east-to-west half described in the foregoing, with resistors R11A to R20A performing the same functions as resistors R1A to R10A. Resistor R22A serves as the screen resistor of tube V3A. A separate set of conductors SL1, SL2 and RL are employed for each half of the circuit as indicated, since the circuit comprises two independent units. It will be observed that conductor SL1 plays no part in full-duplex operation.

Now the manner in which Fig. 7 operates, when serving as a one-way hub-to-hub repeater, will be described. The coupling unit per Fig. 7 may be employed to repeat signals from one hub to a second hub in the same concentration group. When so employed, the coupling circuit per Fig. 7 receives the regular hub voltage of positive 60-volt mark and negative 30-volt space, for instance, from either a hub potentiometer or from the output of a regenerative repeater. The output of the coupling unit connects to a

hub potentiometer. Used in this manner the coupling unit circuit per Fig. 7 may be employed to connect send lead SH of either of two interconnected main hubs consisting of half-duplex legs to the receive lead RH of a secondary hub of receive only legs. This arrangement is shown in Fig. 4. It may also be used in the same manner to connect send lead SH of a primary hub to send lead SH of a secondary hub. In the latter case which is shown in Fig. 3 no connection is made between the receive hub RH and the send hub SH of the secondary hub and a two-way half-duplex repeater must be used to connect the receive hub lead of the secondary hub to the receive hub lead of the primary hub. A regenerative repeater, interconnecting the sending and receiving hub leads of the primary hub directly, then regenerates signals to and from all legs of both hubs.

When the coupling unit per Fig. 7 is to receive voltages of positive 60-volt mark and negative 30-volt space, for instance, input lead SL1 is employed. Since as explained in the foregoing the arrangement per Fig. 7 comprises two separable units, there are two such conductors. One of the leads SL1 is connected through the voltage divider which comprises resistors R1A, R2A, and R3A, to the grid of the left-hand portion of tube V1A. The added series resistor R1A properly orients the signal swings on the grid of the left-hand portion of tube V1A. The remainder of the circuit, comprising one of the separable halves of Fig. 7 remains unchanged. The other conductor SL1 connects to the voltage divider, comprising resistors R11A, R12A and R13A and to the grid 7 of the right-hand portion of tube V1A for the same reason.

Refer now to Fig. 8 which shows a coupling unit for interconnecting hub circuits which operate on a positive 60-volt mark, negative 30-volt space, for instance, to one-way send and one-way receive circuits. Fig. 8 essentially is a two-path connecting link between the jack circuits of the telegraph service boards and one-way sending and one-way receiving repeaters. Fig. 8 also serves as a connecting link between the telegraph service board and a receiving only loop of low resistance or testing equipment requiring a $62\frac{1}{2}$ -milliampere loop, for instance.

The circuit of Fig. 8 converts the hub signals, appearing at the service board, to $62\frac{1}{2}$ -milliampere neutral signals, for instance, which can be used to operate a sounder or teletypewriter magnet over a short loop, or to operate the polar relay in a one-way repeater, or the receiving relay of a test measuring set. An adjustable potentiometer is provided for setting the receive current to $62\frac{1}{2}$ milliamperes, for instance.

The coupling unit circuit per Fig. 8 converts the positive and negative 130-volt signals, for instance, from the polar relay in a one-way repeater to the standard hub voltages of positive 60-volt mark and negative 30-volt space, for instance.

First the manner in which the coupling unit per Fig. 8 functions when transmitting to a receiving only leg will be described. The SL conductor of the circuit per Fig. 8 connects by way of the jack circuits in the service board to the sending hub SH which has signaling voltages of positive 60-volt mark and negative 30-volt space, for instance. The potentiometer comprising resistors R1B and R2B couples these signals to the control grids of tubes V1B and V2B so as to cause them to conduct for mark and cut off for space. The loop current potentiometer LP CUR permits the screen voltages of tubes V1B and V2B to be adjusted so as to produce a combined plate current of $62\frac{1}{2}$ milliamperes, for instance. The plate circuit of tubes V1B and V2B is completed through the connecting circuit to a positive 130-volt termination. The connecting circuit may have a maximum resistance of 800 ohms, for instance, to positive 130 volts and may be either a short cable loop or a local circuit containing a sounder, teletypewriter magnet, polar relay, or other apparatus suitable for operation on a $62\frac{1}{2}$ -milliampere neutral signal, for instance.

Now the manner in which the circuit per Fig. 8 functions for transmission for a send only leg will be described. The circuit per Fig. 8 connects to a one-way repeater by way of lead T1. The polar relay of the one-way repeater receives signals from its associated line or loop circuit and transmits positive 130-volt mark and negative 130-volt space signals, for instance, through a resistor which may be, for instance, 250 ohms to the circuit per Fig. 8. The network consisting of resistors R9B, R6B, R7B and R8B applies open circuit voltages of positive 65-volt mark and negative 105-volt space, for instance, through varistors CR1, CR2, CR3, CR4 and CR5 to the RL lead. The RL lead group connects through the jack circuits of the service board to a hub potentiometer. For the spacing condition a current of 30 milliamperes is drawn from the hub potentiometer causing the hub voltage to drop from the positive 60-volt marking condition to the negative 30-volt spacing condition. Varistors CR1 to CR5 effectively isolate the coupling unit from the hub potentiometer in the marking condition.

Resistors R4B and R5B constitute a coupling between the T1 lead and the TL lead so that open circuit voltages of about negative 50-volt mark and negative 125-volt space, for instance, are produced at the TL lead. The TL lead cross-connects to the switchboard where it is used to light a neon lamp. The neon lamp is terminated in negative 24-volt battery so that the lamp lights only for the spacing condition and thus serves to indicate a hit condition or an open loop condition which are spacing conditions.

When the circuit per Fig. 8 is used only for transmission toward the service board, tubes V1B and V2B are not employed and may be removed from the circuit.

Refer now to Fig. 3 which shows a concentration group consisting of two interconnected half-duplex hub circuits with a single regenerative repeater. In this figure as in Figs. 4, 5, 6 and 9, which show other concentration group arrangements, the legs relay circuit and the associated jack circuits are not shown in full in order to avoid repetition since they are shown in full in Figs. 1 and 2. The jacks are indicated by designated rectangles. In the arrangement per Fig. 3 two hubs at a particular service board are interconnected through a two-way concentration group repeater and the whole concentration group is served by a single regenerative repeater if regeneration is required. The two-way concentration group repeater comprises two electronic line coupling units connected back to back through two unidirectional magnetic relay repeaters. The manner in which a two-way concentration group repeater operates and the manner in which a concentration group comprising two hubs interconnected through such a repeater may be served by a single regenerative repeater are described in detail in the patent application of W. T. Rea, Serial No. 351,345, filed April 27, 1953, now Patent No. 2,690,476 granted September 28, 1954, which is hereby made part of the present application as though set forth herein in full. The arrangement per the present Fig. 3 includes flexible switching circuits to arrange such repeaters for telegraph service board operation.

In the arrangement per Fig. 3 a primary or west receiving hub circuit comprising a receiving hub RH and a sending hub SH are shown at the lower left. One legs relay circuit 61 is shown at the extreme left. It is used to interconnect a telegraph line from a distant city through a line coupling unit to the west receiving and sending hubs or to interconnect a subscriber loop through a loop repeater to these hubs. The receiving hub RH and the sending hub SH are shown extending to the left and it is to be understood that a number of other lines and loops, not shown, are interconnected through other legs relay circuits to the west hubs. The west hub has connected to it a hub and a regenerative jack circuit 67 which is connected through a hub relay

circuit 62 in the manner described for Figs. 1 and 2 in the foregoing. The east hubs are also connected through a legs relay circuit 66 and through a line coupling unit or a loop repeater to a line or a loop facility and the east hubs RH and SH are indicated as extending to the right to imply that other legs and loops, not shown, may be similarly connected to the east hubs. The west hub leads RH and SH which extend through the hub and regenerative repeater jack circuit 67 and the hub relay circuit 62 connect to a hub potentiometer 89 and to a regenerative repeater or hub link 87 as described for Figs. 1 and 2.

It is to be understood that the arrangement per Fig. 3 is employed when more legs and loops are required to be interconnected into a single concentration group than can be accommodated by a single hub. It will be observed that a single regenerative repeater is employed for regenerating the signals received from either hub. This regenerative repeater is indicated as being connected to the west hub. There is no regenerative repeater associated with the east hub. The RH and SH hub conductors in the corresponding circuit of the east hubs are terminated in dual hub potentiometers, no link or regenerative repeater being employed.

As described in detail, in Patent 2,690,476, further identified in the foregoing, signals arriving through the receiving leg of any one of the facilities connected to the west receiving hub RH will pass through the regenerative repeater to the west sending hub SH. From this point the signals will pass to the sending legs of all facilities connected directly to the west hub. The signals impressed on the west sending hub SH will pass through break contact 71 of relay K3 in legs relay circuit 63 and through conductor SL1 into one of the two circuits comprising Fig. 7 described in the foregoing. The output path of the coupling unit per Fig. 7 is through conductor RL and contact 72 to the SH conductor of the east hub. They pass through hub and regenerator multiple jack circuit 68, contact 69 and are impressed on hub potentiometer 70 so as to produce the proper potentials on the east sending hub SH. The signals pass through the sending legs of all of the facilities connected to the east sending hub SH.

The signals impressed upon the RH hub of the west hub circuit pass also through the C conductor of legs relay circuit 64 and contact 74 of the associated relay in legs relay circuit 64 and through conductor B, to the junction of conductor SL and RL. The signals pass through the SL conductor, through line coupling unit 75 and conductor S of the two-way concentration group repeater 76 and through conductor R into the line coupling unit 77 of the two-way repeater, through conductor RL conductor A and contact 78 of the relay in legs relay circuit 64, to the receiving hub RH of the east hub circuit. The signals are impressed through the back contact 80 of the relay of hub relay circuit 65 on the hub potentiometer 82, to produce the proper potentials on the east receiving hub RH. These potentials are impressed through the receiving legs of the facilities connected to the east hub. The purpose of this is to unlock any coupling circuit associated with any facility connected to the east hub which may have last transmitted through the system and also to permit the production of the characteristic double space potential condition on the receiving hub in the event that any two circuits connected into the system attempt to transmit simultaneously so that the spacing signals thereby produced may be transmitted to all of the stations connected into the system as an indication of the attempted simultaneous sending.

As normal communication signals are transmitted from the west receiving hub to the east receiving hub for controlling purposes, the two coupling units 75 and 77 in the two-way concentration group repeater block their

associated sending legs so that the signals may not be transmitted back to their point of origin.

When a double space condition prevails the coupling units 75 and 77 in the two-way concentration group repeater will be unlocked to permit the passage of the mutilated signals between the east and west hubs. If any two circuits interconnected into the system attempt to transmit simultaneously a characteristic double space potential will be produced on all RH conductors which will thereby unlock the coupling units in the line circuits and in the two-way concentration group repeaters and will control the loop repeater so as to transmit the mutilated signals to all stations in the system.

Signals originating in a facility connected to the east hub circuit, as explained in the application per Serial No. 351,345, are received on the east receiving hub RH. They are impressed through the hub and regenerator multiple jack circuit 68 and contact 69 on hub potentiometer 70 to produce the proper potentials.

It will be observed that east hubs RH and SH are not directly interconnected. The signals are directed instead through conductor D, contact 78 and conductor A to the junction of conductors RL and SL. They pass through conductor SL, line coupling unit 77, conductor S, polar receiving repeater 81, conductor R, line coupling unit 75, conductor RL, conductor B, contact 74, conductor C, conductor RH, hub and regenerator jack circuit 67 and contact 86 where they are impressed on hub potentiometer 89 which produces proper potentials to control the coupling units connected to the west hub. The signals pass through the hub link or regenerative repeater 87 and contact 88 to the west sending hub SH where they pass directly out through the connected sending legs. The signals must also be returned to the east sending hub SH for transmission to the facilities connected to the east hub. To do this they pass through one element of the coupling unit per Fig. 7 over a path traced in the foregoing to the east sending hub SH and out over the sending legs of the connected facilities. Line coupling units 75 and 77 through which the signals were passed to the east hub are conditioned to block the reflection of normal signals but to pass double space signals when they occur back to the east receiving hub so that all of the coupling units connected to the east hub will be properly controlled.

Attention is called to the fact that in the arrangement per Fig. 3, a single legs relay circuit 64 is employed to interconnect the two-way concentration group repeater into the system. It is to be understood also that the leg multiple jack, associated with the legs relay circuit 64 employed to interconnect the two-way concentration group repeater into the system, is arranged in the same manner as the legs multiple jack shown in Figs. 1 and 2, that is to say, it is multiplied through the various positions in the service board and includes an idle indicator lamp connected to the idle indicator circuit. The two-way concentration group repeater may be disconnected from a particular concentration group with which it is serving and made available for appropriation for use in other concentration groups at any of the positions in the telegraph service board. Furthermore, the coupling unit per Fig. 7 which serves to interconnect the sending hub of the west hub circuit to the sending hub of the east circuit is interconnected to the system through an individual legs relay circuit 63 and an associated multiple jack circuit, so that it may be released from the concentration group with which it is serving, so as to permit it to be employed in other half-duplex concentration groups or in a full-duplex concentration group.

In Figs. 3, 4, 5 and 9 the jack circuit associated, through the legs relay circuit, such as legs relay circuit 63 in Fig. 3, with the coupling unit per Fig. 7, has three rectangles representing three jacks, designated CONC GRP, FDX and T. When the coupling unit is released by operating legs relay K3, in the same manner as ex-

plained for corresponding relays in other legs relay circuits, the coupling unit per Fig. 7 is extended to other switchboard positions by means of multiple jacks CONC GRP, multiple jacks FDX, and multiple jacks T, not shown, appearing in the other positions, where the coupling unit per Fig. 7 may be appropriated for use, through jack CONC GRP, in interconnecting half-duplex sending hubs into a single concentration group, as explained for Fig. 3, or for full-duplex or round-robin service, to be explained hereinafter, through jack FDX, or for testing through jack T.

As explained in the description of the circuit per Fig. 7, in the foregoing, this coupling circuit may be used in full-duplex operation, to interconnect two line circuits only, for instance, instead of the two half-duplex sending hubs just described. Such a full-duplex application of Fig. 7 is disclosed in Figs. 5 and 6. In order to permit this, the circuit, as has been explained, is arranged with two alternative input conductors, SL1 and SL2, associated with each of the two units per Fig. 7. These conductors, as explained, are connected to different potentiometer arrangements so as to produce the different potentials required for half-duplex and full-duplex operation.

Refer now to Fig. 4 which discloses a one-way concentration group repeater as shown in Fig. 7 repeating between one of two interconnected half-duplex hub circuits and to a receive-only hub circuit.

In the arrangement per Fig. 4 the west hub circuit is equipped with a regenerative repeater or hub link 129 and a hub potentiometer 131. The east hub circuit is equipped with a hub potentiometer 103 and a regenerative repeater or a hub link 127 as required. The receiving only hub circuit is also equipped with a hub potentiometer 119 and a regenerative repeater or hub link 123 as required. The west hub circuit has an RH lead and an SH lead shown extending toward the left which are assumed to be connected to a number of line and loop facilities, not shown. The east hub circuit similarly has an RH and SH lead which are assumed to connect to line and loop facilities, not shown, and the receiving only hub circuit has an RH and an SH lead which connect to receiving only loops and lines, not shown, of the concentration group.

Any of the circuits assumed to be connected to the RH and SH leads of the west hub circuit may transmit through its associated facility and the signals will be received by the west hub conductor RH. The signals will pass through the RH conductor into the hub and regenerator jack circuits 31 through contact 90 of relay K1 in hub relay circuit 32 and will be impressed on the hub potentiometer 131 to produce the proper coupling unit control potentials. The signals will pass through the hub link or regenerative repeater 129 and contact 92 of relay K1 of hub relay circuit 32 and to conductor SH to the west sending hub SH from which they will pass through two branches. One branch connects to all of the sending legs associated with the various facilities connected to the west hub. The signals will pass through all of these except the sending leg associated with the receiving leg from which the signals are being received. The other branch connects through legs relay circuit 107, contact 111, conductor SL1, one element 109 of a coupling unit per Fig. 7, conductor RL, contact 113, hub conductor RH, hub and regenerator jack circuit 115, hub relay circuit 116, contact 117 and will be impressed on hub potentiometer 119. They will pass through the hub link or regenerative repeater 123, contact 121, to the sending hub SH and out to the sending legs of the receiving only circuits connected thereto.

The received signals on the west receiving hub RH are passed also through a two-way concentration group repeater to the east hub circuit. They pass through conductor C into legs relay circuit 94 and through contact 96 of the relay in legs relay circuit 94 through conductor

B to the junction of conductor RL and SL. They will pass through conductor SL into the coupling unit 98 of the two-way concentration group repeater, through conductor S and the polar receiving repeater 100, conductor R, coupling unit 102, conductor RL, conductor A, contact 104 of the relay in legs relay circuit 94 and conductor D to the receiving hub RH of the east hub circuit. They will pass through the hub and regenerator jack circuit 34 into the hub relay circuit 35, contact 108 of the relay in hub relay circuit 35 and will be impressed on hub potentiometer 103 to produce the proper coupling unit control potentials for the circuits connected to the east hub. The signals will pass through the regenerative repeater or hub link 127 to contact 110 of the relay in hub relay circuit 35 to the sending hub SH of the east hub circuit. From the sending hub SH of the east hub circuit the signals will pass through the sending legs of each of the facilities connected to the east hub. The potentials impressed on the RH conductor of the east hub will unlock the sending leg of any circuit connected to the east hub which may last have transmitted into the system. The interconnection of the RH conductors of the west hub and east hub, through the two-way concentration group repeater, prevents the reflection of signals transmitted from either of these hubs back from the other to its point of origin and also produces, almost instantaneously, the potentials characteristic of the double space condition when more than one facility in the system, no matter to which hub they may be connected, attempt to transmit simultaneously. It will be observed that in this arrangement two regenerative repeaters may be required to serve the combined east and west hub circuit. However, when a receiving only hub circuit is connected into the system a separate regenerative repeater may be employed for the receiving-only hub.

The signals originating in any of the lines or loops connected to the east hub circuit will be impressed on the east hub potentiometer 103 to produce the controlling potentials for the east hub circuits. They will pass also through the hub link or regenerative repeater 127 directly to the east sending hub SH. The signals will pass also without regeneration through the two-way concentration group repeater to the west receiving hub RH and will be impressed on hub potentiometer 131. They will pass through regenerative repeater or hub link 129 to the west sending hub SH and out through the connected sending legs.

Refer now to Fig. 9 which shows a full-duplex terminal concentration group. The operation of the basic full-duplex hub circuit without the switching arrangements of the present invention is described in detail in Patent 2,607,852 identified in the foregoing. As described in that patent, ordinarily only two circuits are connectable through a full-duplex concentration group and essentially the equivalent of two hub circuits are required, since it is possible to transmit in only one direction through a single hub effectively at any one time. In full-duplex arrangements, as is well understood in the art, it is required to be able to transmit and to receive simultaneously and, therefore, in a hub system, a second hub is necessary. The circuits in the telegraph service board, as has been explained in the foregoing, are arranged so that they may be employed in different concentration groups at different times. They are arranged also so that they can serve in either a half-duplex or in a full-duplex concentration group. It has been explained that the coupling units are arranged for half-duplex operation so that signals transmitted from a particular station cannot be retransmitted back from the hub to the station wherein they originated. The control of the facility is achieved by producing characteristic potentials on the half-duplex hub circuit in response to marking and spacing signals. It has also been explained that when a double space condition prevails as a result of attempted simultaneous sending, a potential condition

known as the double space condition is produced to characterize the condition and as a result of this all of the coupling units are unblocked to permit the passage of a space due to the presence of the double space signals. As explained in Patent 2,607,852, since each of the line facilities connected into the board is equipped with a line coupling unit and the line coupling unit remains connected to the line facility when it is patched out of a half-duplex concentration group and patched into a full-duplex concentration group, advantage is taken of the potential characterizing the double space condition to unblock the sending side of a line from which a spacing signal is being received, so that if signals are simultaneously being transmitted from the opposite station, they will pass freely through the unblocked sending leg of the coupling unit. The operation of the arrangement per Fig. 9 depends upon this characteristic. Whereas, ordinarily, a west line, for instance, may be connected to an east line through two full-duplex hub circuits, for what is known in the art as full-duplex through operation, it is possible to interconnect a line through two full-duplex hub circuits of a full-duplex concentration group to a full-duplex station for terminal operation and Fig. 9 shows one of the typical full-duplex terminal arrangements.

In the circuit per Fig. 9 a line facility is assumed to be connected through a line coupling unit and contacts 228 and 229 of the relay in the legs relay circuit 220 to the full-duplex hub circuits. A corresponding line facility could be connected through another legs relay circuit 224 on the right of Fig. 9. In the arrangement shown in Fig. 9, however, instead of a line facility, a terminal arrangement comprising a receiving only and a sending only line are assumed to be connected through a coupling unit per Fig. 8, described in the foregoing, to the two right-hand hubs.

It will be assumed that signals are being transmitted from the line facility at the extreme left in Fig. 9. They will pass through the line coupling unit, conductor A, contact 228, of the relay in legs relay circuit 220, conductor D, sending hub conductor SH2 and contact 230 of relay K3 in legs relay circuit 221 where the path divides into parallel branches. One branch extends through contact 231 to the full-duplex potentiometer 250 which modifies the potentials for full-duplex operation. The other branch of the circuit extends through conductor SL2 into one element 252 of a coupling unit per Fig. 7, and passes out on conductor RL through contact 232, receiving hub RH, through the west-to-east hub and regenerator jack circuit 223 and contact 233 to hub potentiometer 240. The circuit extends through conductor RL and a regenerative repeater or a hub link 253, conductor SL, contact 234 and through the west-to-east hub and regenerator jack circuit 223, sending hub SH, conductor C, into legs relay circuit 224 and contact 235, to the coupling unit for receiving only plus a sending only loop or line per Fig. 8. The signals will pass to the receiving only facility connected to this coupling unit.

For the opposite direction of transmission, signals may be transmitted from the sending only loop or line through the coupling unit per Fig. 8, contact 236 of legs relay circuit 224, conductor D through the RH conductor, the east-to-west hub and regenerator jack circuit 222, hub relay circuit 257, contact 242, to hub potentiometer 247. The signals are passed through the RL conductor and the regenerative repeater or hub link 259, conductor SL, contact 244, east-to-west hub and regenerator jack circuit 222, conductor SH, conductor C, contact 229 of the relay in legs relay circuit 220, conductor B and the line coupling unit to the line.

It will be observed that in this arrangement if regeneration is required a separate regenerator is necessary for each of the full-duplex hubs. It will be observed also that a hub potentiometer is required for each of the hubs and it will be observed that a full-duplex poten-

tiometer is required for cooperation with the line repeater connected to legs relay circuit 220, so as to unlock the sending leg so that signals may pass therethrough as explained. No full-duplex potentiometer is required for cooperation with the facility connected to the right-hand side of Fig. 9, since the sending and receiving facilities are independent, that is to say, the circuit does not comprise a line having a sending leg and a receiving leg controlled by a coupling unit joining the two.

In the round-robin method of operation, which is well known in the art, a one-way transmission path passes from transmitting equipment at the station which is momentarily using the round-robin circuit, through all telegraph offices which are served by the particular round-robin transmission network and terminates in receiving equipment at the station from which transmission is being originated. Switching means as shown in the lower part of Fig. 6 provide for the insertion of any particular station into the round-robin transmission path. Similar or equivalent means are provided at all offices included in the transmission path. It will be obvious that only one station at a time may transmit and that all stations must receive the transmission, the originating station receiving its own transmission after passage around the complete round-robin transmission loop. Such a one-way transmission path or ring is conveniently obtained by using one side of a full-duplex transmission facility, the other side of the same full-duplex facility affording another independent transmission path differing from the first only in the direction of propagation of signals around the closed transmission path.

Refer now to Fig. 5 and Fig. 6, with Fig. 6 to the right of Fig. 5, which taken together show a hub concentration arrangement for duplex round-robin service.

Round-robin circuit, Figs. 5 and 6, essentially comprises two independent segments of one-way rings which utilize one or more full-duplex circuits. The two coupling units per Fig. 7 and their associated full-duplex potentiometers and the hub potentiometer and regenerator or hub link circuit, associated with each of these units, are connected to serve the west and east line repeaters. Signals transmitted in one round-robin circuit or ring pass from the west repeater to the east repeater and those transmitted in the other round-robin ring circuit pass from the east repeater to the west repeater. Signals from one of the round-robin rings incoming from the west line through legs relay circuit 140 are received through conductor D and pass through a legs relay circuit 141, arranged for a full-duplex termination corresponding particularly to legs relay circuit 221 of Fig. 9 described in the foregoing. Legs relay circuit 141 terminates the incoming circuit in a full-duplex potentiometer and directs the signals through one element of a coupling unit per Fig. 7. The signals then pass out of jack circuit 141 through conductor RH and through a west-to-east regenerative jack circuit 142 and a hub relay circuit 150 to a hub potentiometer and through a regenerative repeater or a hub link as required. The output conductor SH of the jack circuit 142 then may pass through a legs switching circuit arranged for round-robin service, indicated by the dotted line, if such a circuit is employed on the west-to-east portion of the round-robin ring circuit. Such a legs switching circuit arranged for round-robin service is shown connected in the east to west portion of the circuit and will be described hereinafter. The path then loops through conductor C into legs relay circuit 144, the line coupling unit for the line east, over the line east and through one or more distant offices in the round-robin ring and back through the west line and through the local circuit just traced. The other round-robin ring circuit sends signals in from the east line repeater. These pass through legs relay circuit 144 and over lead D to lead SH2. The signals pass through one element of a coupling unit per Fig. 7 and then out of jack circuit 152 through conductor RH into the east-to-west hub and regenerator jack circuit

143 through hub relay circuit 154 to the hub potentiometer and the hub link or regenerative repeater. The signals pass out of hub relay circuit 154 and out of jack circuit 143 to lead SH.

At this point in the circuit the round-robin ring extends through the legs switching circuit arranged for round-robin service. Here three receiving branches in parallel extend as spurs from the ring through legs relay circuits 145, 146 and 147 to three coupling units per Fig. 8 for stations connected individually to the three coupling units. The receiving side of each of these three station circuits is always connected to the round-robin ring circuit so that each station may receive any message transmitted through the ring. The ring may be cut or opened and the sending leg of any one of these three stations may be connected so that its outgoing signals may be transmitted around the ring through all intermediate points and received by the receiving elements of all three stations 145, 146 and 147. This switching is accomplished by operation of relay 157, 159 or 161 in conjunction with station 145, 146 or 147, respectively.

When none of the stations connected through legs relay circuits 145, 146 and 147 is sending, each of relays 157, 159 and 161 is released, as shown, and the ring extends through contacts 156, 158 and 160 in series to the return conductor 179 of the ring, which passes through conductor C and into legs relay circuit 140 to close the round-robin ring. If relay 157, for instance, is operated the signals instead of returning directly to the west line can pass only through legs relay circuits 145, 146 and 147, and through a coupling unit per Fig. 8 in each station circuit. The round-robin ring will thus be cut locally. Signals sent from the station associated with legs relay circuit 145 will pass through contact 162 of relay 157 and then appear on lead 179 and pass over lead C to legs relay circuit 140 and thence out over the full-duplex transmission circuit in an east-to-west direction and finally appear at east line Fig. 6 and on lead D to provide for reception at stations associated with legs relay circuits 145, 146 and 147, as previously described, so that this station will be effectively connected on one end of the round-robin ring. When relay 157 is operated the closing of contact 165 connects hub potentiometer 168 to the station sending leg so as to produce the proper controlling potentials. Similarly, if relay 159 or 161 is operated, send elements of stations associated with legs relay circuit 146 or 147, respectively, will be connected to the sending end of the round-robin ring. The closing of contacts 166 or 167 will also connect hub potentiometer 168 to the sending leg of the connected facility.

What is claimed is:

1. A telegraph system having in combination a hub repeater jack concentration group in a telegraph switchboard, a telegraph channel comprising a telegraph repeater, said repeater having a leg interconnected through a coupling unit, said coupling unit having a space discharge transmission direction control element, said leg extending through a single-relay, magnetic legs relay circuit and a concentration jack circuit to a potential controlled hub, said jack circuit forming part of said concentration group, and multiple appearances of said jack circuit, at a plurality of positions in said switchboard, to afford access to said channel at said positions.

2. A system in accordance with claim 1 including a first control for said relay, said relay responsive to said control to release said channel from said concentration group, and means for interconnecting said released channel to other concentration groups through said multiple appearances of said jack circuit.

3. A system in accordance with claim 1 including means in said legs relay circuit responsive to the connection of another telegraph channel to said jack circuit for substituting said other channel for said channel in said concentration group.

4. A system in accordance with claim 1, another telegraph channel and means for adding said other channel to said concentration group.

5. In a telegraph system, in combination, a plurality of telegraph channels each having an individual hub-type telegraph repeater, said repeaters each having a connection extending through an individual potential controlled coupling unit for regulating the direction of transmission of communication signals through its respective channel, each said channel connectable through an individual magnetic relay, said relay having means for disconnecting its respective coupling unit and channel and alternatively for extending said channel through an individual channel access circuit, each said circuit having multiple means of access to its respective channel, and a connection from each said coupling unit to a common hub, said hub having means responsive to the impressing of telegraph signals thereon for producing transmission direction control potentials for said units, so as to control the direction of telegraph transmission through said channels.

6. A system in accordance with claim 5, and means responsive of the interconnection of another telegraph channel to one of said means of access for controlling the individual relay connected to said means of access, so as to substitute said other telegraph channel for a channel normally connected to said hub.

7. In a telegraph system, a potential controlled concentration group of hub-type telegraph repeaters, comprising a first and a second set of sending and receiving hubs interconnected into a single effective hub unit at the same telegraph repeater station, a first plurality of telegraph channels connected directly to said first set of hubs, a second plurality of telegraph channels connected directly to said second set of hubs, a channel access circuit having multiple appearances connected to each of said channels and means responsive to controls connectable to said means of access for effectively connecting another channel to or disconnecting a channel from said hubs.

8. In a full-duplex hub-type telegraph system, in combination, a first and a second telegraph channel each comprising a sending leg and a receiving leg, a potential controlled transmission direction control circuit, individual to each of said channels, interconnecting said sending leg and said receiving leg in each of said channels, said sending leg and said receiving leg of each of said channels extending through a legs relay circuit individual to each of said channels and connectable to a multioutlet channel access circuit, individual to each of said channels, a first hub interconnecting said sending leg of said first channel to said receiving leg of said second channel and a second hub interconnecting said sending leg of said second channel to said receiving leg of said first channel, and potential producing means connected to said hubs for controlling said transmission direction control circuits, so as to permit simultaneous transmission in opposite direction through said interconnected channels.

9. A system in accordance with claim 8 including means, responsive to the connection of a third channel

to one of said means of access associated with said first channel, said third channel having an individual transmission direction control circuit interconnecting a sending leg and a receiving leg in said third channel, for disconnecting said first channel and its individual transmission direction control circuit from said hubs and substituting said third channel for said first channel.

10. In a telegraph system, in combination, a first half-duplex telegraph hub concentration group, comprising a plurality of telegraph channels, each of said channels having an individual hub telegraph repeater circuit, each of said channels comprising an individual potential responsive transmission direction control circuit interconnecting an individual pair of legs comprising an individual sending leg and an individual receiving leg in each of said channels, each pair of said legs connectable through an individual single relay legs relay circuit to an individual channel access circuit and to a common receiving hub and to a common sending hub both common to all of said channels, said hubs having means connected thereto for producing distinctive potentials to control said transmission direction control circuits, each of said channel access circuits having a plurality of means of channel access connected in parallel to its respective channel, and relay control means connectable to any of said means of access, so as to control the connection to and disconnection from said hubs of the channel connectable to said hubs through said relay.

11. A system in accordance with claim 10 having a second half-duplex telegraph hub concentration group corresponding to said first hub concentration group and the hubs of said second group connected to the hubs of said first group, so as to form a single effective hub concentration group at the same repeater station.

12. In a hub telegraph repeater system, in combination, at a single telegraph repeater station, a first and a second hub, a first plurality of telegraph channels each equipped with an individual hub-type repeater connected to said first hub, a second plurality of telegraph channels each equipped with an individual hub-type repeater connected to said second hub, said hubs interconnected through potential responsive transmission direction control means, an individual channel access circuit each having a plurality of outlets connectable to each of said channels for controlling the disconnection of the associated channel from its hub and means connected to said hubs responsive to telegraph signals impressed on said hubs for producing distinctive potentials on said hubs to regulate the direction of transmission of signals through said hubs and said connected channels.

References Cited in the file of this patent

UNITED STATES PATENTS

2,349,586	Bonorden et al. -----	May 23, 1944
2,352,272	Large et al. -----	June 27, 1944
2,528,120	Davey -----	Oct. 31, 1950
2,542,208	Purvis -----	Feb. 20, 1951
2,594,993	Rea -----	Apr. 29, 1952
2,657,336	Ostendorf -----	Oct. 27, 1953