May 23, 1944. A. R. BONORDEN ET AL 2,349,586

INVERSE NEUTRAL TELEGRAPH REPEATER CONCENTRATION GROUP SWITCHING

Filed Oct. 24, 1940 6 Sheets-Sheet 1

FIG. 1

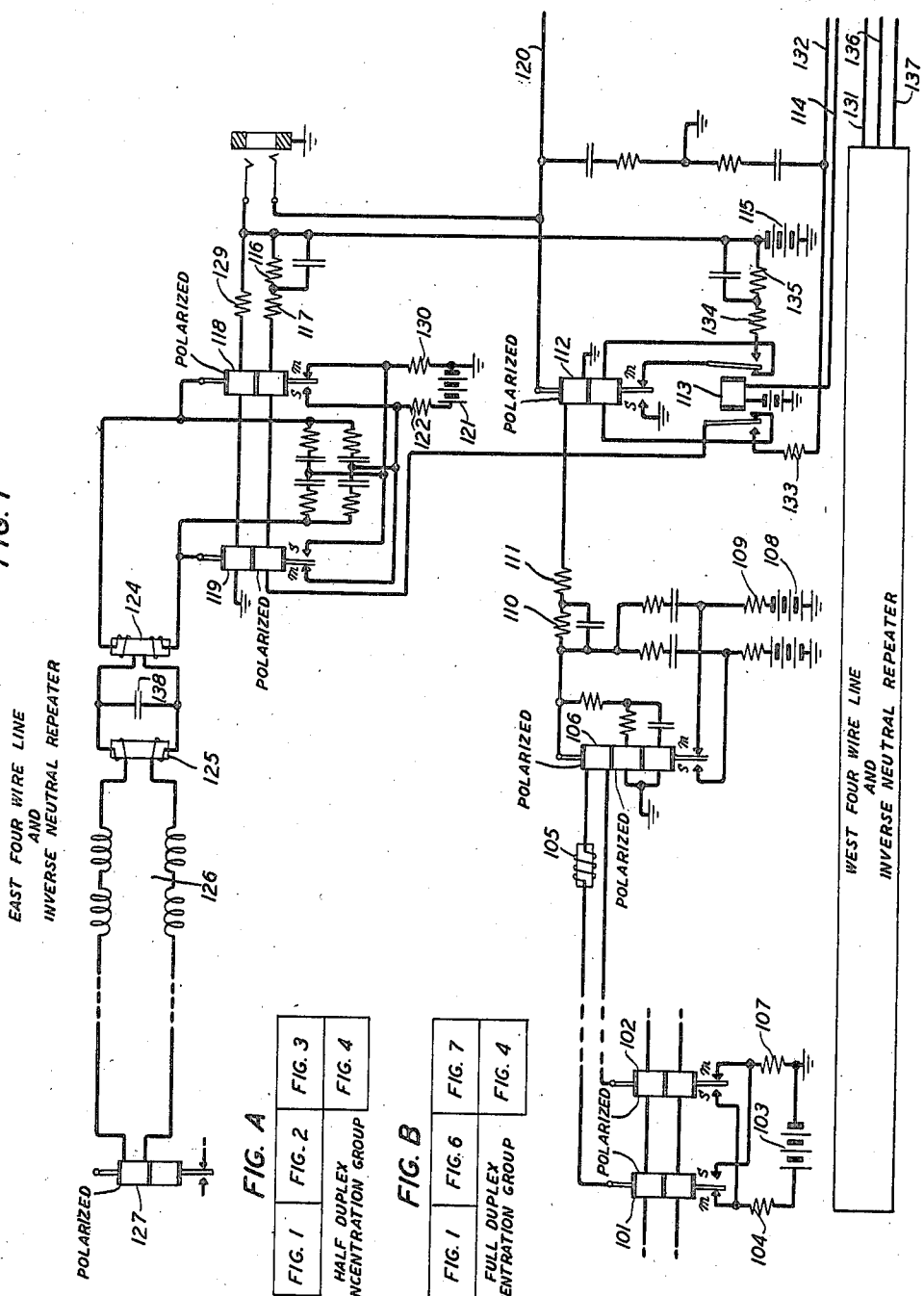

FIG. A — HALF DUPLEX CONCENTRATION GROUP

FIG. 1	FIG. 2	FIG. 3
		FIG. 4

FIG. B — FULL DUPLEX CONCENTRATION GROUP

FIG. 1	FIG. 6	FIG. 7
		FIG. 4

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Filed Oct. 24, 1940 6 Sheets-Sheet 2

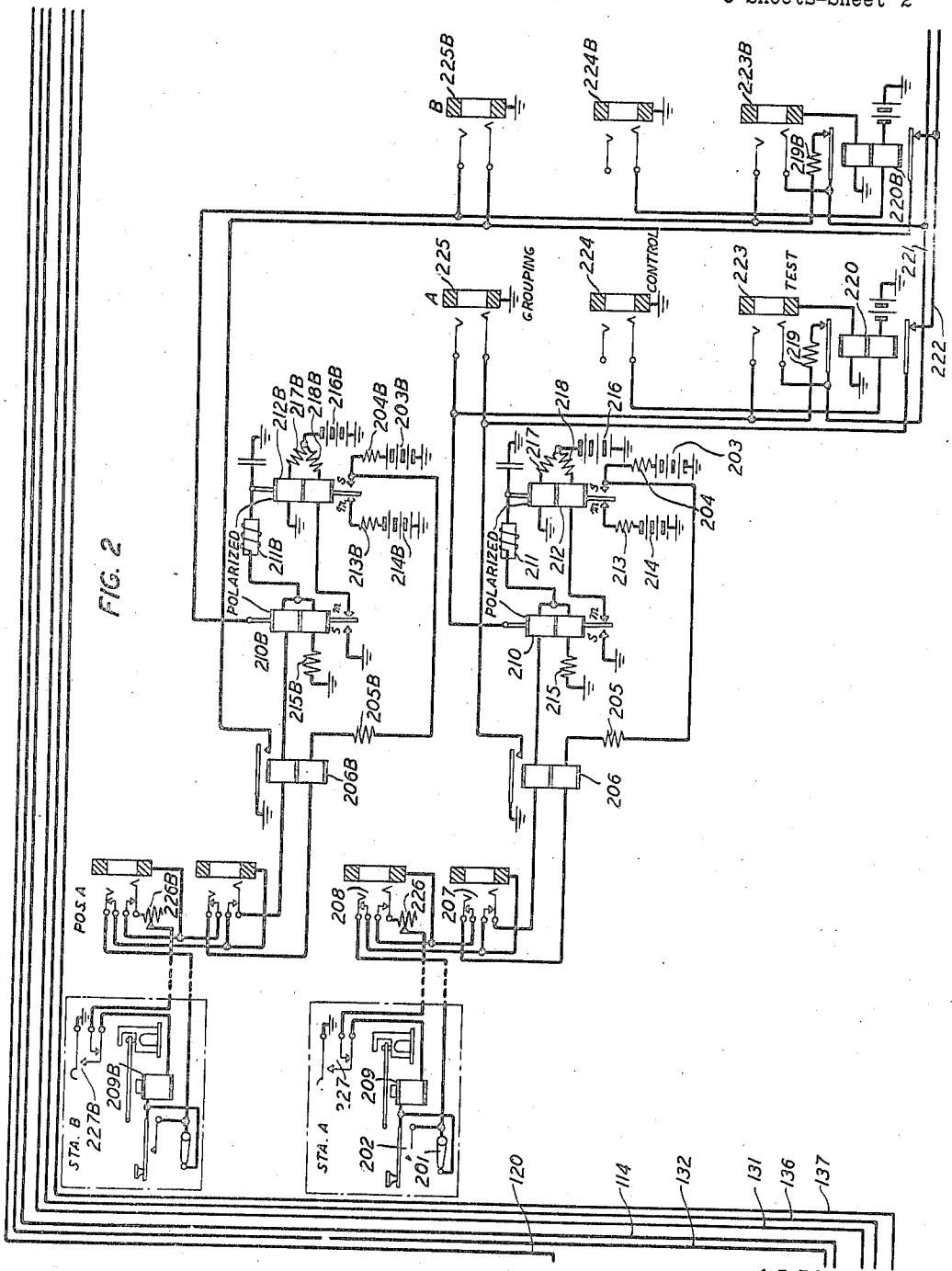

FIG. 2

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Filed Oct. 24, 1940 6 Sheets-Sheet 3

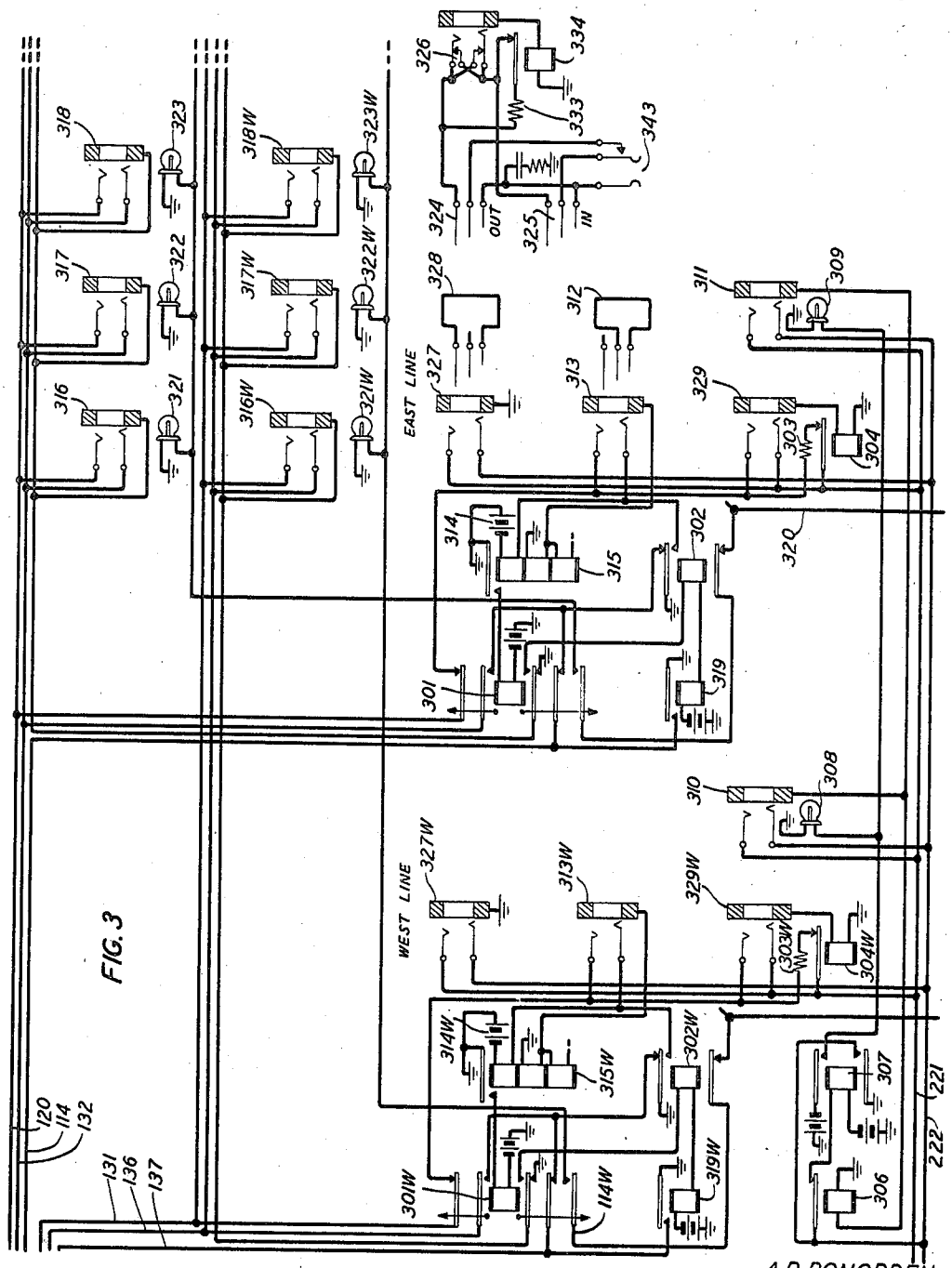

FIG. 3

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Filed Oct. 24, 1940 6 Sheets-Sheet 4

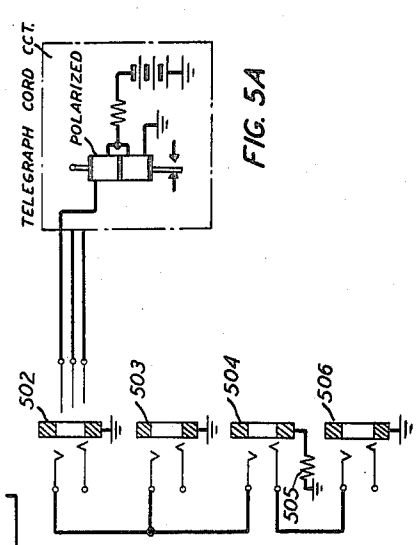

FIG. 5A

FIG. 5

FIG. 4

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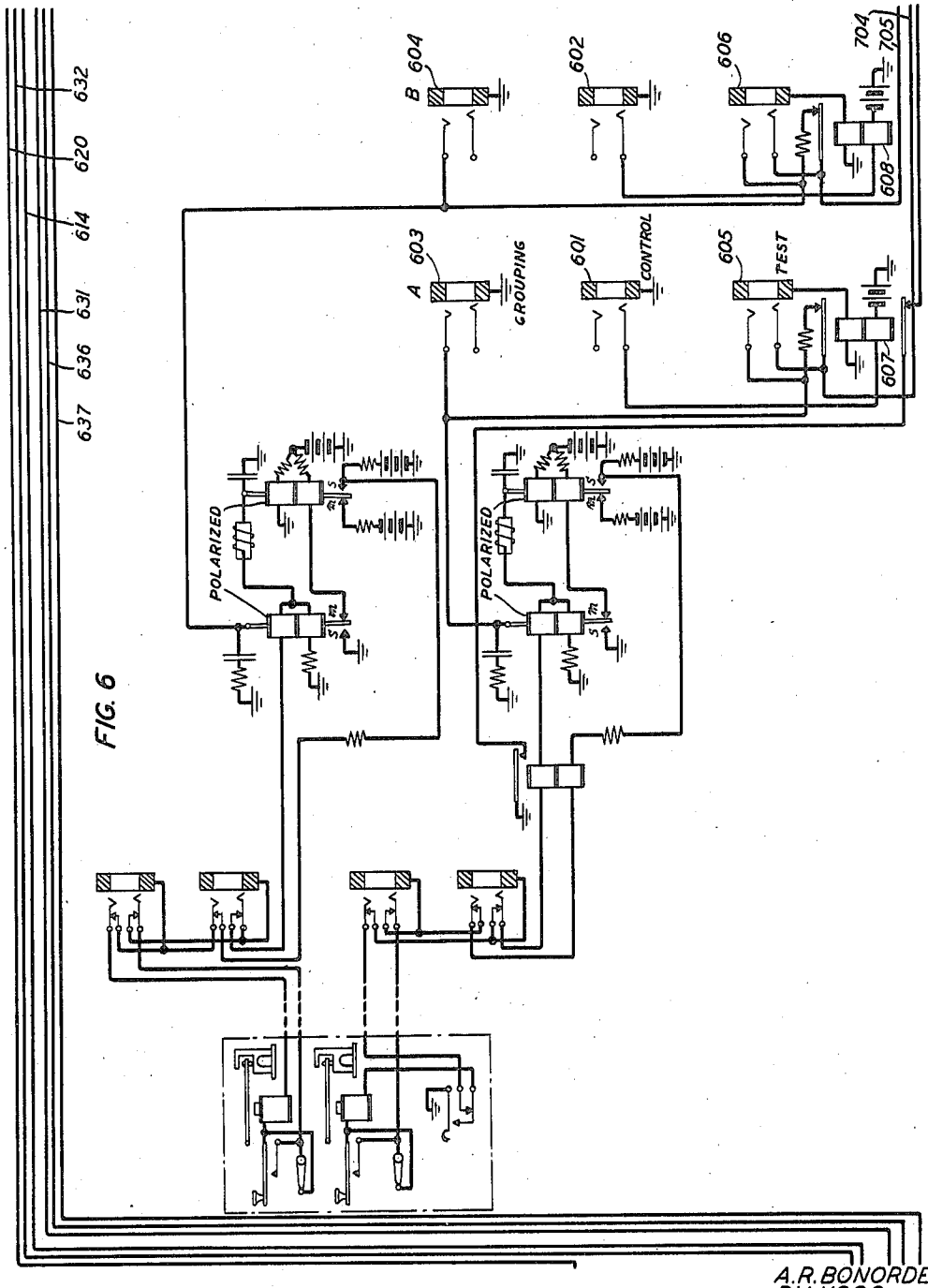
Filed Oct. 24, 1940 6 Sheets-Sheet 5



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Filed Oct. 24, 1940 6 Sheets-Sheet 6

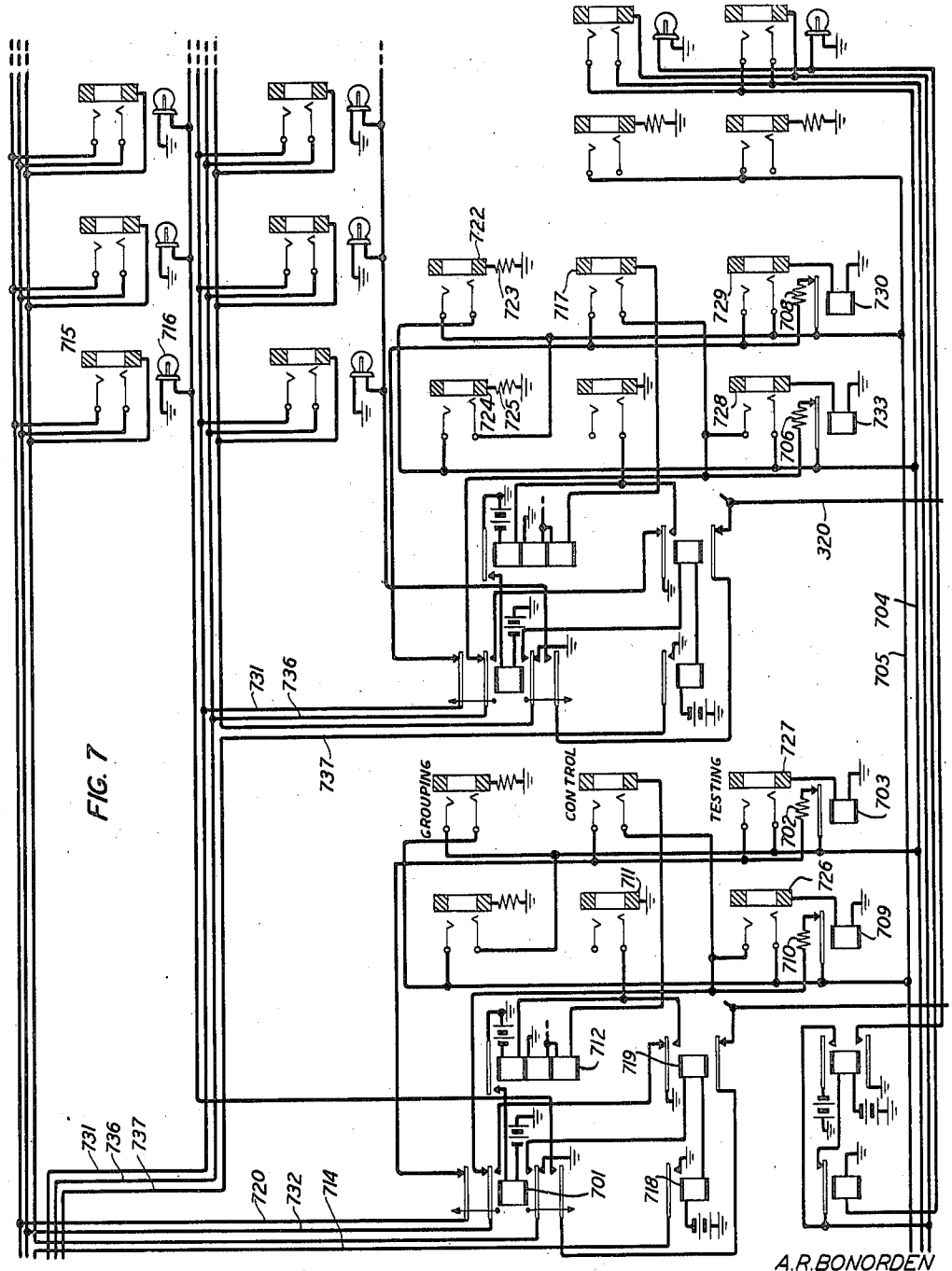

FIG. 7

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UNITED STATES PATENT OFFICE

2,349,586

INVERSE NEUTRAL TELEGRAPH REPEATER CONCENTRATION GROUP SWITCHING

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Application October 24, 1940, Serial No. 362,548

21 Claims. (Cl. 178—73)

This invention relates to telegraph systems and more particularly to telegraph systems wherein private branch lines are associated together, in local, state-wide, or nation-wide networks on a semipermanent basis as distinguished from a telegraph exchange switching system.

An object of this invention is the improvement of arrangements for associating telegraph circuit elements, such as lines and station loops in telegraph networks on a semipermanent basis, in order to facilitate additions to and subtractions from the network and to facilitate the substitution of new circuit elements for existing circuit elements, as well as the testing of the various circuit elements in telegraph networks.

The operation of telegraph systems wherein private telegraph lines are associated together into networks which remain interconnected for indefinite periods has heretofore been characterized by a lack of flexibility. That is to say, the addition to the network, or the subtraction from the network of telegraph lines or station loops, or the substitution in the network of one telegraph line or station loop for another, required compensatory adjustments of one or more of the telegraph repeaters in the network, because the repeaters were arranged in series and the current in the various repeaters was affected when the resistance was changed as the network was altered. Furthermore, added repeaters had to be adjusted to provide the proper polarity as well as type of operation, such as half or full duplex operation.

To overcome this difficulty, a new type of telegraph repeater was devised, which provides what is known as the inverse neutral type of transmission on the drop side, for use primarily in service where private telegraph lines were associated in networks on a semipermanent basis. The operation of such inverse neutral repeaters is described in Patents 2,056,277, F. S. Kinkead et al., October 3, 1936, 2,069,224, G. C. Cummings, February 2, 1937 and 2,069,251, F. S. Kinkead, February 2, 1937.

When circuit elements of a private line network appear in a telegraph office in which the new inverse neutral repeater is used, as described in the above-mentioned patents, each telegraph station loop and telegraph line is connected into what is known in the art as a concentration group through its own individual inverse neutral repeater. The drop sides or legs of all of the line repeaters and station loop repeaters are interconnected through a common point, which is otherwise known as the hub of the concentration group. From this common point or hub, the leg of each line repeater and station loop repeater extends in series through the armature and marking contact of a receiving relay and through the winding of a sending relay to negative battery common to all repeaters. This common battery has its positive terminal grounded. No current flows through the various legs of a concentration group during the marking condition. For the spacing condition, the armature of the receiving relay in a particular leg is actuated to engage with a grounded contact. This causes current to flow through each of the other legs toward and through the hub point to ground through the single spacing contact. A sending relay having a winding in series in each of the other legs is energized to transmit the spacing signal to the circuit connected to each of the other legs in the same concentration group.

For the full duplex condition two independent hubs are provided, as it is impossible to transmit in two directions simultaneously through a single hub. The transmission in each set of connected legs is otherwise the same as for the half duplex condition.

It may be observed, therefore, that in the use of inverse neutral repeaters the legs of the various repeaters, when joined in a concentration group, are all connected in parallel. One end of each leg is joined at the common electrical point or hub. The other end of each leg terminates in battery of the same potential and magnitude for marking. Any repeater when sending toward the hub connects ground to the hub point and transmits signals simultaneously to all other legs in the concentration group. The signals are "open and close" or neutral signals, as they are known in the art, but they are inverted from the usual, in that the marking signals are no-current signals and the spacing signals are current signals, hence the term "inverse neutral."

When each loop leg and each line leg is terminated in its own individual inverse neutral repeater, it becomes electrically, for the purpose of connection into a concentration group, an independent unit. Since each repeater leg of a line or loop radiating from the hub point terminates in battery of the same polarity and magnitude for the marking condition, so that no current flows for this condition, and since, electrically, ground is connected, as a practical matter, directly to the hub point for the spacing condition, the current conditions in any leg when

it is receiving from the hub, are unaffected by the addition or subtraction of another leg to the concentration group or by the substitution of a different leg for any leg forming part of a concentration group. When transmitting toward the hub, the only effect is a change in magnitude of spacing current in the transmitting leg, from the single spacing contact to the hub point, as the number of connected legs is changed.

When the circuit elements of private telegraph line networks are arranged so that each includes its own inverse neutral telegraph repeater and becomes, for the purposes of association into a network, an electrically independent unit, it is possible to terminate the legs of line repeaters and loop repeaters in a switchboard and to make such changes in private line concentration groups as may be necessary, simply by a switching or patching operation at the switchboard, without the necessity for making poling or current adjustments in the leg side of the various repeaters in the concentration group to accommodate such changes. As will be shown later, the type of operation, viz. half or full duplex, of any line repeater is automatically effected at the time the repeater is patched.

In one of its major aspects, therefore, this invention is a switching system for inverse neutral telegraph repeater circuits, adapted to exploit the inherent characteristic of inverse neutral repeaters that, for the purpose of association in concentration groups, each telegraph line or loop leg, equipped with an inverse neutral repeater, is electrically an independent unit.

In this invention, control circuits are arranged to adapt inverse neutral repeater circuits, as used in semipermanent concentration groups, so that they may be controlled at telegraph switchboard positions. To this end, telegraph line circuits extending to telegraph central offices in distant cities are equipped with inverse neutral repeaters and their legs are extended through leg multiple jack circuits which provide a jack appearance within reach of each attendant in the line-up of switchboard positions. This makes every telegraph line facility available, through the medium of a jack outlet, to every switchboard attendant in the switchboard line-up. The line side of the line repeater circuit is adjusted once for all, so as to provide the optimum signaling conditions. Since the leg of each line circuit in the board is equipped with an inverse neutral repeater, and is, therefore, an independent entity electrically, it may be used to communicate with the distant central office as a separate facility. Or it may be added to a network without the necessity for compensatory adjustments on the leg side.

In this invention, an appearance of a particular private line network may include a number of station loops, extending from various points in the local area where one of the switchboard line-ups of this invention is assumed to be located, into the switchboard. Each of the local station loops will have an independent inverse neutral loop repeater connected to it. Each leg of such loop repeater will be terminated in a particular position in the board in a group of three jacks which will be termed hereafter "loop concentration jacks." All of the jacks associated with loop circuits which are to be formed into a particular concentration group will appear, preferably side by side, at some one position in the switchboard line-up, so that the loop circuits may be administered by an attendant at that position. The loop jacks may be multipled to a second position, so that at times, a second attendant may supervise the concentration group. The line circuits, the repeater legs of which, as has been pointed out, are multipled throughout the board, must be interconnected to the loop circuits so that the concentration group may be extended to other portions of the network appearing in switchboards in distant cities as required. This is done by selecting the proper line facilities from the entire group which are multipled throughout the board and extending the leg of each one which is required into a group of three other jacks, termed "line concentration jacks," each group of jacks being individual to a line circuit at the particular position where the concentration group is to be administered. The legs of each of the loop and line repeaters which are to be associated in a particular concentration group, after passing through its individual group of jacks at a particular attendant's position, are all joined in a common electrical point which becomes the hub of the concentration group.

The connecting together of the individual leg conductors to form the hub may be effected in any convenient manner. In order to reduce the possibility of disconnecting any line or loop inadvertently from a concentration group with which it is normally associated, the individual conductors may be extended to individual punchings on a terminal strip and strapped together with a common soldered connection. When thus assembled, the line circuits and loop circuits in a concentration group each have groups of jacks, individual to each line circuit and loop circuit, all of which appear before a particular attendant in the switchboard line-up who is responsible for the administration of the service. Since, as has been pointed out above, all of the telegraph lines from distant cities, which come into the telegraph office where the switchboard of this invention is assumed to be located, are each equipped with an individual inverse neutral repeater which makes it an independent entity and each line has an appearance, in the form of a multiple jack, within cord reach of each attendant, any idle line in the multiple may be connected on a temporary basis into a particular telegraph network by a patch from the multiple at the position into one of the concentration jacks at the particular position where the concentration group for that network appears. It is to be understood, of course, that the bank of line leg multiple jacks extending through the switchboard are terminations of circuits which extend to many different cities and it is necessary to select one extending to the proper destination. This may be determined from reference to the jack designation strip.

The normal network, as required to provide the proper number of telegraph lines to distant cities and the proper number of loops to stations in the local area served by the switchboard of this invention, will be set up in what is essentially a permanent concentration group. Each line and loop leg will be extended through its own individual group of concentration jacks in the switchboard position where the concentration group is to be administered and joined together in a hub, preferably by a soldered connection. The jacks in the various individual line and loop legs provide means for making changes in the network as required on a temporary basis by means of patches. They also provide means for testing, monitoring, measuring bias, communicating with the attendant, etc., and, in general, permit the

complete administration of the various private line networks, the testing and supervision of the elements of a network, the addition of lines or loops, the disconnection of a line or a loop or the substitution of a new line or loop for one forming part of a network. All of this may be performed by an attendant seated at a switchboard. As pointed out above, since the leg of each line and loop is equipped with its own individual inverse neutral repeater, these additions, subtractions and substitutions may be made without the necessity for making any compensating adjustments in the network or in the individual repeaters.

The invention may be more fully understood from the following description when read with reference to the various associated drawings in which:

Fig. 1 represents two four-wire full metallic telegraph line circuits, equipped with inverse neutral line repeaters, arranged for conversion from full to half duplex operation when connected to full or half duplex concentration groups;

Fig. 2 represents two telegraph station loop circuits equipped with two inverse neutral loop repeaters and two sets of loop concentration jacks, for connecting two local stations into a half duplex concentration group;

Fig. 3 represents two line leg multiple circuits and two sets of line concentration jacks, the last mentioned for use in terminating two lines arranged for half duplex operation and includes a station calling-in circuit by means of which a station attendant may call an attendant at a service board;

Fig. 4 represents an idle indicator control circuit for controlling lamps which momentarily indicate all idle lines to remote points, in response to the actuation of a key by an attendant who requires a new line, to enable the attendant to quickly select a line to a particular distant terminal for connection to a concentration group.

Fig. 5 represents a splitting circuit which is used with a telegraph cord circuit for testing lines before the lines are connected to a concentration group;

Fig. 5A represents a telegraph cord circuit for use in connection with Fig. 5 for testing lines before adding them to a concentration group;

Fig. 6 represents a local station connected through two separate loops to two inverse neutral loop repeaters and two sets of loop concentration jacks, for use in full duplex operation;

Fig. 7 represents two leg multiple circuits and four sets of line concentration jacks for use in terminating two lines to remote terminals arranged for full duplex operation.

The rectangle Fig. A bearing the legend "Half duplex concentration group" indicates the manner in which Figs. 1, 2, 3 and 4 are assembled to form a half duplex concentration group, comprising two lines to two distant terminals and two local station loops, at the telegraph service board.

The rectangle Fig. B bearing the legend "Full duplex concentration group" indicates the manner in which Figs. 1, 4, 6 and 7 are assembled to form a full duplex concentration group comprising two lines interconnected through a telegraph service board, as the switchboard of this invention is known to provide full duplex operation between two remote terminals. It shows also a single patron's station in the local area served by the telegraph service board, connected through two loops into the full duplex line to provide full duplex operation between the local station and the two remote terminals.

Half Duplex Concentration Group

A half duplex concentration group will first be described.

Figs. 1, 2, 3 and 4 are arranged in relation to each other as indicated in the rectangular block diagram Fig. A, bearing the legend, "Half duplex concentration group." As thus arranged, they constitute a concentration group, comprising two telegraph line circuits and two telegraph loop circuits, together with a calling-in signal circuit and an idle indicator control circuit. The telegraph line and loop circuits are connected together at a telegraph central office, through a new telegraph facility to be known as a telegraph service board. The operation of the fundamental switching circuits of this new board are to be described herein.

From the office where the telegraph service board is located, one telegraph line circuit is assumed to extend to a telegraph central office to the east and the second to a telegraph central office to the west. One loop connects a local telegraph station designated A, of a first patron, in the same local area as that in which the service board is located into the concentration group at the service board. The second loop connects a local telegraph station, designated B, of a second patron, also in the same local area as that in which the service board is located, into the same concentration group at the service board.

The circuits are arranged to form a half duplex telegraph concentration group. By this is meant, in this instance, that either loop station may send telegraph signals which are transmitted to the other loop station and over the line east and line west simultaneously, or either line may send telegraph signals which are transmitted to each loop and over the other line simultaneously. It is not possible, however, for any station to receive from other stations while it is sending.

In the description of a half duplex concentration group, apparatus in the circuits for station A and the east line will be designated by numbers only. The letters B and W will be added to corresponding apparatus in the circuits for station B and the west line respectively.

The manner in which a loop station transmits to the other loop and to the two lines simultaneously will first be described. It will be assumed that loop station A transmits. To do this the shunt **201**, which short-circuits the transmitting contacts at station A when the circuit is idle, will be opened and the contacts of key **202** will be closed so that the transmitting key **202** may take control of the circuit.

The armature of relay **212** is held in engagement with its left-hand or marking contact by the effect of current flowing from battery **216** through resistance **217** and the top winding of relay **212** to ground. No current flows through the bottom winding of relay **212** for this condition as will be explained below.

When the transmitting key **202** is closed, a circuit may be traced from ground through positive battery **203**, through resistance **204**, through resistance **205**, through the bottom winding of relay **206**, through the tip and break contact of jack **207**, through the break contact and ring of jack **208**, through the variable resistance **226**, normal make contacts of call signal key **227**, through the winding of the sounder **209**, through

the closed contacts of key 202, through the tip and break contact of jack 208, through the break contact and ring of jack 207, through the top winding of relay 206, through the top winding of polar relay 210, through inductance coil 211, through the armature of relay 212, through resistance 213, through negative battery 214 and back to ground. Positive and negative battery are thus connected to the two ends of the loop circuit and current flows, for the marking or closed condition, through the loop circuit. The effect of the current flowing through the top winding of relay 210 tends to actuate the armature of relay 210 to engage with its right-hand or marking contact. It preponderates over the effect of current flowing through the bottom winding of relay 210, over a circuit from ground through negative battery 214, through resistance 213, through the left-hand or marking contact and armature of relay 212, through inductance coil 211, through the bottom winding of relay 210 and resistance 215 to ground, which current tends to actuate the armature of relay 210 to engage with its left-hand or spacing contact and the armature of relay 210 is thus maintained in engagement with its right-hand or marking contact.

Relay 206 is so arranged that when current flows through both its top and bottom windings, as is the case when the loop is closed, the effect in one winding is balanced by the effect in the other winding and its armature remains in its normal unoperated position as indicated.

When the armature of relay 210 is in engagement with its right-hand or marking contact, it connects negative battery to the hub of the concentration group. The circuit for this may be traced from battery 216, through resistance 218, through the bottom winding of relay 212, through the right-hand or marking contact and armature of relay 210, through test resistance 219, through the top back contact and armature of relay 220, to conductor 221. Conductor 221 may be considered electrically as a point which constitutes the hub of the circuit.

Station B is joined into the hub in a corresponding manner. For the marking condition, station B connects negative battery, indicated 216B, over a path similar to that traced for station A, which passes ultimately through testing resistance 219B to hub 221.

The manner in which one of the telegraph lines is connected into the concentration group will now be explained. The circuit of the line east will be used for this purpose. This telegraph line is a four-wire metallic circuit. Its operation is described in detail in the application of R. B. Hearn, Serial No. 342,431, filed June 26, 1940, now Patent No. 2,259,637, granted Oct. 21, 1941. As therein described, the circuit may be arranged to function either half duplex or full duplex dependent upon whether it is connected into a full duplex or a half duplex concentration group. In this instance it is connected into a half duplex concentration group and therefore is arranged to function half duplex.

Refer now to Fig. 1 which shows in detail a four-wire metallic telegraph line connecting a distant telegraph central office, located, it is assumed, to the east, into the concentration group at the office where the concentration group is established and which indicates diagrammatically, by a rectangular box, an identical telegraph line for the telegraph line west which, it is assumed, connects a central office located to the west into the concentration group. Although a four-wire metallic circuit is shown for this purpose, carrier line circuits, one-way polar circuits, and other line circuits, when terminated in proper inverse neutral type repeaters, may be used in place of the four-wire metallic line and the associated inverse neutral repeater shown.

The upper two line conductors of Fig. 1 constitute the path over which the distant repeater to the east receives from the concentration group. The lower two line conductors of Fig. 1 constitute the path over which the distant repeater to the east transmits into the concentration group.

Relays 101 and 102 are polar relays in the transmitting circuit at the distant central office. When the armatures of these relays are in the positions indicated, which is for the marking condition, a path may be traced from ground through battery 103, through resistance 104, the left-hand contact and armature of relay 101, through inductance coil 105, the top winding of polar relay 106, the armature and right-hand contact of relay 102 and through resistance 107 back to ground. Apparatus corresponding to coils 124, 125 and 126 together with the associated condenser 138 may be inserted, if desired, in this path at the distant central terminal, in the same manner as they are connected in the two top conductors of Fig. 1. The function of this apparatus is to suppress noise caused by telegraph thump on the telephone circuit operated over the same pair of cable conductors. The effect of the current in the top winding in the path traced above is to operate the armature of relay 106 into engagement with its right-hand or marking contact. The operation of the circuit through the bottom winding of relay 106, known in the art as a vibratory circuit, is to tend to speed up the action of the relay. It is well known in the art and will not, therefore, be described herein in detail.

When the armature of relay 106 is in engagement with its right-hand or marking contact, a circuit may be traced from ground through negative battery 108, through resistance 109, through the right-hand or marking contact and armature of relay 106, through resistances 110 and 111 and through the top winding of polar relay 112 to ground. The effect of this current is to actuate the armature of relay 112 into engagement with its right-hand or marking contact. No current flows through the bottom winding of relay 112 for this condition as the circuit through the bottom winding of relay 112, connects at one end to the hub 221 of the concentration group and at the other end to negative battery. This circuit may be traced from negative battery 115 through resistances 116 and 117, through the bottom windings of polar relays 118 and 119, through the left-hand armature and front contact of relay 113, through the bottom winding of relay 112, through the right-hand front contact and armature of relay 113, through the right-hand or marking contact and armature of relay 112, through leg conductor 120, through Fig. 2 into Fig. 3 to parallel branches. One branch continues through the top armature and back contact of relay 301, through test resistance 303 and the back contact and armature of relay 304 to the hub 221 of the circuit. The other branch extends in multiple through the tips of the multiple jacks 316, 317, 318, etc., one of which is accessible at each position in the telegraph service board of this invention.

A biasing circuit for relays 118 and 119 may be

traced from battery 115, through resistance 129 and the top windings of relays 118 and 119 to ground. The effect of this current tends to actuate the armatures of relays 118 and 119 to engage with their right and left-hand contacts respectively for the marking condition. This effect is not opposed as there is no current flowing through the bottom windings of these relays for the marking condition of the concentration group, since all of the legs of the concentration group terminate in battery of the same polarity for the marking condition.

The loop over which the distant office to the east receives may be traced from ground, through battery 121 to its positive terminal, through resistance 122, through the left-hand or marking contact and armature of relay 119, through the bottom winding of inductance coils 124 and 125, through the bottom winding of repeating coil 126, through the bottom line conductor to the distant terminal, through the winding of the receiving relay 127, through the top line conductor, through the top windings of the repeating coil 126, through the top windings of inductance coils 125 and 124, through the armature and right-hand or marking contact of relay 118 and resistance 130 back to ground.

The four-wire line to the west indicated by the rectangular box at the bottom of Fig. 1 is arranged in the identical manner as that described for the four-wire line to the east. It connects negative battery of the same magnitude as battery 115 in the east line through an identical circuit to leg conductor 131, which corresponds to conductor 120 of the east line, through the top outer armature and back contact of relay 301W and test resistance 303W, through the back contact and armature of relay 304W to hub 221.

Thus each line and each loop leg connects negative battery of the same magnitude to the hub of the concentration group for the marking condition.

If a spacing signal is transmitted from any station loop circuit or from any telegraph line forming part of the concentration group, the leg of the circuit transmitting the spacing signal will be connected to ground which grounds the hub and operates a relay in each of the other legs to transmit the spacing signal into each of the other connected circuits. The manner in which this is performed will now be explained.

It will be assumed that the operator at station A opens the contacts of the transmitting key 202 to send a spacing signal. This breaks the loop circuit for station A, heretofore traced. The top winding of relay 210 is deenergized. The armature of relay 210 is actuated, under the influence of current through its bottom winding, to engage with its left-hand or spacing contact which is grounded. This disconnects negative battery 216 from the leg which extends through resistance 219 into the hub 221 and connects ground through resistance 219 to hub 221.

When ground is connected to the hub, a circuit may be traced from hub 221 through the upper armature and back contact of relay 220B, through test resistance 219B, through the armature and right-hand or marking contact of relay 210B, through the bottom winding of relay 212B and resistance 218B, to battery 216B. The effect of this current flowing through the bottom winding of relay 212B preponderates over the effect of current flowing through the top winding of relay 212B which has been holding the armature of relay 212B in engagement with its left-hand or marking contact and the armature of relay 212B is actuated to engage with its right-hand or spacing contact.

Loop B is arranged in the identical manner described for loop A. When loop A was traced it was shown that the two ends of the loop terminated in battery of opposite polarity for the marking condition. Similarly, the two ends of loop B terminate in battery of the opposite polarity for the marking condition. When, however, the armature of relay 212B is actuated to engage with its right-hand armature, negative battery is disconnected from one end of the loop and both ends are terminated in positive battery of the same magnitude so that no current flows in the loop. The sounder 209B at station B is deenergized and a spacing signal is received at station B.

The manner in which the same spacing signal is received at the east central telegraph terminal will now be explained.

When the spacing signal is received in the hub from station A, ground, as has been shown, is connected through resistance 219 to hub 221 and a circuit may be traced through the armature and back contact of relay 304 through testing resistance 303, through the top outer back contact and armature of relay 301, through leg conductor 120, through Fig. 2 into Fig. 1, through the armature and right-hand contact of relay 112, through the right-hand armature and front contact of relay 113, through the bottom winding of relay 112, through the left-hand front contact and armature of relay 113, through the bottom windings of relays 119 and 118, through resistances 111 and 115 and battery 115 to ground. The effect of current flowing in the bottom windings of relays 119 and 118 for this condition is such that it tends to actuate the armature of relay 119 to engage with its right-hand contact and the armature of relay 118 to engage with its left-hand contact and this effect preponderates over the effect of the current flowing through the top windings, so the armature of relay 119 is actuated to engage its right-hand contact and the armature of relay 118 is actuated to engage its left-hand contact.

When the armatures of relays 119 and 118 are actuated as described in the foregoing paragraph, the polarity of battery 121 in relation to the two ends of the east send line through the receiving relay at the distant office will be reversed. That this is so may be understood by observing that there are two conductors extending from each of resistances 122 and 130 respectively. One conductor extends from each resistance to contacts which are in engagement with the armatures of relays 119 and 118 when their armatures are in the positions shown in Fig. 1 and one conductor extends from each of said resistances to a contact on the other of the relays with which each armature makes engagement when in the spacing condition. Thus as the two relays 119 and 118 respond to a spacing signal, the polarity of battery 121 connected to the ends of the line for the marking condition is reversed, resulting in a spacing signal being transmitted to the distant receiving relay 127.

The spacing signal originating at station A is transmitted to the distant receiving relay connected to the west line in the same manner as described above for the east line.

Thus as the armature of the relay 210, which receives from station A and transmits toward the hub, is actuated so as to connect ground and negative battery alternately to the hub 221, the

armature of the receiving relay in the inverse neutral repeater of each of the other legs connected to the hub, whether it be a loop leg or a line leg, is operated simultaneously to transmit spacing and marking signals into its loop or line.

When signals are transmitted from a distant office over a telegraph line, it will be assumed over the east line, relays 101 and 102 in the distant office are operated from a connected circuit not shown. This reverses the connections between the two conductors of the bottom two-wire line and battery 103. Relay 106 is in turn actuated. As the armature of relay 106 is actuated between positive and negative battery, relay 112 responds. As the armature of relay 112 is actuated, negative battery and ground are alternately connected to hub 221 and marking and spacing signals are impressed upon all other legs forming part of the concentration group.

In the same manner signals may be transmitted from the distant western office over the west line into its respective inverse neutral repeater and thence to the hub to actuate the sending relay in each individual inverse neutral repeater in each other leg whether loop or line.

From the above description it should be apparent how any loop or telegraph line may transmit marking or spacing signals to all telegraph circuits forming part of a half duplex concentration group.

Breaking operation in a duplex concentration group

It is possible to transmit a break signal from any circuit connected into a half duplex concentration group, to prevent any circuit which is transmitting to the other circuits of a concentration group from continuing to transmit. The manner in which this is performed will first be described for the condition in which signals are being transmitted from the distant office over the east line and the attendant at loop station A breaks.

When signals are being transmitted from the distant office over the east line, it has been shown that relays 106 and 112 follow the signals to connect ground and negative battery alternately to hub 221. If the attendant at station A wishes to stop the transmitting from the east line, so that station A may transmit, key 202 is opened and is maintained in the open condition. The opening of key 202, as has been described, results in ground being connected to the hub when relay 212 next closes its marking or right-hand contact. Since the key 202 is maintained open, a permanent ground is connected to the hub resulting in a permanent spacing signal being transmitted from the hub out over each connecting leg. In the case of the line which is receiving signals from the distant office, if the armature of relay 112 is in engagement with its left-hand or spacing contact, in response to a spacing signal transmitted from the east line toward the hub, nothing will happen momentarily in its send side, as ground from the hub will be connected to one end of conductor 120 and it will meet ground on the left-hand or spacing contact of relay 112. As soon as the armature of relay 112 is actuated to engage with its right-hand contact, however, the ground from the hub will be connected to one end of the path through the bottom windings of sending relays 119 and 118 and battery 115 will be connected to the other end over the circuit heretofore traced. Under this condition the armature of relay 112 is maintained in engagement with its right-hand contact, as the effect of the current flowing through the bottom winding of relay 112, tending to actuate the armature of relay 112 toward the right, preponderates over the effect of spacing signal current from relay 106 tending to actuate the armature of relay 112 toward the left. Relays 118 and 119 will be operated when the armature of relay 112 is on its right-hand contact, from ground connected to the hub. With the armatures of relays 118 and 119 actuated to their spacing contacts, a permanent spacing signal is transmitted toward the distant office to the east as a breaking signal.

If either loop station is transmitting, any line or the other loop may break. It will be assumed that station A is transmitting and that the east telegraph line breaks. This is performed in the following manner. A permanent spacing signal is transmitted from the east telegraph terminal into the hub, operating relay 106 to its left-hand or spacing contact. This will operate relay 112 to spacing when relay 210 next closes its right or marking contact to remove ground from hub 221. This results in the connection of permanent ground to hub 221 from the left-hand contact and armature of relay 112. A circuit may be traced from the grounded hub 221, through the armature and back contact of relay 220, through resistance 219, to the armature of relay 210. If the armature of relay 210 is again in engagement with its left-hand or spacing contact, nothing happens momentarily. When the armature of relay 210 next engages its right-hand contact, the circuit will be extended through the bottom winding of relay 212 and resistance 218 to battery 216. This operates the armature of relay 212 so that its armature engages its right-hand or spacing contact. This disconnects negative battery 214 from one end of the loop through station A and connects both ends of the loop to positive battery 203. This results in a permanent spacing signal being transmitted over the loop which is received by sounder 209 at station A as a breaking signal.

As a general proposition, it may be stated that, when inverse neutral repeaters are interconnected, a spacing signal transmitted toward the hub, by any repeater connected to the hub, will result in the connection of ground to the hub and a spacing signal will be transmitted simultaneously from the hub through all of the other repeaters connected into the hub, and further, a permanent spacing signal transmitted from any repeater while another repeater in the concentration group is transmitting toward the hub, will result in the loss of control, by the station which is transmitting, of the relay in the repeater which transmits toward the hub, when the station which is transmitting next sends a marking signal toward the hub. The relay which transmits toward the hub will then be held to marking and simultaneously the permanent spacing breaking signal will be transmitted to the station which was transmitting.

Circuit for permitting station connected into a half duplex concentration group to call switchboard

The arrangement of Figs. 1, 2, 3 and 4 per Fig. A is equipped with a calling-in signal by means of which any loop station connected into the concentration group may signal the attendant who is administering the concentration group at the service board.

The three jacks associated individually with

each station loop and each telegraph line in any particular concentration group are all located in the same attendant's position at the service board. The service board is a multiposition board. Various concentration groups are administered at various positions. The attendant in charge of a particular position controls a certain number of concentration groups such as the concentration group per Fig. A, comprising Figs. 1, 2, 3 and 4.

The manner in which an attendant at a station, such as station A, may summon an attendant at the position in the service board where the concentration group is being administered is as follows.

The attendant at station A grounds one side of the station loop circuit. This may be done by momentarily actuating the call signal key 227 in Fig. 2, which first grounds the lower loop conductor through the set and opens the upper loop conductor.

When the station loop circuit is closed, the effects of the currents in the top and bottom windings of differentially connected relay 206 neutralize each other, so that the armature of relay 206 remains in the condition shown. During the transmission of a spacing or a break signal from station A, when the loop is opened, no current flows through either winding of relay 206. No current flows when a spacing signal is transmitted toward station A as both ends of the loop are connected to battery of the same polarity and magnitude for this condition. When the lower loop conductor is grounded and the upper loop conductor is opened, however, a circuit may be traced from ground through sounder 209, make contact and armature of key 202, through the tip and break contact of jack 208, the break contact and ring of jack 207, the top winding of relay 206, the top winding of relay 210, inductance coil 211, the armature and left-hand contact of relay 212, resistance 213 and battery 214 to ground, operating relay 206. With relay 206 operated, a circuit may be traced from ground through the armature and front contact of relay 206, the bottom armature and back contact of relay 220, conductor 222, which may be considered electrically as the hub of the calling-in circuit into Fig. 3, conductor 305, the back contact and armature of relay 306, through the winding of relay 307 to battery, operating relay 307 which locks from its bottom contacts under control of relay 306. The operation of relay 307 connects battery through the top armature and front contact of relay 307 through the filament of lamps 308 and 309 in parallel to ground, lighting both of these lamps as a signal that some station associated in the concentration group is calling in. One of these lamps, such as the primary appearance lamp 308, is located at the same position as the one in which the loop and line concentration jacks of the concentration group are located. The secondary appearance lamp 309 is located at an adjacent position to provide the advantage of teamwork since with this arrangement any of four service board attendants may answer the call through the associated jacks.

Any other station, such as station B, connected through a station loop into the concentration group may light the same lamps 308 and 309 by an operation similar to that described for station A. This should be apparent from reference to the station loop and loop repeater for station B. Ground from the armature of relay 206B is connected through the bottom armature and back contact of relay 220B to conductor 222 in parallel with the ground from relay 206.

In response to the lighting of the lamps 308 or 309, the service board attendant administering the concentration group may connect an attendant's telegraph transmitting and receiving set circuit operating on the inverse neutral principle to jack 310 or jack 311. This connecting circuit will not be described in detail hereunder as it does not form part of the present invention. At this point attention is called to the fact that battery connected to the sleeve of the attendant's circuit operates relay 306 over an obvious path. The operation of relay 306 breaks the operating path heretofore traced for the operation of relay 307 and relay 307 releases, extinguishing the lamps. The hub of the concentration group, conductor 221, is connected in multiple to the tip of jacks 310 and 311 to provide a connection for the transmitting lead in the attendant's circuit. By means of inverse neutral repeater connected to the tip of jacks 311, it is possible for the attendant to transmit and receive signals to and from the various stations and lines comprising the concentration group or to monitor on all signals transmitted through hub 221.

The rings of jacks 310 and 311 are connected in multiple to the common calling-in or signal hub conductor 222. This is to provide a recall feature in the attendant's connecting cord. A recalling operation is performed at a station in the same manner as a calling-in operation. If an attendant's cord circuit is already connected to either jack 310 or 311 and any one of the stations connected into the concentration group through a station loop repeater wishes to again summon the attendant's attention, the lower station loop conductor is grounded. This connects ground, in the manner already described, to conductor 222 and to the ring of both jacks 310 and 311. This ground operates a relay in the attendant's cord circuit connected to either jack to light a supervisory lamp as an indication that a station is recalling.

Connecting supervisor circuit and other circuits to concentration group

Jacks 310 and 311 also provide means for establishing a connection to a supervisor. By means of a patching cord circuit it is possible to connect a test signal supply circuit to the concentration group through jacks 310 and 311. Also, jacks 310 and 311 may be used with suitable connecting circuits for the measurement of bias or distortion.

Releasing a line from a half duplex concentration group

Because each telegraph line to a distant city and each telegraph loop to a local station appearing in the telegraph service board is terminated in its own individual inverse neutral repeater, it is possible in the system disclosed herein to make changes in a concentration group such as removing lines or loops, adding lines or loops or substituting lines or loops, without the need for making compensatory adjustments in the leg side of any repeater to accommodate the change. The invention herein permits these changes to be made flexibly at the switchboard position where the concentration group is administered with a minimum of effort on the part of a service board attendant.

It is necessary on occasion to make temporary changes in a concentration group, such as to replace a line or loop which may be defective or to provide additional facilitites in a concentration group such as additional lines or loops, or to remove a line or loop at the termination of its daily service period. The manner in which a telegraph line is disconnected from a concentration group will now be explained. The east line will be used for the purpose.

To perform this operation a control plug, such as plug 312, having its ring and sleeve conductors interconnected, is inserted into a cooperating jack, such as release control jack 313. This connects the ring and sleeve of jack 313. A circuit may then be traced from ground, through the middle winding of relay 315, to the sleeve of jack 313, through the sleeve of plug 312 to the ring of plug 312, through the ring of jack 313 and the top winding of relay 315, through battery 314 back to ground, operating relay 315. The operation of relay 315 connects ground through its upper armature and front contact and the winding of relay 301 to battery, operating relay 301. The operation of relay 301 breaks the connection between the leg conductor 120 and the hub 221 as previously traced, thus disconnecting the east line from the concentration group. The operation of relay 301 also breaks the connection which extends from battery through the winding of relay 113 in Fig. 1, and conductor 114, into Fig. 3, through the bottom middle armature and back contact of relay 301 and the top back contact and armature of relay 302 to ground, thus disconnecting ground formerly furnished through the top armature and back contact of relay 302. Relay 113 releases. This places the inverse neutral repeater in the east line in its normal condition which is the full duplex condition.

It has been explained that the circuit per Fig. 1 may function either full duplex or half duplex dependent upon whether it is connected into a full duplex or half duplex concentration group. When it was connected into the half duplex concentration group as explained above, it was conditioned to function half duplex through the operation of relay 113. Now that it has been released, the repeater is restored to its normal full duplex condition. Even though it is no longer serving in the concentration group described above, it may be appropriated for use with another concentration group which may operate full duplex or half duplex. If the new concentration group is to operate full duplex, relay 113 will remain unoperated. If the new concentration group operates half duplex, relay 113 will be again operated.

To return to the operation of relay 301, its operation sends a permanent spacing signal to the distant eastern terminal. This is performed as follows. A circuit may be traced from ground through the armature and back contact of relay 302, through the top inner front contact and armature of relay 301, through conductor 132, through the left-hand back contact and armature of relay 113, which is now released, through the bottom windings of relays 119 and 118, through resistances, 117 and 116 and negative battery 115 back to ground. This operates relays 119 and 118, reversing the polarity of battery 121 as connected to the sending line and sending a permanent spacing signal to the distant eastern terminal.

The operation of relay 301, also, by the transfer of its bottom innermost armature from its back to its front contact, disconnects ground from the sleeves of the multiple jacks 316, 317 and 318 and connects the sleeves of these jacks to battery through the windings of relays 302 and 318. The object of the connection of ground to the sleeve while the line is connected into a concentration group was to permit monitoring on the circuit through a multiple jack. The plug of a monitoring circuit may be inserted into a multiple jack at any position in the board and ground on the sleeve of the multiple jack operates a relay in the monitoring circuit which conditions the monitoring circuit for monitoring. The purpose of the change from ground on the sleeve to battery through the relays will be understood from the description below.

The operation of relay 301 performs one other switching operation. It extends a circuit, which may be traced from ground, through the filament of lamps 321, 322 and 323 in parallel, through the bottom outermost front contact and armature of relay 301, through the bottom back contact and armature of relay 302 and through conductor 320 to a front contact of relay 401 in Fig. 4 which forms part of the idle indicator control circuit which will now be explained.

Idle indicator control circuit for indicating line available for connection to concentration group

It has been explained that each telegraph line connecting the service board to a distant city, whether connected into concentration jacks at a particular attendant's position or not, is extended through a group of multiple jacks throughout the switchboard line-up. Some means must be provided for distinguishing between the lines which are serving as part of an operating concentration group and those which are available to be connected into a concentration group on a temporary basis by means of a patching operation. A line may be connected into a concentration group or it may be released from, or not connected to, a concentration group for relatively long intervals. If a lamp were lighted throughout either interval as an indication of the condition, it would mean that many lamps would be burning in the switchboard at all times. This has a number of disadvantages including battery drain, reduced life of lamps and reduced contrast between lighted and unlighted lamps, such as station calling-in signal lamps 308 and 309 described above.

In order to provide the advantages of a normally unlighted switchboard, and the other advantages enumerated above, the idle indicator control circuit is furnished. Its function is to light the lamps associated with all idle telegraph lines to distant cities momentarily, in response to the actuation of a key by an attendant who requires such a line, so that a selection of a line to a particular city may be made if such a line is available.

If an attendant at a particular position in the telegraph service board line-up requires a telegraph line to a distant city and wishes to know which lines are available so that he may make a selection, the attendant operates a key such as 402, Fig. 4, at the particular attendant's position. There is one such key at each position in the line-up. Keys at other positions are indicated by keys 403 and 404. When key 402 is operated, relay 405 is operated over an obvious circuit. The operation of relay 405 closes a cir-

cuit from ground through the bottom front contact and armature of relay 405, through the winding of relay 406 and resistance 407 through battery to ground. Relay 406 will operate and lock up through its top middle front contact and armature to ground. The operation of relay 406 will connect ground through its bottom inner front contact and armature and the winding of relay 401 to battery, operating relay 401. The operation of relay 401 will connect battery through its various contacts in parallel to a number of conductors extending to various leg multiple circuits. Each of said conductors is arranged so that it may be multipled to a number of leg multiple circuits. A circuit may be traced from battery through the top armature and front contact of relay 401, through conductor 320, through the bottom armature and back contact of relay 302, through the bottom outermost armature and front contact of relay 301 and through the filaments of lamps 321, 322 and 323 in parallel to ground, lighting each of the lamps, as an indication that the telegraph line circuit to a distant city associated with these lamps is available for use. Only such circuits as are available for use will have their associated idle indicating lamps lighted as the path to the lamps in the case of circuits which are not idle will not be closed.

The lamps indicating that a circuit is available for use remain lighted for a short interval only, while a selection of one of them is being made and then the lamps are extinguished through the operation of the idle indicator control circuit. The manner in which this is performed will now be explained.

When relay 406 is operated a circuit may be traced from plate battery 408 through resistance 409 and conductor 410, through resistances 411 and 412 in parallel, through the bottom armature and front contact of relay 405, through the filament of vacuum tube 413 and resistance 414 to ground, lighting the filament. After a momentary interval key 402 is released, in turn releasing relay 405. This removes ground which has been connected through the front contact and top armature of relay 405 to the upper terminal of condenser 415 and condenser 415 is charged over a path from battery 408 through resistance 409, through resistance 416 and the top innermost armature and front contact of relay 406 to the upper terminal of condenser 415, the bottom terminal of which is grounded. When the top plate of condenser 415 and the grid of tube 413, connected in parallel with the top plate of the condenser, have assumed a proper positive potential with respect to the cathode of tube 413, current will flow through the plate circuit of the tube from positive battery 408, through resistance 409, through the winding of relay 417 to the plate of tube 413, from the plate to the filament of tube 413 and through resistance 414 to ground, operating relay 417. The magnitude of resistance 416 and the capacity of condenser 415 establish the interval necessary to charge condenser 415 to the proper positive potential and the interval has been established for use with the idle indicating lamps of the inverse neutral circuits at approximately six seconds.

When relay 417 is operated, ground is connected to the left-hand terminal of resistance 407. This short-circuits the path through the winding of relay 406 to ground, releasing relay 406. The release of relay 406 breaks the path heretofore traced through the filament of tube 413. The release of relay 406 also disconnects battery 408 from the top terminal of condenser 415. The battery connection of the condenser will be replaced by direct ground through the top outermost armature and back contact of relay 405 which will discharge condenser 415. When the filament of tube 413 is extinguished current will no longer flow through the tube and relay 417 will be released. The idle indicator control circuit is thus returned to normal.

If at any time a key such as 403 is operated momentarily, in turn operating relay 405 before the timing circuit has been permitted to complete its cycle, condenser 415 will be discharged from ground connected to the top front contact and armature of relay 405 and the entire timing cycle will be repeated.

Replacing a line forming part of a half duplex concentration group with a line which has been released from a different concentration group

The concentration group is arranged so that a line forming part of a concentration group may be replaced by a second line. This second line may be a line which has been released from another concentration group or it may be a spare line. A spare line is one which is not normally connected into a concentration group, a spare line terminates in multiple jacks and a leg multiple circuit, but it is not provided with a group of three concentration jacks and connected into a hub as is a line which is arranged to normally form part of a concentration group.

In this section the operation of replacing a line in a concentration group by a line which has been released from another concentration group will be described.

In order to replace a line forming part of a concentration group with a new line which has been released from a concentration group and is temporarily idle, first the idle indicating circuit described in the foregoing is operated, so that an idle line to the proper distant city may be indicated, if one is available, in order that the idle line may be selected for use. If such a line is available, the attendant, by means of a patching operation, through the leg patching cord circuit, shown at the right of Fig. 3, will connect the new line to the concentration group and, as a result of the patching operation, the old line will be automatically released from the concentration group and the new line will function in its stead.

For the purposes of this explanation, it will be assumed that the line west has been previously released from another concentration group in another position of the board and it will be assumed that it connects at the distant end to the desired distant termination. The line west will be used to replace the line east.

Plug 324 will therefore be inserted into jack 316W when lamp 321W lights, indicating that the line is idle. Plug 325 will be inserted into jack 313. A circuit may then be traced from battery through the windings of relays 319W and 302W in series, through the bottom innnermost front contact and armature of relay 301W, relay 301W being operated while a line is released, through the sleeve of jack 316W, through the sleeve of plug 324, sleeve of plug 325, sleeve of jack 313 and the low resistance middle winding of relay 315 to ground. Relays 319W and 302W operate in series with the low resistance middle winding of relay 315. Relay 315 operates. The operation of relay 315 in turn operates relay 301. The

operation of relay 301 breaks the leg path from the east line repeater into the hub 221 of the concentration group, disconnecting the east line from the concentration group and performs all of the other operations heretofore described attending the operation of this relay.

The leg of the new line repeater is connected through the tip of jack 316W, tip of plug 324, tip and break contact of jack 326, tip of plug 325, tip of jack 313, test resistance 303, break contact and armature of relay 304 into hub 221 to incorporate the line west into the concentration group.

It was pointed out that relays 319W and 302W operated in the west line which has replaced the east line in the concentration group. The operation of relay 319W connects ground to conductor 114W which extends into the winding of a relay in the west inverse neutral repeater corresponding to relay 113, which conditions the west repeater to function half duplex in the same manner as described for the east repeater. Relay 302W in operating in the new leg multiple circuit for the new line opens the idle indicating circuit for the west line as the west line has now been appropriated and disconnects ground from the leg of the repeater removing the permanent spacing signal which was transmitted to the distant western terminal while the line was idle. The operation of relay 302W also locks relay 315W from ground through its top armature and front contact to hold relay 315W operated. The reason for this is that the west line was made available for use by a releasing operation, such as just described above, or by means of inserting a control plug into a control jack, as previously described. This operation is performed at another position in a jack corresponding to jack 313W, namely at the particular position where the concentration group with which the west line is assumed to be normally associated is administered. The removal of the releasing plug would release relay 315W and reconnect the west line into the concentraion group with which it is normally associated. This is prevented by the locking of relay 315W when relay 302W operates.

The foregoing explains how a line released from the concentration group with which it is normally associated may be appropriated by an attendant to replace a line normally forming part of another concentration group.

The manner in which a line which is normally spare, as distinguished from a line which is released from a concentration group with which it is normally associated, is connected into a half duplex concentration group as a substitute for a line forming part of a half duplex concentration group will now be explained.

Replacing a line forming part of a half duplex concentration group with a spare line

As stated above, spare lines are distinguished from lines ordinarily forming parts of concentration groups, in that spare lines appear only in multiple jacks at each attendant's position and are not extended through their leg multiple circuits into three individual concentration jacks at a particular position, through which they are extended to a hub so that they normally form part of a particular concentration group. A spare line may be appropriated, by means of a patching operation from one of its multiple jacks, at any position, to a particular jack in a line normally forming part of a concentration group, to replace a line normally forming part of a concentration group.

In order to replace a line normally forming part of a concentration group with a spare line, a patch is made from a multiple jack of the spare line to the control jack of the line which is to be replaced.

For purposes of this explanation it will be assumed that the west line is now a spare line. In order that the west line may simulate a spare line, it will be assumed that its relay 301W is permanently operated. Each spare line throughout the board is arranged so that electrically it is the equivalent of a line which normally forms part of a concentration group, except that each of the circuits extending through the various armatures of its relay corresponding to relay 301W is closed through its respective front contact instead of through its back contact as shown for the normal unoperated condition of relay 301W in Fig. 3. Further, a spare line is not provided with a concentration jack circuit.

It will be assumed that the spare west line is to be used to replace the east line which normally forms part of a half duplex concentration group. First the idle indicator circuit is operated and a lamp such as 321W is lighted indicating that the line is available. The plug 324 is inserted into jack 316W and plug 325 is inserted into jack 313.

As a result of this operation the tip of the spare line is extended into the hub of the concentration group in the same manner as described above. The sleeve of the spare line is extended over a circuit, exactly the same as described before, for a released line, starting from battery connected to relay 319W in the spare line and ending in ground connected to relay 315 in the replaced east line. Relays 319W, 302W and 315 are operated in series. Relay 319W in operating conditions the repeater in the west line to function half duplex as described heretofore. Relay 302W in operating disconnects the idle indicating circuit at its bottom armature and front contact. The operation of relay 302W also operates relay 315W as described above, but this performs no useful function in the case of a spare circuit, as it did in the case of a released circuit described above. The operation of relay 315 releases the replaced line from the concentration group.

Adding a released line to a half duplex concentration group

It will now be assumed that the west line has been released from a concentration group at another attendant's position and that it is to be added to the concentration group comprising the east line instead of replacing the east line.

It should be remembered that a plug such as 312 is inserted into a jack such as 313W in the attendant's position, where it is assumed that the west line is normally associated into another concentration group. This operates relay 315W in turn operating relay 301W in the manner heretofore described.

The attendant who desires to add a line operates the idle indicating key at the position where the concentration group to which the line is to be added is administered. Once again the idle indicating lamps of all available lines are lighted.

In order to add the west line to the concentration of which the east line forms a part, the attendant inserts plug 324 into line multiple jack

316W when lamp 321W lights. Plug 325 is inserted into jack 327.

As a result of this operation the tip of the west line is connected through the tip of jack 316W, tip of plug 324, tip and break contact of jack 326, tip of plug 325 and tip of jack 327 to hub 221. This connects the transmission conductor of the west line into the concentration group of which the east line forms a part.

A circuit may also be traced from battery through the winding of relay 319W, winding of relay 302W, bottom innermost front contact and armature of relay 301W, relay 301W being operated when the west line is released in a manner heretofore described, through the sleeve of jack 316W, sleeve of plugs 324 and 325 and sleeve of jack 327 to direct ground. This operates relays 319W and 302W which conditions the west line for half duplex operation, disconnects the idle indicator lamp circuit and provides ground to hold relay 315W operated in the same manner as heretofore described.

It should be observed that in the operation of adding a line, a different jack in the line concentration jack circuit normally forming part of a concentration group is used than the jack which is used for releasing a line or for replacing a line forming part of a concentration group with a released line or a spare line. All of these latter operations involve a releasing operation, which must be performed by connection to a jack such as 313 which controls the operation of the releasing relay such as 315. When a line is to be simply added to a concentration group, connection is made to jack such as 327 and the releasing relay remains unaffected.

Adding a spare line to a half duplex concentration group

A spare line may be added to a concentration group. It will be again assumed that the west line is a spare line. That is, it is not provided with a group of individual concentration jacks and its relay 301W is blocked operated.

The attendant, at the position where the concentration group to which the spare line is to be added is administered, operates the idle indicator control circuit and, when all of the lamps associated with idle lines light, selects the spare west line for addition to the particular concentration group of which the east line forms a part.

Plug 324 is inserted into jack 316W and plug 325 is inserted into jack 327 of the east line. The tip of the west line is connected into the hub over a circuit heretofore traced. Relays 319W and 302W operate in the same manner and perform the same functions as described above. The west line thus becomes a part of the concentration group with which the east line is normally associated.

Supervision in half duplex patching operations

When lines are arranged so that a permanent spacing signal is received at the service board, while they are idle, a circuit feature of the service board provides for observing that the permanent spacing condition on the line has been removed before a spare or released line is connected into a concentration group. It will be assumed that the east line is a spare line in the idle condition and that a permanent spacing condition is imposed on it at the distant terminal.

In such cases, when an idle indicating lamp lights in response to the operation of a key such as 402 by an attendant who is seeking an available line to a particular distant city, a patch is not made immediately to a concentration group. Instead the attendant inserts the plug 501 of a telegraph cord circuit, indicated as Fig. 5A, into jack 502 of the splitting circuit of Fig. 5. The telegraph cord circuit per Fig. 5A is not shown in detail in this application as it is not a part of this particular invention. The attendant also inserts plug 324 into a multiple jack, such as 316 and plug 325 into jack 503 of Fig. 5. With these circuits interconnected in this manner, the conductor over which communication signals are received over the line circuit incoming from the distant office is extended through the tip of multiple jack 316, tip of plug 324, tip and break contacts of jack 326, tip of plug 325, tip of jack 503, tip of jack 502, tip of plug 501 and into the telegraph cord circuit, where it passes ultimately through the winding of a telegraph receiving relay such as 507, to negative battery. At the same time ground is connected through the sleeve of jack 503, sleeve of plug 325, sleeve of plug 324, sleeve of jack 316, through the bottom innermost contact of relay 301 which is operated, and the windings of relays 302 and 319 to battery. Relays 319 and 302 operate from the direct ground on the sleeve of jack 503. This operation of relay 302 removes ground from the path heretofore traced through the windings of relays 119 and 118 to negative battery 115. This results in the removal of the permanent spacing signal which was being transmitted to the distant terminal over the east line and a change of relays 110 and 118 to marking. The operation of relay 319 operates relay 113 which changes the line repeater from the full duplex to the half duplex condition.

When the marking signal is received at the distant terminal, the attendant thereat may respond in such manner that the permanent spacing condition imposed at the distant office on relays 101 and 102 is removed and changed to marking. As a result of this, relays 106 and 112 are in turn changed to the marking condition. When ground is removed from the armature of relay 112, the permanent spacing signal is removed from conductor 120 and the tip circuit heretofore traced into the telegraph cord circuit. When the receiving relay 507 connected to the tip circuit responds to the marking signal, the attendant knows that the east line may be connected into the concentration group, or he may communicate with the distant attendant and cooperate in making any tests necessary to assure proper transmission of the line and associated repeaters. The attendant thereupon disconnects plug 325 from jack 503 and connects it instead into a jack in a line circuit of the concentration group such as jack 313W or 327W depending upon whether the line is to replace an existing line in a concentration group or be added to a concentration group.

Releasing a station circuit from a half duplex concentration group

Station loops normally connected to a concentration group may be released from the concentration group for test purposes, or for transfer to other concentration groups or because their daily working period is ended. To perform this operation, a plug such as 312 having its ring and sleeve conductors interconnected is inserted in a jack such as 224.

A circuit path is established as a result of the

above operation extending from ground, through the sleeve of jack **224**, sleeve of plug **312**, ring of plug **312**, ring of jack **224** and bottom winding of relay **220** to battery, operating relay **220**. The operation of relay **220** disconnects the station from the concentration group, by disconnecting the loop repeater transmission lead from the hub **221** at the top armature and back contact of relay **220** and disconnecting the loop calling-in lead at the bottom armature and back contact of relay **220**.

Adding a station circuit to a half duplex concentration

After a loop has been disconnected from a concentration group it may be added to a different concentration group by inserting the plug **324** into a jack such as **225** and the plug **325** into a line jack such as **327**. This extends the tip or transmission conductor of the loop repeater through the tip of jack **225**, tip of plug **324**, tip and break contact of jack **326**, tip of plug **325**, tip of jack **327**, into the hub **221** of the concentration group. It also extends the loop repeater calling-in conductor through the ring of jack **225**, ring of plug **324**, make contact of key **333**, which is operated for this purpose, ring of plug **325**, ring of jack **327** into the common calling-in conductor or signal hub **222**.

While a station loop repeater is released, connection may be made to jacks such as **225** for testing purposes. This provides access to both the transmission conductor and the calling-in conductor of the loop repeater. Ground on the sleeve of the jack **225** is provided for controlling relays in the sleeves of cooperating testing cord or jack circuits.

Transmitting "good night" or permanent spacing signal

When a station loop repeater is released, it may be arranged to transmit a permanent spacing or "good night" signal toward the station by inserting a control plug such as **328** into a jack such as **225**. This connects ground from the sleeve of jack **225**, sleeve of plug **328**, tip of plug **328**, tip of jack **225** to the transmission conductor of the loop repeater which transmits a permanent spacing signal to the station.

If it is desired to transmit a "good night" or permanent spacing signal over all of the circuits formed into a concentration group, a plug having its tip and sleeve conductors interconnected, such as **328**, may be inserted into jack **327**.

A circuit is established under the above condition which may be traced from ground through the sleeve of jack **327**, sleeve of plug **328**, tip of plug **328**, tip of jack **327**, into the hub conductor **221**. As has been shown, a ground connected to the hub of the concentration group transmits a spacing signal over each line and loop leg formed into the concentration group.

Further, since the tip of jack **327** is common to the hub, a monitoring circuit, not shown, may be connected to jack **327** and signals may be received in the monitoring circuit from the hub over the tip of jack **327** and through the tip of the plug of the monitoring circuit.

Provision for testing and observing "hits" on a leg in a half duplex concentration group

Jacks **223**, **223B**, **329**, **329W** and **326** provide means for connecting a testing circuit to a line or loop leg and testing it separately from the concentration group and for observing for "hits" by means of a trouble indicator cord circuit, not shown. Whether a line or a loop leg is normally associated with a concentration group, or, in the case of a line, is serving as a substitute in a concentration group, connection of a trouble indicator cord circuit to jacks such as **329**, **223** or **326** will permit observation for hits occurring on the associated leg. When a line or loop leg is added to a concentration group through the medium of the patching cord terminating in plugs **324** and **325**, such observations will be obtained through jack **326**.

Attention is particularly called to the resistances **219** and **219B** in Fig. 2 and **303**, **303W** and **333** in Fig. 3. One end of each of these resistances is connected to a tip conductor of one of each of the above jacks. The opposite end of each of these resistances connects through the contacts of the test relay to a ring conductor of the corresponding jack. These resistances are connected in series in the leg lead in each instance. When signals are being received from a leg, a potential drop in a particular direction occurs in its associated resistance. When signals are being sent to the leg through the resistance, the drop is in the reverse direction. Further, when signals received from one leg are sent to a group of legs associated together in a concentration group, a greater current flows in this leg than when it is sending to a line or loop. The drop for the first of these conditions is therefore greater. This assumes that at least three repeater legs are joined in a concentration group. If a linear loop is in trouble, so that it is causing random false spacing signals to be transmitted toward the hub, this condition may be detected by connecting to jacks, such as **223**, **223B**, **329** and **329W**, a device which is responsive to changes of potential across two points and which discriminates between such changes in reverse direction.

Relays **220**, **220B**, **304**, **304W**, and **334** each have a winding connected between ground and the sleeve of an associated jack. These relays are arranged so that they may be operated or remain released, depending upon the resistance inserted in the connection to battery in the sleeve circuit of the cooperating cord circuit. When a trouble indicator cord circuit is connected to any one of the jacks for the purpose of observing "hits" on the associated leg, since the trouble indicator cord is arranged to respond to a drop across the test resistance in a particular direction, the resistance must remain in circuit and the test relay remains unoperated.

Jacks **223**, **223B**, **329**, **329W** and **326** also provide means for monitoring on or communicating over a concentration group. The ring of each of these jacks connects directly to the hub of the concentration group. An inverse neutral repeater terminated in a receiving device only for monitoring, or in a sending and receiving device combined for communication, may be connected by means of a plug to the ring conductor of each of these jacks. Under these circumstances, if it is desired to monitor on the whole concentration group or communicate over the whole concentration group, the resistance of the connected sleeve circuit will be high to prevent the operation of the relays, such as **220**, **304** and **334**.

If it is desired to split the leg of a loop or a line off from a concentration for testing it separately, connection is made to jacks such as **223**, **329** and **326** and the sleeve of the connecting circuit is arranged so that it connects to battery through a low resistance to permit test relays

such as 220, 304 and 334 to operate. This disconnects the associated leg from the concentration group. The leg is extended through the associated tip conductor and the hub 221 through the associated ring conductor of the cooperating jack into the connected circuit for testing. By connecting the inverse neutral repeater in the cooperating connected circuit through a splitting key, it is possible to communicate with the leg which has been cut off from the hub over the tip or with the circuits which remain associated in the concentration group over the ring of jacks such as 223, 329 or 326.

Full Duplex Concentration Group

A full duplex concentration group will now be described.

In a full duplex concentration group, separate independent hubs are required for transmission in opposite directions. The sending loops, receiving loops and lines may be connected together in various ways, depending upon the traffic requirements. The arrangement to be described will therefore be a typical arrangement. In this typical arrangement, a telegraph service board will be used to interconnect an east line, a west line and a local patron's station. Full duplex service is provided between the east terminal and the west terminal over the east and west lines in tandem. The patron's station is equipped with two loops for full duplex operation.

For full duplex operation, Figs. 1, 6, 7 and 4 are arranged as indicated in the rectangular box Fig. B, bearing the legend "Full duplex concentration group." This exemplifies a typical arrangement including two lines and a local station comprising two loops. The two lines may be assumed to be an east line, which extends to a distant eastern terminal, and a west line which extends to a distant western terminal.

Although the detailed description will again assume the use of four-wire metallic line circuits, it should be understood that carrier line circuits, two path polar circuits or differential duplex line circuits may be used when terminated in the proper inverse neutral type of repeater which provides separate send and receive legs on the "drop side." The legs appear in leg multiple circuits as previously described and each leg is extended from the leg multiple circuit through a line concentration jack circuit to a hub. The sending leg of one line is connected through the hub to the receiving leg of the other line in each instance.

Since two hubs are required in full duplex operation, one for east-to-west transmission and one for west-to-east transmission, in order to provide a subscriber's local station with full duplex service through such concentration groups, it is necessary to provide two separate loop circuits extending from any subscriber's premises to the telegraph service board. One such loop connects a local station circuit including a telegraph transmitting and receiving instrument at the subscriber's premises with an individual inverse neutral loop repeater at the service board terminal. It is extended via the leg of the loop repeater into an individual concentration jack circuit. From this loop concentration jack circuit it is connected into one of the two hubs.

In a similar manner a second sending and receiving instrument on the subscribers premises is connected through a loop circuit to an individual inverse neutral loop repeater. It is extended via the leg of the loop repeater into an individual concentration jack circuit. From the concentration jack circuit it connects to the other of the two hubs.

Thus, there is an individual hub and concentration group for transmitting in each direction. Both are independent.

In the case of full duplex operation, the concentration group for the east-to-west hub and the concentration group for the west-to-east hub are located at the same attendant's position at the telegraph service board. If it is desired, a multiple appearance of the concentration jacks may be provided at a second attendant's position. The leg multiple jacks of the line circuits and the idle indicator lamps and control circuit are arranged in the same manner as described above for a half duplex concentration group.

Refer now to Figs. 1, 6, 7 and 4 arranged for full duplex operation. In the numbering of the apparatus for a full duplex concentration group, numbers only, without any letter suffixes, will be used as both station loops extend to the station of but one patron and the sending leg of one line repeater is connected to the receiving leg of its cooperating line repeater.

It was shown in the description above that the east line in Fig. 1 was convertible from a full duplex to a half duplex and vice versa. It was shown that when a line was released from a concentration group or serving as a spare line, the relay such as 113 in the line repeater was released and the line repeater was conditioned to function as a full duplex repeater. In such case two separate legs extended from the repeater through the leg multiple circuit. On the other hand, when a line was normally connected to a half duplex concentration group, relay 113 was operated and only one leg from the line repeater was used, in which case sending and receiving was performed over the single leg. In the arrangement now to be described, the line is normally connected into a full duplex concentration group. Under such a condition relay 113 remains released and two legs extend from the line repeater through the leg multiple circuit and into separate line concentration jacks for each leg. To provide for the four line legs from the two lines, four sets of line concentration jacks are required. When signals are transmitted from the distant terminal to the east, negative battery and ground are alternately connected to receive leg conductor 120. Conductor 120 connects through conductors 620 and 720, through the top outer armature and back contact of relay 701, through test resistance 702, and the back contact and armature of relay 703 to hub 704 which is the east-to-west hub.

The send leg, by means of which signals are transmitted to the distant west terminal, is connected to the same hub, so that the east terminal may transmit to the west terminal. The circuit may be traced from hub 704, through the armature and back contact of relay 733, resistance 706, through the top inner back contact and armature of relay 707, through conductors 736, 636 and 136 into the rectangle exemplifying the west repeater and line. There the path will be continued through the left-hand break contact and armature of a relay such as 113 (which remains released), through the bottom windings of relays such as 119 and 118 in series, through resistances such as 117 and 116 in series to negative battery such as 115. Thus signals impressed on relays 101 and 102 at the east terminal pass through

hub 704 to a receiving relay such as 127 at the west terminal.

In a similar manner, signals impressed on relays such as 101 and 102 at the west terminal connect negative battery and ground for marking and spacing through the contacts of a relay such as 112 in the west repeater. These signals are impressed through conductors 131, 631 and 731, through the top outer armature and back contact of relay 707, through resistance 708 to hub 705, which is the west-to-east hub. From hub 705 a path may be traced through the armature and back contact of relay 709, resistance 710, top inner back contact and armature of relay 701, conductors 732, 632 and 132, left-hand back contact and armature of relay 113, bottom windings of relays 119 and 118, resistances 117 and 116 to negative battery 115. This results, as has been previously shown, in the reception of signals by receiving relay 127 at the east terminal.

One loop from the local station is connected through an individual loop repeater and an individual group of concentration jacks to hub 704, and the other through corresponding facilities to hub 705.

In the station circuit shown in Fig. 6 there is a telegraph key and a sounder in each loop. The equipment in the station loops may be varied to suit conditions. For example, where a station circuit is to be restricted to receiving only, the equipment on the loop would comprise only a sounder. The polar relay, by means of which the inverse neutral repeater receives signals transmitted from the local station and transmits them toward the hub, would be blocked in the mark position or would be removed from its jack mounting and replaced with a dummy relay base strapped to obtain the same effect. Such loops would not be equipped for calling in the service board attendant, hence the call signal key, at the station, corresponding to key 227 in Fig. 2 and the differentially connected relay, such as 206 in Fig. 2, would be omitted.

With the concentration group described, the east and west line may communicate on a full duplex basis. Signals transmitted from the east to the west terminal will be recorded by the sounder in one loop at the local station. Signals transmitted from the west to the east terminal will be recorded by the receiving instrument in the other loop at the local station. The telegraph key in one loop at the local station may be used to communicate with the east terminal. The transmitter in the other loop at the local station may be used to communicate with the west terminal.

Attention was called above to the fact that the connections for full duplex service are widely variable dependent on the traffic desired. As an illustration, it is possible to connect a group of lines such as described herein, so that they radiate from a service board in many directions and to interconnect all of their sending legs into a common hub. A loop from a local station having a transmitting instrument could be connected to the common hub to establish a broadcast arrangement. All of the receiving legs of line repeaters from the various distant terminals could be connected into a common hub and extended through a separate loop to the receiving instrument at the local station. Transmission from the various distant stations to the local station could be scheduled on a time basis to prevent interference or, if one distant terminal were transmitting to the local station and a second distant terminal started to transmit simultaneously, the local station could signal over its broadcast transmitter that the station receiver was busy.

Releasing a line from a full duplex concentration group

The manner in which a line which normally forms part of a full duplex concentration group is released from a concentration group will now be described.

To exemplify this operation the east line will be released from the concentration group described above. To release the east line, a ring sleeve short circuiting plug, such as plug 312, is inserted in jack 711. This establishes a circuit from ground, through the sleeve of jack 711, sleeve of plug 312, ring of plug 312, ring of jack 711 and top winding of relay 712 to battery, operating relay 712. The operation of relay 712 in turn operates relay 701 over an obvious circuit, to break the connections of the send and receive legs of the east line from hubs 705 and 704 at the top inner armature and back contact and top outer armature and back contact, respectively, of relay 701.

The west line may be released by a similar operation performed in a corresponding jack in the west line.

Replacing a line forming part of a full duplex concentration group with a line which has been released from a different concentration group

In order to substitute a released line for a line normally forming part of a full duplex concentration group, it is first necessary to find a released idle line to the desired distant terminal which is available to serve as a substitute. In the case of all idle lines, both released and spare, a path is closed from ground connected to the filaments of the idle indicating lamps of each circuit in multiple, through its associated leg multiple circuit, to battery in the idle indicator control circuit. The attendant operates the idle indicator control key at the position where the concentration group is being administered. This lights the multiple lamps of every telegraph line in the service board which is not at the moment serving in a concentration group. The attendant selects one connected to the desired distant terminal from reference to a designation strip associated with the lighted lamps. A patch is made from the multiple jack associated with the available line, at the attendant's position where the concentration group is administered to the control jack of the line in the full duplex concentration group which is to be released and replaced by the new line. This automatically releases the old line and connects the two legs of the new line into the two hubs.

It will be assumed, in order to demonstrate this operation, that the concentration group consists of the west line and the local station loops. It will be assumed also that the east line is idle. The east line, it will be assumed, normally forms part of another concentration group instead of the concentration group described above, from which other concentration group it has been released by an operation such as described in the preceding section herein.

Under the above circumstances, the two line concentration jack circuits associated with the two legs of the east line would appear at the position where the concentration group with which the east line is normally associated is ad-

ministered. A ring sleeve short circuiting plug would have been inserted in jack 711 at that position. Relays 712 and 701 would be operated.

The attendant at the position where the concentration group, comprising the west line and the two loops to the single local station, is being administered first operates key 343 to close the ring circuit of the patching cord and then inserts plug 324 into jack 715 when lamp 716 lights and inserts plug 325 into jack 717 in the west line.

A circuit may then be traced from battery through the windings of relays 718 and 719 in series, the bottom innermost front contact and armature of relay 701, sleeve of jack 715, sleeves of plugs 324 and 325 in series, sleeve of jack 717, and the bottom and middle windings of relay 721 to ground, operating relays 719 and 721. The bottom winding of relay 721 in the leg multiple circuit normally forming part of a full duplex concentration group is a high resistance winding. The object of this is to reduce the current in the sleeve circuit last traced so that relay 718 cannot operate for the full duplex condition. This prevents the operation of relay 113 in the line repeater and maintains the line repeater in the full duplex condition. Relay 707 follows the operation of relay 721. Relay 707 disconnects the old west line from the concentration group. Relay 719 disconnects the idle indicator control circuit to prevent lamps such as 716 from lighting during the interval while the east line is serving in a concentration group. Relay 719, at its top break contact, disconnects the ground which sends a permanent spacing signal over the sending leg of a released line. At the top make contact, relay 719 connects ground to the top winding of relay 712 to maintain relay 712 operated. This prevents the release of relay 712 by the removal of the short-circuiting plug from its control jack at the position where its normal concentration group is administered, which would otherwise reconnect the east line into its normal concentration group.

The ring and tip circuits of jack 715, plug 324, plug 325 and jack 717 in series extend the sending and receiving legs of the east line through test resistances 706 and 708 into hubs 704 and 705, respectively. It is pointed out that the sending leg of the new east line joins the hub to which the sending leg of the old west line was formerly connected. The receiving leg of the new east joins the hub to which the receiving leg of the old west line was formerly connected.

Replacing a line forming part of a full duplex concentration group with a spare line

As in the case of a half duplex concentration group, it is possible to substitute a spare line for a line normally forming part of a full duplex concentration group.

Attention is again called to the fact that a spare line is a line which is not normally connected through a line concentration jack circuit to a hub or hubs. It is equipped with a leg multiple circuit, but the leg multiple circuit is wired in such manner that it corresponds electrically to a circuit in which a relay such as 701 or 707 is permanently operated.

It will be assumed that the east line is arranged as a spare and it will be used to replace the west line which is normally connected into a concentration group with the two-loop station circuit as described above.

When lamp 716 is lighted, key 343 is operated, plug 324 is inserted in jack 715 and plug 325 is inserted in jack 717. Relays 721 and 707 in the old leg multiple circuit operate to cut the old line off from the concentration group. Relay 719 in the spare line operates to disconnect the idle indicator lamp circuit and to disconnect the ground which is transmitting a permanent spacing signal to the distant east terminal. The operation of relay 719 also connects ground to the lower terminal of the top winding of relay 712, to hold the relay operated. In the case of a spare line, however, this serves no purpose. The reason for this is that in a spare line it is not necessary to guard against the removal of a releasing plug. A spare line is not provided with a concentration jack circuit and is not normally a part of a concentration group. In the case of a spare line, therefore, it is not necessary to hold relay 712 operated over a separate path to guard against the removal of a releasing plug which is the function performed by ground connected to the top front contact of relay 719 for a line normally forming part of a concentration group.

The tip and ring circuits of the spare line join the two hubs of the concentration group in the same manner as for a released line.

Relay 718 does not operate due to the high resistance of the bottom winding of relay 721 for a line normally connected into a full duplex concentration group. Attention is called especially to the fact that the bottom winding of relays in the leg multiple circuits, such as 712 and 721 in Fig. 7 or 315 and 315W in Fig. 3, is of high resistance. The bottom winding of these relays is used when the leg multiple circuit is normally connected into a full duplex concentration group. The middle winding of these relays is of low resistance. Hence, when line circuits are associated with a half duplex concentration group, connection from the associated release control jack is made to the middle winding. When the line circuits are associated with a full duplex concentration group, connection is made from the associated release control jack to the high resistance winding. It is by means of relay windings having resistances of different magnitudes connected to the sleeves of the release control jacks, such as 717 and 313, that it is possible to control an idle released line or an idle spare line which is being added to a concentration group so that it is conditioned properly to function either full or half duplex, depending upon whether the concentration group to which it is joined is full or half duplex.

Adding a released line to a full duplex concentration group

In order to add a released line to a full duplex concentration group, the multiple jack such as 715 of a released line, which is found to be available, is patched by means of plug 324 and plug 325 to a jack such as 722. Key 343 is first operated to close the ring circuit. In this case there is no old line to be released, so the sleeve circuit of the added line, instead of being extended to ground through a high resistance relay winding, is connected to ground through high resistance 723. The relays in the added line function as described above for the relays in a released line which is substituted in a full duplex concentration group.

Access to the two hubs of full duplex concentration groups for the purpose of adding lines may be had by means of two jacks in any line already joined in the concentration group, such as 722 or 724. The connection of the tip and ring circuits

of these jacks to the two legs is reversed, to permit the sending and receiving legs of an added line to be connected to either hub as required.

Adding a spare line to a full duplex concentration group

The operation of adding a spare line to a full duplex concentration group is the same as described in the last section above for a released line. To reiterate, a spare line when available for connection to a concentration group is electrically the equivalent of a released line.

Adding a station circuit to a full duplex concentration group

A station loop which is spare or which has been released from a concentration group with which it is normally associated, by a ring sleeve short-circuiting plug inserted in a jack such as **601** or **602**, may be patched into a full duplex concentration group by inserting plug **324** into jack **603** and plug **325** into jack **724**. Similarly a second plug such as **324** may be inserted into jack **604** and the corresponding plug **325** may be inserted into jack **722**.

For a full duplex station circuit it is necessary, as has been explained, to provide two loops equipped with individual inverse neutral repeaters to connect the local station into the two hubs. It is necessary to connect each of the two legs of the station loops to the proper hub. This may be done by connecting the proper loop to the particular jack of jacks **722** and **724** which connects into the desired hub to provide the desired traffic arrangement. When patching station loops key **333** is positioned so as to leave the ring circuit opened.

Observing hits and testing in full duplex concentration groups

Observing hits and testing in full duplex concentration groups is performed in the same manner as for half duplex concentration groups. In the case of observing for hits, a trouble indicator cord circuit or "hit" indicator as it is otherwise known is connected to jacks such as **605, 606, 726, 727, 728** or **729**. The condition on the sleeve of the connecting trouble indicator cord circuit is such that the associated test relays **607, 608, 709, 703, 733** and **730** are prevented from operating while observing for hits is in progress. Observing for hits on a full duplex concentration group is possible in the case of lines only on a receiving leg, that is, a leg by means of which a distant terminal transmits toward the hub, and while there is no transmission of communication signals over this branch of the circuit. That this is the case should be apparent by observing that even though the line, by means of which signals are transmitted to a distant terminal, is momentarily grounded by a hit, the associated inverse neutral repeater cannot be operated. Consequently there can be no drop in potential across the associated test resistance to be recorded by the hit indicator.

Supervision in full duplex patching operations

A line which is available for connection into a concentration group and which is arranged so that a permanent spacing signal is being transmitted from the distant terminal toward the telegraph service board while it is idle, may be observed, to insure that the spacing condition has been removed from the line before it is connected into a full duplex concentration group.

When a lighted idle indicator lamp designates a line which is to be connected into a full duplex concentration group, a patch is made by connecting plug **324** into the leg multiple jack and plug **325** into jack **504** of Fig. 5. Ground through high resistance **505** conditions the leg multiple circuit and hence the line repeater to function full duplex. Key **343** is closed. The tip and ring circuits of the jacks and plugs in series extend the legs of the inverse neutral repeater in the full duplex line to the tips of jacks **502** and **506**, respectively. By connecting two plugs, such as **501** of two Figs. 5A to jacks **502** and **506**, observations may be made to insure that the line to be added to the full duplex concentration group is in proper condition before the line is added to the concentration group. This latter operation is performed by withdrawing plug **325** from jack **504** and connecting it to a line jack such as **717** or **722**, depending upon whether the new line is to replace a line already forming part of a concentration group or is simply to be added.

What is claimed is:

1. In a telegraph system, the method of operating a multiposition telegraph concentration board, which comprises (1) connecting each telegraph channel, which may be connected into a network, permanently to an individual hub type repeater, (2) providing direct access to the hub legs of said channels at a plurality of operator's positions and direct access to each leg of each hub type repeater of each channel which may be assembled into the same network at the same attendant's position in the concentration board, (3) joining the leg of each hub type repeater of each channel which is to be assembled into a common network through switching facilities at the attendant's position where direct access to each of said legs is provided, to permit the administration of telegraph repeater concentrations at an operator's position in a multiposition switchboard by effecting the addition, subtraction or substitution of telegraph channels in networks while precluding the necessity for adjusting telegraph repeaters in the network to accommodate the changes.

2. In a telegraph system, the method of establishing an operable network of telegraph channels through telegraph repeaters which comprises (1) equipping each channel which may be formed into a network with an individual hub type repeater, (2) extending the leg of each hub type repeater in each line, which is connected to a distant central terminal and which may be connected into a network, through an individual multiple outlet in the various positions of a multiposition telegraph switchboard, (3) joining the legs of the hub type repeaters of all telegraph lines which connect to distant terminals and of all station loops which lines and loops normally form part of a particular concentration group through switching facilities at a particular position in said multiposition board, to permit the administration of telegraph repeater concentrations at a switchboard position by effecting the addition, subtraction or substitution of telegraph channels in networks while precluding the necessity for adjusting telegraph repeaters in the network to accommodate the changes.

3. In the process of establishing telegraph networks, comprising telegraph channels connecting telegraph central terminals, said networks including telegraph repeaters at the junction of said channels, as new steps in the process, to expedite the formation and changing of networks

and to eliminate the procedure of adjusting the repeaters when said networks are being established or changed, (1) equipping each channel with an individual hub type repeater, (2) connecting the hub type repeater leg, which extends to the hub of hub type repeater concentration group, through a plurality of multiple appearances in a multiposition telegraph switchboard, so that hub type repeater networks comprising any of the lines connected to the board may be built up by an attendant at any of a plurality of positions in the switchboard without the necessity for making adjustments in the various repeaters to accomplish the changes.

4. In a telegraph system, a telegraph office, a plurality of telegraph channels extending into said office, an inverse neutral repeater permanently connected in each of said channels, means at said office for interconnecting certain of said channels into an inverse neutral repeater concentration group, and relay switching means at said office for controlling the addition of another of said channels to said concentration group.

5. In a telegraph system, a telegraph office, a plurality of telegraph channels extending into said office, an inverse neutral repeater permanently connected in each of said channels, means at said office for interconnecting certain of said channels into an inverse neutral repeater concentration group, and relay switching means at said office for controlling the substitution of another of said channels for a channel connected into said concentration group.

6. In a telegraph system, an inverse neutral concentration group comprising a plurality of telegraph channels each permanently equipped with an inverse neutral repeater, all connected into a hub, an individual telegraph channel separate from said concentration group equipped also with an inverse neutral repeater, and a relay switching circuit in said concentration group, for controlling the connection of said individual channel into said concentration group.

7. In a telegraph system, an inverse neutral repeater concentration group comprising a plurality of telegraph channels each equipped with an inverse neutral repeater, all connected into a common hub, and relay switching means for controlling the release of one of said channels from said concentration group.

8. In a telegraph system, an inverse neutral concentration group comprising a plurality of telegraph channels each equipped with an inverse neutral repeater, all connected into a common hub, another channel equipped with another inverse neutral repeater, means in said concentration group and in said other channel for connecting said other channel to said hub, and means responsive to the connection of said other channel to said hub for disconnecting a channel which formed part of said concentration group from said hub.

9. In a telegraph system, a telegraph switchboard comprising a plurality of attendant's positions, individual inverse neutral repeater concentration groups comprising groups of telegraph channels associated into individual hubs at individual positions in said switchboard, a group of independent telegraph channels separate from said concentration groups, each of said independent channels equipped with an individual inverse neutral repeater, means of access to said independent channels at each of said attendant's positions, and means at each of said positions for connecting any of said independent channels to any of said concentration groups.

10. In a telegraph system, a telegraph office, a telegraph switchboard therein, a plurality of attendant's positions at said switchboard, a group of telegraph channels, an individual repeater in each of said channels, means at a particular position in said switchboard for interconnecting said channels into an operable telegraph network, a separate telegraph channel, an individual repeater in said separate channel, means of access to said separate channel at each of said positions, means at said particular positions for connecting said separate channel to said network, and means in said network and in said separate channel precluding the necessity for adjustment in said network or in said separate channel to compensate for said connection of said separate channel to said network.

11. A system in accordance with claim 10, and means in said system responsive to the connection of said separate channel to said network for disconnecting a particular channel from said network.

12. In a telegraph system, a group of telegraph channels each permanently equipped individually with a telegraph repeater, a switchboard, an attendant's position at said switchboard, means at said attendant's position for interconnecting a plurality of said channels into an operable telegraph network, relay means at said position for controlling the addition of a channel to said network, controlling the subtraction of a channel from said network or controlling the substitution of a channel for a channel in said network, and means in said channels and in said network precluding the necessity for making adjustments in said repeaters to accommodate said changes.

13. In a telegraph system, a telegraph line circuit for connecting a first and a second telegraph central terminal, an inverse neutral repeater therein, a circuit including the hub point of an inverse neutral concentration group, a relay circuit for controlling the connection of said line to said hub, means in said line circuit for conditioning said line to function either full duplex or half duplex, and control means in said relay circuit for said conditioning means.

14. In a telegraph system, the method of operation of hub type repeaters to provide full duplex operation between a group of stations which comprises the formation of two separate hub concentrations, interconnecting each of the stations of said group individually to each of said concentrations, transmitting from each of said stations in one direction through one hub and receiving in each of said stations in the opposite direction through the second hub.

15. In a hub type repeater telegraph system, a first telegraph terminal, a second telegraph terminal, a plurality of hub type telegraph repeaters interconnected to form two separate individual hub concentrations connecting said terminals and means in said concentration for providing simultaneously two-way telegraph operation between said terminals.

16. A system in accordance with claim 15, a local telegraph station, and separate telegraph channels connecting said station and each of said concentration to provide simultaneous two-way telegraph service over said system for said local station.

17. In a telegraph system, a first, second and third telegraph station, a first and a second telegraph channel connecting said first and said sec-

ond station, a third and a fourth telegraph channel connecting said second and said third station, inverse neutral repeaters in said channels at said second station, means at said second station for interconnecting said first and said third channels through an inverse neutral hub, means also at said second station for interconnecting said second and said fourth channels through a second hub.

18. In a telegraph system, a telegraph channel including an inverse neutral repeater, a leg extending from said repeater, a first means connected to said leg for extending said leg to the hub of a first concentration group, a second means connected to said leg for extending said leg, when released from said first concentration group, to a second concentration group and means individual to said first concentration group for releasing said channel from said first concentration group.

19. A system in accordance with claim 18 in which said means for extending said leg to said second concentration is a multiple jack circuit comprising a pack at each of a plurality of positions in a switchboard.

20. A system in accordance with claim 18 in which said means for releasing said channel comprises a relay having a pair of contacts connected in series in said leg and a winding connected to a single concentration jack at a particular position in said board so that said channel may be released at one point only in said board.

21. In a telegraph service board, a first plurality of inverse neutral repeaters interconnected into a first concentration group, a second plurality of inverse neutral repeaters interconnected into a second concentration group, relay means associated with said first group for releasing any of said first plurality from said first group, means in said board for interconnecting said released repeater to said second group, and means associated with said released repeater, operable upon the connection of said repeater to said second group for preventing the reconnection of said released repeater to said first group.

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