Sept. 29, 1936. E. M. STAPLES 2,055,638

COMMUNICATION SYSTEM

Filed July 7, 1934 4 Sheets-Sheet 1

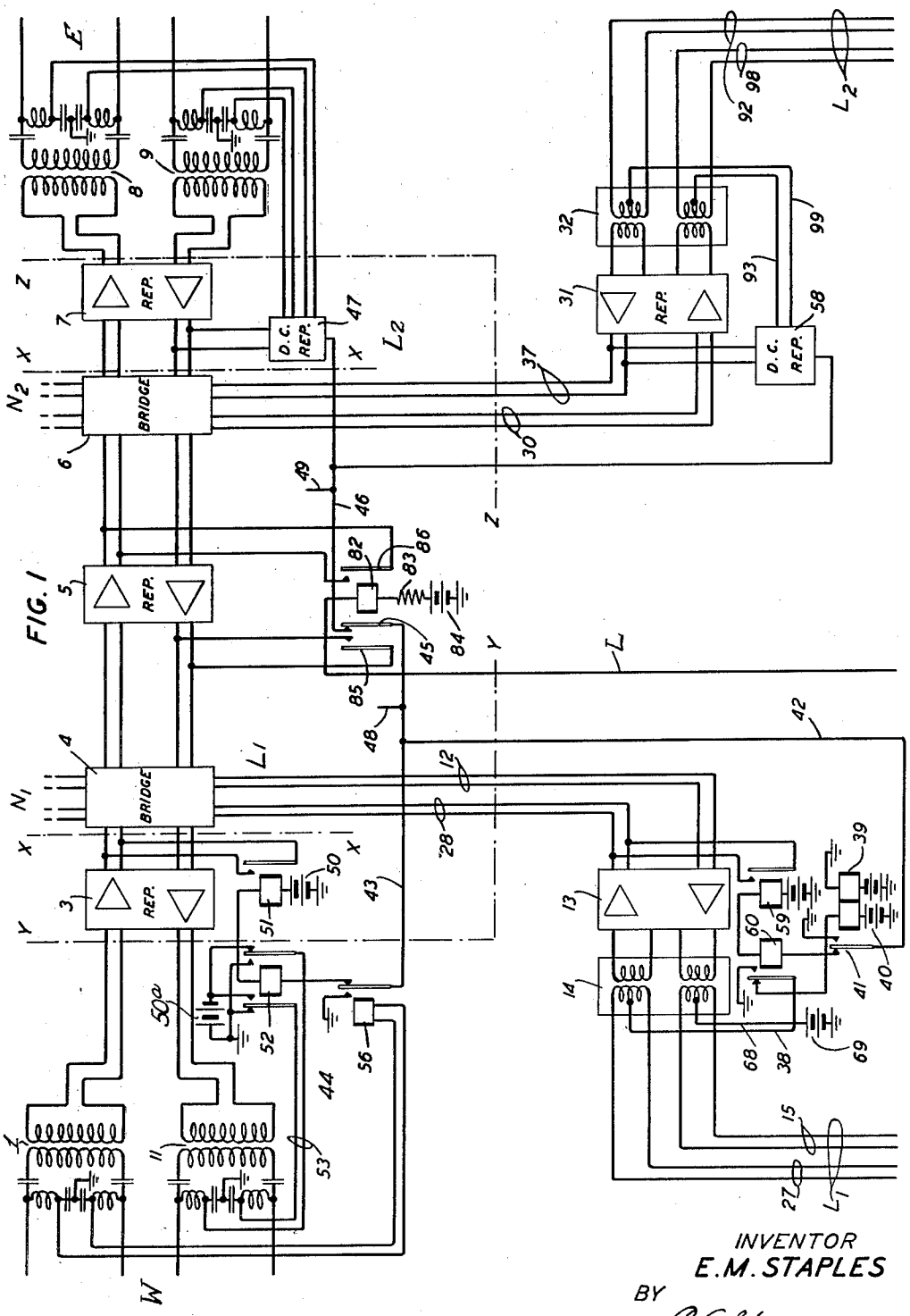


FIG. 1

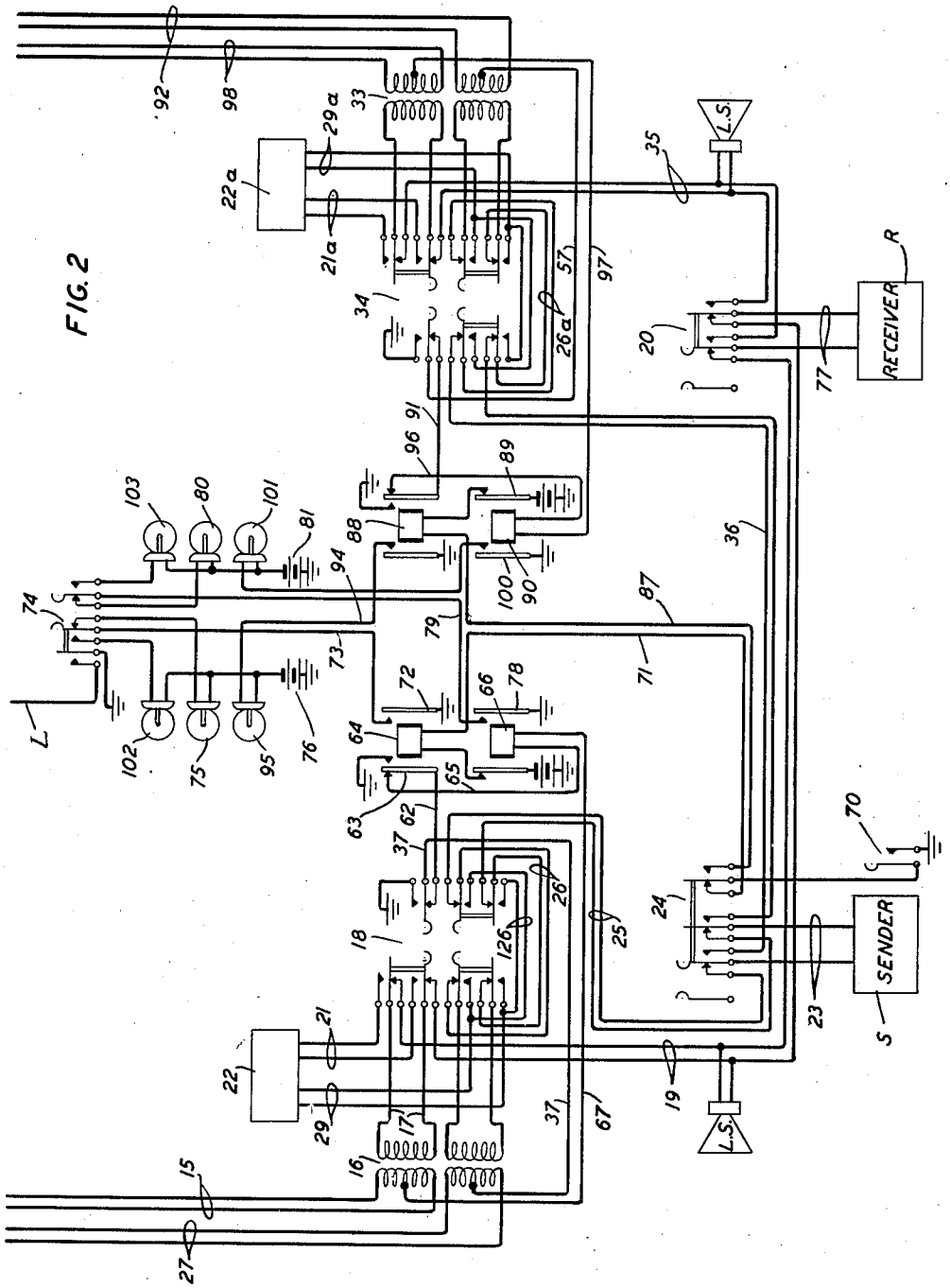
INVENTOR
E.M. STAPLES
BY
C. L. Sprague
ATTORNEY

Sept. 29, 1936. E. M. STAPLES 2,055,638

COMMUNICATION SYSTEM

Filed July 7, 1934 4 Sheets-Sheet 2

FIG. 2



INVENTOR
E. M. STAPLES

BY
C. A. Sprague

ATTORNEY

Sept. 29, 1936. E. M. STAPLES 2,055,638

COMMUNICATION SYSTEM

Filed July 7, 1934 4 Sheets-Sheet 3

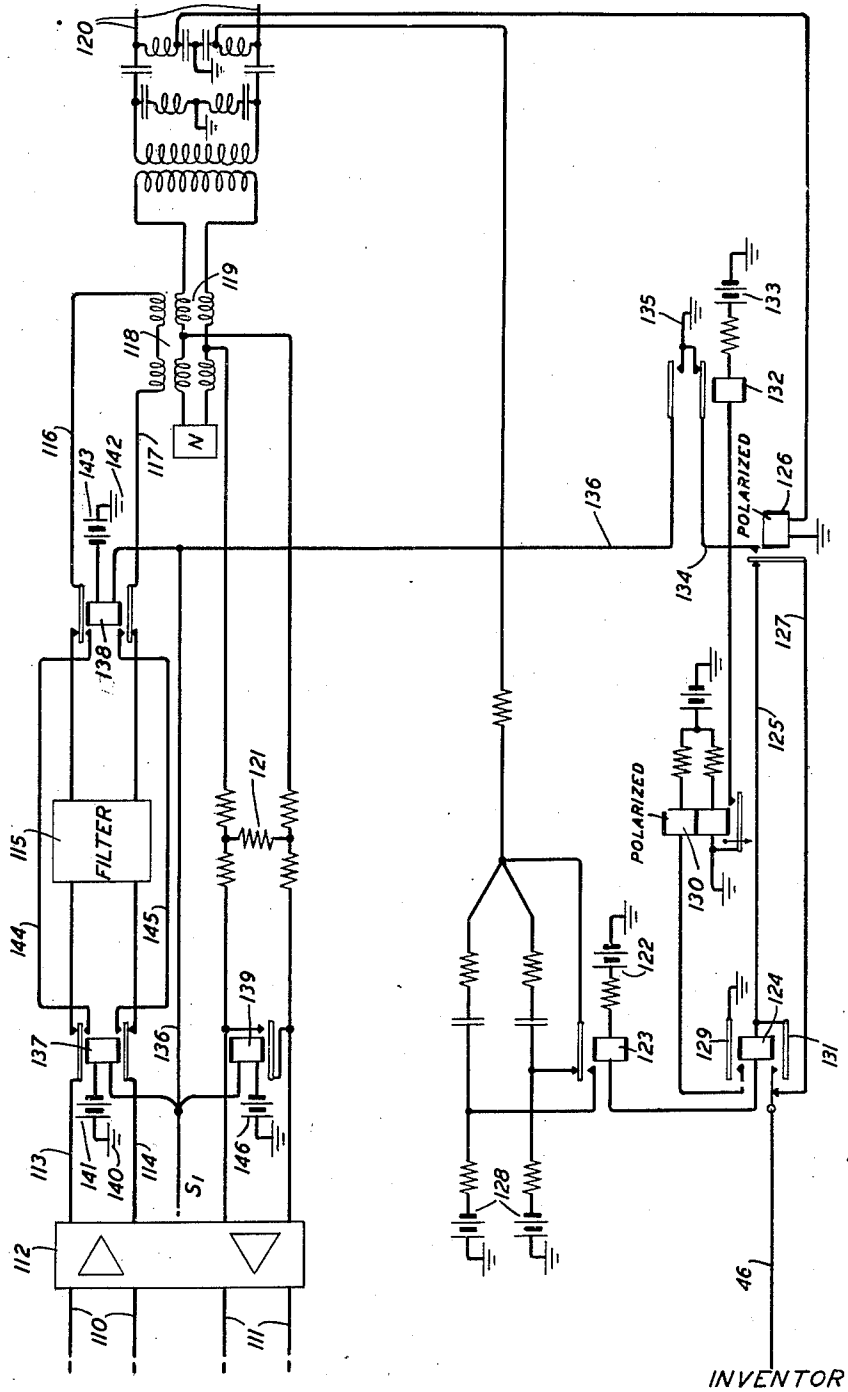


FIG. 3

INVENTOR
E. M. STAPLES
BY
C. A. Sprague
ATTORNEY

Sept. 29, 1936. E. M. STAPLES 2,055,638

COMMUNICATION SYSTEM

Filed July 7, 1934 4 Sheets-Sheet 4

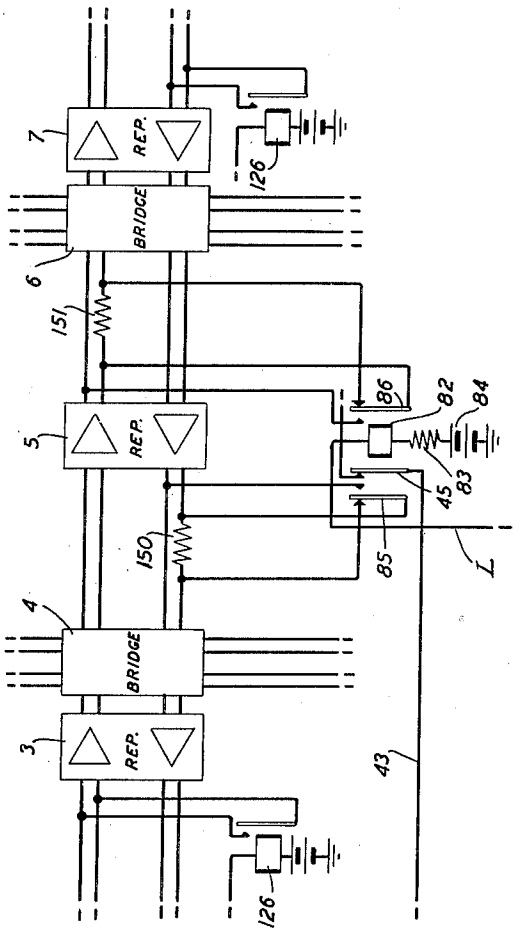


FIG. 4

INVENTOR
E.M. STAPLES
BY
A. Sprague
ATTORNEY

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UNITED STATES PATENT OFFICE

2,055,638

COMMUNICATION SYSTEM

Elliot M. Staples, Hohokus, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application July 7, 1934, Serial No. 734,180

22 Claims. (Cl. 179—43)

This invention relates to communication systems and more particularly to a line network over which different types of signals may be transmitted.

The invention has special reference to leased lines, that is, to the case where a network is provided and then turned over to a customer to be operated and controlled by him.

An object of the invention is to provide a network which includes means for interconnecting a series of lines at a number of points in such manner that various types of signals as well as control currents may be transmitted from any one of the lines to any number or all of the other lines, with means for "splitting" it at selected points to thereby divide the network into a plurality of sections each of which may be operated independently of the others.

As an example of a practical embodiment, the invention will be described as applied to a network for use in a telephotograph or picture transmission system and to a station at which six lines are interconnected. Control currents may be transmitted to condition the network for broadcasting picture or speech currents, or the network may be used for two-way telephone conversations from a station associated with any one of the lines to stations associated therewith and with the other lines; the interconnecting station being provided with a splitting arrangement, whereby the network may be divided into two sections having three lines associated with each section. It is to be understood that any number of lines may be interconnected at a splitting station, that splitting may be so effected that different numbers of lines may be associated with the respective portions of the sections local to the splitting station, and that the splitting arrangement may be used with a network including either four-wire or two-wire lines.

According to the embodiment to be described in detail, a central office of the company supplying the service, which includes an arrangement for interconnecting six lines of a network, also includes apparatus for splitting the network. This office is connected to a customer's local station by means of two pairs of terminal loops over which telephotographic and broadcast speech currents, as well as network conditioning control currents, may be transmitted and received, and two-way telephone currents may be transmitted, to or from all lines when the network is not split and to or from each section independently when the network is split, and a loop circuit including means for controlling the splitting apparatus.

A detail description of the invention follows and is illustrated in the attached drawings in which:

Fig. 1 is a schematic showing a central office at an interconnecting point;

Fig. 2 is a schematic illustrating a customer's station local to the central office;

Fig. 3 shows a two-wire line connection to the splitting station which may be substituted for that to the right or left of section line XX of Fig. 1; and

Fig. 4 illustrates a different arrangement for use at a central office.

By placing Fig. 1 above Fig. 2 there is provided a diagram of a complete station at an interconnecting point which embodies the invention.

The following description is based on the assumption that the telephotographic sending apparatus at the respective stations of the system operates to produce and supply to the line the lower side-band of a picture modulated carrier current, which may extend over a frequency range from about 1000 cycles to 2600 cycles, and that direct current control currents may be transmitted from any station of the system, including that local to the splitting office, by simplex or composite connections over the circuits respectively employed for similarly directed picture modulated or speech currents.

Referring to Fig. 1, W is a west line, E is an east line, N_1 is a first north line, N_2 is a second north line, L_1 is a first pair of terminal loops connecting the central office to the customer's station, L_2 is a second pair of terminal loops connecting the central office to the customer's station and L is a loop over which the splitting relay is controlled.

At the central office, the west and east lines are connected through a composite set and repeating coil 1, the upper path of the two-way repeater 3, a bridge circuit arrangement 4, the upper path of a two-way repeater 5, a bridge circuit arrangement 6, the upper path of a two-way repeater 7, a repeating coil and composite set 8, for one-way transmission through the central office, and, for the oppositely directed transmission, by a composite set and repeating coil 9, the lower path of the two-way repeater 7, bridge circuit arrangement 6, the lower path of the two-way repeater 5, bridge circuit arrangement 4, the lower path of the two-way repeater 3, and the repeating coil and composite set 11. The respective transmission paths described above are connected to the north line N_1 and N_2 and the local station terminal loops L_1 and L_2 through the bridge circuit

arrangements 4 and 6. The composite set 1, and other similar sets, comprise the usual choke coils and condensers associated with the line as shown. These sets terminate in conductive paths over which direct current signals may be transmitted.

Bridge circuits 4 and 6 are of the type disclosed in U. S. Patent 2,019,603 of C. W. Green issued November 5, 1935. Briefly, these bridges are designed to provide conductive paths for interconnecting several four-wire or two-wire lines, with the two-wire lines all connected to the bridge on a four-wire basis, so that each transmitting line may transmit into all the other receiving lines except its own receiving line and, as to that, it is substantially conjugate. For a complete disclosure of the design and operation of these bridges, reference may be made to the above mentioned Green patent.

The path for receiving signals at the local station from the central office extends over the two right hand conductors 12 of the loop circuit, the lower transmitting path of repeater 13, the lower repeating coil 14, conductors 15, the upper repeating coil 16, conductors 17, to the upper left hand lever and normal contacts of key 18. With this key in the normal position as shown, the receiving path is extended through conductors 19, the normal and lever contacts of key 20 to the picture receiving machine R.

Signals may be transmitted from the sending machine S, with key 18 in normal position as shown, via conductors 23, the two adjacent left hand levers and normal contacts of key 24, conductors 25, the two right hand lower normal and lever contacts of key 18, conductors 26, the two lower left hand normal and lever contacts of key 18, lower repeating coil 16, conductors 27 of the loop circuit L_1, the upper repeating coil 14, the upper transmitting path of repeater 13 and conductors 28 to the bridge arrangement 4.

For two-way telephone conversations, the key 18 is thrown to the right and thereby moves its left hand lever contacts out of engagement with the normal contacts associated with the respective levers and into engagement with the alternate contacts respectively associated with them. Conductors 26 and 19 are thereby open-circuited and hence the picture receiving and transmitting machines are disconnected from the respective circuits of the terminal loops L_1, and the receiver and transmitter of the telephone set 22 are connected to these loop circuits, respectively. The telephone receiver is connected via conductors 21, the two upper left hand alternate and lever contacts of key 18 and conductors 17 to the upper repeating coil 16 and the telephone transmitter is connected via the conductors 29 and the two lower left hand alternate and lever contacts of key 18 to the lower repeating coil 16.

The sending and receiving machines S and R, respectively, or the transmitter and receiver of a second telephone set 22A may be connected through the terminal loops L_2 to the bridge arrangement 6 over circuits similar to those described above for loops L_1.

For picture reception at the local station over loop L_2, key 20 is actuated to disconnect the receiving machine from conductors 19 and to connect it to conductors 35. Incoming picture currents are transmitted from the cable bridge 6 via conductors 38, lower path of repeater 31, lower repeating coil 32, conductors 92, upper repeating coil 33, the two upper right hand lever and normal contacts of key 34, conductors 35 and the alternate and lever contacts of key 20 to the receiving machine.

For picture transmission from the local station over loops L_2, key 24 is actuated to disconnect the sending machine S from conductors 25 and to connect it via conductors 23, the two left hand lever and alternate contacts of key 24, conductors 36, the two lower left hand normal and lever contacts of key 34, conductors 26a, the two lower right hand normal and lever contacts of key 34, the lower repeating coil 33, conductors 92, upper repeating coil 32, upper transmitting path of repeater 31 and conductors 37 to the bridge arrangement 6.

For two-way telephone conversations, the key 34 is thrown to the left and thereby disengages its right hand lever contacts from the associated normal contacts and engages these lever contacts with the alternate contacts respectively associated with them. Conductors 26a and 35 are thereby open-circuited, the picture sending and receiving machines are disconnected from the sending and receiving loop circuits L_2, and the telephone transmitter and receiver of set 22A are respectively connected to these loop circuits. The telephone transmitter is connected via conductors 29A, the two lower right hand alternate and lever contacts of key 34, lower repeating coil 33, conductors 92, the upper repeating coil 32, upper transmission path of repeater 31 and conductors 37 to the bridge arrangement 6. The telephone receiver is connected via conductors 21A, the upper right hand alternate and lever contacts of key 34, upper repeating coil 33, conductors 92, lower repeating coil 32, lower transmission path of repeater 31 and conductors 30 to the bridge 6. Obviously incoming telephone currents are transmitted from the bridge 6 via conductors 30, etc., as traced in the preceding sentence, to the receiver of the telephone set 22a.

Keys 18, 34 and 24 are provided with additional contacts which control the supply of current impulses to a circuit including means actuated by these impulses to condition apparatus units associated with the different lines, as will be hereinafter set forth, and also to control the supply of current to local circuits which include means for indicating traffic conditions in the network at all times during the operation of the system.

If the attendant at the customer's station desires to talk one way to all stations connected to the network, he first throws key 18 to the left to break the connection through the right hand normal and lever contacts and complete circuits through the associated alternate contacts. This serves to cause the right hand lever contacts of key 18 to disengage their normal contacts to thereby open the circuit through conductors 25 and hence disconnect the sending machine S from the outgoing loop L_1, and to force these lever contacts into engagement with their alternate contacts, whereby the transmitter of the telephone set 22 is connected via conductors 29 and 126, the two lower right hand alternate and lever contacts of key 18, conductors 26, the two lower left-hand normal and lever contacts of key 18, the lower repeating coil 16, and through the outgoing circuit of loop L_1, as traced above for the sending machine S, to the bridge arrangement 4. At the same time the upper right hand key lever is separated from its normal contact and engages its alternate contact to apply ground to conductor 37, which connects through the secondary winding of the lower repeating coil 16, loop conductors 27, the lefthand winding of upper repeating coil

14, conductor 38 and the lefthand winding of relay 39, to one terminal of battery 40, the other terminal being grounded. Current flow from battery 40 over the above described simplex circuit operates the relay 39, the armature 41 of which is pulled up to apply ground to the conductor 42. This conductor is connected via conductor 43 to a direct current repeater 44 associated with the west line at the central office, and over the armature 45 and conductor 46 to a direct current repeater 47 associated with the east line at the central office and also to similar direct current repeaters (not shown) associated with the north lines N_1 and N_2 via conductors 48 and 49. Since these direct current repeaters are all of the same design and operate in the same manner, the following description of that shown at 44 will apply to the others.

Current flows from the battery 50 of repeater 44 through the windings of relays 51 and 52 connected in series, conductors 43 and 42, armature 41 to ground at the direct current repeater associated with loops L_1 and thence to the other terminal of battery 50. Relay 51 operates to short circuit the upper output circuit of alternating current repeater 3, while relay 52 operates to reverse the connection of battery 50*a* and thereby reverse the direct current supplied through conductors 53 and composite set of equipment 11, included in the lower pair of line wires of the west line and thence over these conductors to polarized relays, associated with alternating current repeaters included in the section of the line connecting this station repeater to the next station repeater to effect certain control functions at the line repeaters, and through polarized relay 56 of the direct current repeater associated with the next western station. Since the line repeaters and their mode of operation are not a feature of this invention, they are not further described. Relay 56 is operated to apply ground to a conductor, similar to conductor 43, whereby its relay 51 is operated to short circuit the upper output leads of the alternating current repeater at this station, and its relay 52 is operated to apply control current of desired sign to the lower conductors of the next section of the west line, whereby the alternating current line repeaters and the next western station repeater are controlled as described above. This cycle of operation will be repeated at each of the succeeding alternating current line and station repeating points of the west line.

In a similar manner, direct current repeater 47 will operate to short-circuit the lower, or input, path of line repeater 7 and to reverse the current supplied over the upper pair of wires of the adjacent section of the east line to control the line repeaters and the direct current repeater at the next eastern station, in the manner described above for the west line, and so on for the line and direct current repeaters at the successive alternating current station repeating points in the east line. The line and direct current repeaters associated with other lines radiating from the splitting station, for example, lines N_1 and N_2 will be controlled in an identical manner, as will be the line and direct current repeaters associated with all lines included in the network.

Instead of using key 18, the attendant could have used key 34, in which case the microphone of telephone set 22–A would have been connected through the outgoing repeating coil windings of 33 and 32 and associated path of alternating current repeater 31 to the bridge arrangement 6, and ground would be applied to conductor 57 to control the operation of the direct current repeater 58, identical with the direct current repeater associated with terminal loop L_1, which in turn operates through the direct current repeaters 47 and 44 and like repeaters associated with the north lines N_1 and N_2 to control all of the direct current repeaters associated with all lines included in the network and, by virtue of the operation of these repeaters, to control the alternating current repeaters associated with all lines, in the manner described above for the west line.

All stations are connected to the network either directly, or through bridges, by means of connections similar to loops L_1 or L_2. As a result of the operation of the direct current repeater preceding each of these stations, the conductor corresponding to 43—42, will be grounded and relays 59 and 60 of the terminal loop repeater will be operated. Relay 59 will short circuit the output circuit of the alternating current repeater 13, and relay 60 will apply ground to the circuit including conductor 38, upper winding of repeating coil 14, conductors 27, secondary winding of the lower repeating coil 16, conductor 37, upper right hand lever of key 18, which will be in normal or non-operated position at each of the terminal stations, and hence this lever will engage its upper normal contact to complete a circuit through conductor 62, armature 63, conductor 65, relay 66, conductor 67, left-hand winding of upper repeating coil 16, conductors 15, left-hand winding of lower repeating coil 14, conductor 68 to battery 69, the other terminal of which is connected to ground. Current flow over this circuit will cause relay 66 to operate and thereby complete a circuit from ground, the right hand armature 78 of relay 66, conductor 79, right hand lever and normal contact of key 74, lamp 80, battery 81 and through ground to armature 78, whereby lamp 80 is lighted to indicate that a signal current is being received. At a station in which a line of the network terminates, only two relays, corresponding to relays 64 and 66, and two signal lamps, corresponding to lamps 75 and 80, will be used.

As a result of the propagation of the control currents over the lines of the network, all alternating current repeaters will be controlled to repeat signal currents in but one direction, i. e., over the lower pair of conductors of the west line, upper pair of conductors of the east line and over a corresponding pair of conductors of each north line, and the unused conductors, i. e., those provided for east transmission in the west line, for west transmission in the east line and for south transmission in the north lines, will be short circuited. Short circuiting of the unused conductors serves to prevent undesired currents, produced in them by extraneous sources, and commonly referred to as "noise currents", from affecting the useful currents transmitted through the pair of conductors being used for signal transmission.

The attendant at the station local to the splitting station, having his microphone connected to the outgoing conductors 27 of his loop circuit by virtue of the operation of his key 18 or 34, as described above, may broadcast over the network that he is about to transmit a picture. This broadcast is received by means of loud-speakers LS, which are permanently connected to the receiving conductors 19 at the respective stations. At the splitting station, a loud-speaker is connected to each receiving loop circuit, i. e. to conductors 19 and 35. While detail instructions re-

garding the picture transmission to be effected may be broadcast, the system is designed to permit use of the network as a two-way circuit over which telephone conversations may be carried on for the transmission of traffic information.

If the network is to be used for two-way telephony, the attendant at the local station, as well as those at the stations which are to receive the picture, throw keys 18 to the right or talking positions. Operation of key 18 at the local station from its left hand, or speech broadcasting position, to its right hand, or talking position, causes the right hand lever contacts of this key to be disengaged from the associated alternate contacts, whereby the telephone transmitter is disconnected from the outgoing circuit of the loop L_1 and ground is removed from conductor 37, with the result that the control circuit is broken, whereby the direct current and associated alternating current repeaters of the terminal loops and the network are all restored to normal, and the network is in a condition to be used for two-way telephone transmission.

With key 18 in the right hand, or talking position, the left-hand lever contacts are respectively caused to disengage the associated normal contacts and to engage their alternate contacts. The two lower left hand lever contacts of this key thereby connect the telephone transmitter, via conductors 29, to the primary winding of the lower repeating coil 16, and the receiver is connected through conductors 21 and the upper alternate and lever contacts and conductors 17, to the primary winding of the upper repeating coil 16. Coils 16 are respectively connected by conductors 27 and 15, the upper and lower repeating coils 14 and the upper and lower transmission paths of the alternating current repeater 13 to the cable bridge 4 and via circuit connections provided therein through the respective outgoing and incoming paths over the lines of the network to the desired connected stations. The attendants at the stations having completed the telephone conversation, restore keys 18 to normal; thereby disconnecting their telephone sets from the incoming and outgoing paths of their respective loop terminal circuits and connecting conductors 19 and 25 thereto, and hence, associating the picture receiving and sending machines, with the respective paths.

Let it be assumed that a picture is to be transmitted to all stations or to certain stations associated with all of the lines. As herein shown, the connections between the local station and central office are such that terminal loop L_1 is used for transmission over all lines. However, terminal loop L_2 could be used for this purpose if desired. The local sending apparatus and the receiving apparatus at the respective receiving station having been made ready, the attendant at the local sending station operates his starting key 70 to apply ground to conductor 37 over the following circuit: from ground through key 70, left hand lever and normal contact of key 24, conductor 71, relay 64, left hand armature of relay 66, battery and through ground to the point of beginning. Current flowing through this circuit causes relay 64 to operate to apply ground, via conductor 62, upper normal and lever contacts at the left of key 18, to the conductor 37. Grounding this conductor causes the direct current repeaters, along the lines comprising the network, to operate as described above in connection with the conditioning of the network for broadcasting speech. That is, all alternating current repeaters are conditioned for one-way transmission, and their output leads for the oppositely directed transmissions are short circuited. The system is therefore conditioned to permit a picture to be broadcast over the network.

Operation of relay 64 completes a second circuit from ground through its armature 72, conductor 73, inner left hand contact lever of key 74 and its associated normal contact, lamp 75, battery 76 and through ground to the point of beginning. Lamp 75 lights to indicate that a picture is being transmitted from the local station in all directions through the central office.

Picture current, which preferably is a picture modulated carrier current produced by scanning a picture to be transmitted with a beam of light modulated at a carrier frequency rate, which is definitely related to the rate at which the picture is scanned and utilizing the resultant doubly modulated light to activate a light sensitive electric device, is transmitted over conductors 23, lever contacts and associated normal left hand and middle contacts of key 24, conductors 25, the two lower normal and lever contacts at the right of key 18, conductors 26 and the two lower normal and lever contacts at the left of key 18, windings of the lower repeating coil 16, conductors 27, the upper windings of repeating coil 14, upper transmitting path of the alternating current repeater 13, conductors 28, connecting circuit of bridge 4, lower transmission path of alternating current repeater 3, repeating coil of the coupling unit 11 and line to western stations, and through a connecting circuit of bridge 4 via upper transmitting path of alternating current repeater 5, connecting circuit of bridge 6, upper transmitting path of alternating current repeater 7, repeating coil and composite set 8 to the eastern stations. The picture current is also transmitted via a connecting circuit of bridge 4 to one circuit of line N_1 and through a connecting circuit of bridge 6 to one circuit of line N_2, which lines are provided with repeaters, composite sets and repeating coils, respectively, similar to 3, 1 and 11.

If a picture current, transmitted from a remote station over all lines, is to be received at the local station, terminal loop L_1 will be used, although terminal loop L_2 could be used equally well by operating keys 24 to connect conductors 35 to the receiving machine. In the first case, i. e., using loop L_1, the control circuit will have been rendered effective by the operation of the starting switch at the sending station to condition the lines of the network and the terminal loop for reception, with the result that the outgoing path of the repeaters of all lines including repeaters 3, 13, 7, 31 and those associated with lines N_1 and N_2 will be short circuited, key 18 will be in normal position and conductors 15 will be connected by the upper repeating coil 16 to the receiving machine R over the following circuit: the two upper lever and normal contacts at the left of key 18, conductors 19, normal and lever contacts of key 20 and conductors 77 to the machine R.

The direct current repeater of loop L_1 controlled by the operation of starting key 70 at the remote sending station will operate relay 60 to apply ground to conductor 38, thereby completing the following circuit: from ground, conductors 38, 27, 37, upper right-hand lever and normal contact at the left of key 18, conductor 62, armature 63, conductor 65, winding of relay 66.

conductor 67, upper repeating coil 16, conductors 15 and 68, battery 69, its grounded terminal and through ground to the point of beginning. The relay 66 will operate to open the circuit through its left hand armature to the battery and to complete the following circuit through its right hand armature 78: from ground through armature 78, conductor 79, right hand normal and lever contacts of key 74, lamp 80, battery 81 to ground and therethrough to the point of beginning, whereby lamp 80 is lighted to indicate that signal currents, transmitted from some remote station to all lines, are being received.

If the network is to be split at the central office so that western and eastern sections may be provided for independent operation, the local attendant operates key 74. When this is done, the outer left hand key lever engages its alternate contact to complete the following circuit: from ground, through this outer key lever and alternate contact, conductor L, relay 82, resistance 83, battery 84 and through ground to the point of beginning. Relay 82 operates to pull up its armatures. The outer left hand armature 85 short circuits the lower transmission path of the alternating current repeater 5, the right hand armature 86 short circuits the upper transmission path of alternating current repeater 5 and the inner left hand armature 45 opens the control circuit, thereby rendering both the alternating current, direct current and control circuits of the two sections independent of each other.

Bridges 4 and 6 are so designed that when armatures 85 and 86 operate to short circuit the respective output paths of repeater 5, the transmission paths of other lines respectively interconnected thereby are not appreciably affected. This applies, however, to the situation where a bridge of the second type referred to in the above mentioned Green patent is used, i. e., in which the attenuators are given, by way of example, as comprising resistance of 5545 ohms in each side of the lines. While this value of resistances is used under certain given operation conditions, other values may be used.

In case bridges 4 and 6 comprise attenuators including resistances of low value in each side of the line, i. e., as set forth for the first example referred to in the above mentioned Green patent, the output paths of repeater 5 can not be directly short circuited without affecting the transmission paths of other lines respectively interconnected by the bridges. To avoid this and at the same time to permit splitting the circuit, short circuits are applied to the outputs of repeater 5 and resistances substantially equal to the impedance of the output paths of repeater 5 are connected between the short circuit and the bridges when relay 82 operates. This is shown in Fig. 4 to be described later.

Where bridges 4 and 6 include resistances in each side of the line and of the higher order mentioned above, the short circuits are applied between the output circuits of repeaters 3, 7, 13 and 31 and the bridges, with which they are respectively associated, in order to prevent the detrimental effect of extraneous currents. However, where the bridges 4 and 6 include resistances in each side of the line which are of the lower order given in the first example of the Green patent, these short circuits are applied to the same side of each line but to the input circuits of repeaters 3, 7, 13 and 31. This prevents the short circuits from affecting the other transmission paths respectively interconnected by the bridges.

If a picture transmission is to be effected over the east section, loops L_2 are used. Key 24 is operated to cause its lever elements to engage with its alternate contacts, thereby disconnecting conductors 23 from conductors 25 and connecting them to conductors 36 and disconnecting the starting key lead from conductor 71 and connecting it to conductor 87. Keys 20 and 34 being in their normal positions, operation of the starting key 70 applies ground to the circuit, including conductor 87, relay 88, right hand armature 89 of relay 90, battery and through ground to key 70. Current flowing through this circuit operates relay 88 to apply ground through its right hand armature, conductor 91 and upper normal and lever contacts of key 34, conductor 57 to the right-hand winding of lower repeating coil 33, conductors 92, the upper winding of repeating coil 32, and conductor 99 to direct current repeater 58, which operates in the same manner as the direct current repeater associated with loop L_1, to control the direct current repeaters associated with the lines included in the eastern section, i. e., east and N_2 lines, to condition the latter for picture transmission thereover. At the same time the left hand armature of relay 88 completes a circuit from ground through this armature, conductor 94, lamp 95, battery 76 and ground, and lamp 95 is operated to indicate picture transmission from the local station to the eastern section. The path of the picture current is via conductors 23, the two left hand lever and alternate contacts of key 24, conductors 36, two lower left hand normal contacts and lever contacts of key 34, conductors 26*a*, two lower right hand normal and lever contacts of key 34, lower repeating coil 33, conductors 92, upper repeating coil 32, upper transmission path of repeater 31, and through connections of bridge 6 to lines E and N_2. When transmission of the picture is completed, start key 70 is released to restore the apparatus units of the section to normal, whereby this section is made ready for the transmission of another picture.

A picture may be received from a station connected to the east section by operating key 20 to connect conductors 77 to conductors 35. When the starting key at the remote sending station is operated, the control circuit becomes effective to control the apparatus units on the lines to energize a relay of the direct current repeater 58 which corresponds to relay 60 of the direct current repeater associated with loops L_1. Operation of this relay causes ground to be applied to the following circuit: conductors 99, 92, 57, upper lever and normal contacts of key 34, conductor 91, right hand armature of relay 89, conductor 96, relay 90, conductor 97, right-hand winding of upper repeating coil 33, conductors 98, right-hand winding of lower repeating coil 32, conductor 93 and a battery, included in direct current repeater 58, corresponding to battery 69 of the direct current repeater associated with loop L_1; whereby the relay 90 is operated to pull up its armatures. Armature 89 disconnects battery from the circuit including relay 88, which controls the circuit through local sending key and lamp 95, and its left hand armature 100 completes the following circuit: from ground through this armature, lamp 101, battery 81 and ground to armature 100. Lamp 101 is thereby lighted to indicate that a picture is being received from some station of the eastern section. The picture

current is transmitted from bridge 6 via conductors 30, lower transmission path of repeater 31, lower repeating coil 32, conductors 98, upper repeating coil 33, the two upper right hand lever and normal contacts of key 34, conductors 35, alternate contacts and key levers of key 20, conductors 77 to the receiving machine R.

When reception of the picture has been completed, the start switch at the sender of the remote eastern station is opened to break the control circuit, and the apparatus units of this section are restored to normal.

For picture operation over the western section, the transmitting key 24 and the receiving key 20 are restored to their normal positions to disconnect the sending and receiving machines from the eastern section and connect them to the western section. Picture transmission and reception over the western section are effected in the manner described above for transmission over the entire network.

Keeping in mind that the splitting key 74 has been operated and hence that its key levers engage their alternate contacts, a circuit is completed through the lamp 102 under control of relay 64 when key 70 is operated to start transmission of a picture over the western section. This circuit is as follows: from ground through key 70, right-hand lever and normal contacts of key 24, conductor 71, relay 64, left hand armature of relay 66, battery and through ground to key 70. Relay 64 operates to apply ground through its left hand armature 63 to conductor 37 for conditioning the circuits of loop L_1 and western lines W and N_1, and by its right hand armature 72 to complete a circuit from ground, armature 72, conductor 73, middle lever and alternate contact of key 74, lamp 102, battery 76 and through ground to armature 72.

When a picture is being received from the western section, with the splitting key 74 operated, relay 66 is energized by the operation of the starting key 70 at the transmitting station, in a manner similar to that described above in connection with reception from any station associated with the complete network. This serves to complete a circuit through lamp 103 over the following circuit: from ground, the right hand armature 78 of relay 66, conductor 79, left hand lever and alternate contact of key 74, lamp 103, battery 81 and via ground to the point of beginning.

While sending a picture to the western section, key 20 may be operated to connect the receiving machine to the eastern section, whereby a picture may be received from a remote station of this section. Again key 20 may occupy its normal, i. e., non-operated position to connect the receiving machine to the western section and key 24 may be actuated. In this case, the sending machine will be connected to send a picture to the eastern section, and the receiving machine will be connected for picture reception from the western section.

While the splitting arrangement has been described as applied to four-wire cable circuits, it may be used at a station for interconnecting four-wire cable lines with four-wire open-wire lines, or at a station where either type of four-wire lines is connected with two-wire open-wire lines.

For two-wire open-wire line connection, the circuit shown in Fig. 3 may be substituted for that included between bridge 4 or 6 and all lines interconnected by these bridges. In other words, it may be used in place of the arrangement shown in some detail at the right and left, respectively, of section lines X—X, Fig. 1.

The circuit of Fig. 3 will be hereinafter described, by way of example, as a substitute for the circuit shown between section line X—X and the east line. Leads 110 and 111 correspond to the output and input leads, respectively, of the bridge circuit 6 and repeater 112 corresponds to the repeater 7. The output or sending leads, i. e., the upper transmission path of the repeater, are normally connected by leads 113 and 114 to the input terminals of a filter 115, the output terminals of which are connected by leads 116 and 117 to outside winding 118 of a three-winding transformer, the middle windings 119 of this transformer have their terminals respectively connected through a repeating coil and composite set to the east line 120 and to the balancing network N and mid-taps of winding 119 are connected to the input leads of repeater 112, i. e., the lower transmission path of the repeater. The two-wire line is thereby conjugately related to the four-wire output circuit of the repeater 112. The input leads for the repeater 112 include a resistance pad 121.

Associated with this terminal apparatus is a direct current repeater provided with a connection to the control circuit lead 46. When this lead is grounded by the operation of the direct current repeater associated with terminal loop L_1 or L_2 of the local station or direct current repeater 44 of the west line, due to the talking key being thrown to the broadcast position or to the starting key for the picture sending machine having been closed to operate relay 39 of the loop circuit direct current repeater or relay 56 of repeater 44, current flows from ground at the direct current repeater of the two-wire teminal, battery 122 through relay 123, relay 124, conductor 125, armature of polarized relay 126, conductor 127 which extends to lead 46 of Fig. 1 through the armature of relay 56 of direct current repeater 44 and armature 41 of relay 39 included in the direct current repeater associated with loops L_1 and through ground to the grounded terminal of battery 122. Relay 123 operates to pull up its armature and thereby disconnects lower battery 128, which normally applies direct current of one sign to the lower conductor of the two-wire line 120 and connects upper battery 128 to supply direct current of opposite sign over the following circuit: from upper battery 128 through the armature of relay 123 and a composited connection over the line. Relay 124 operates through one armature 129 to apply ground to a circuit including the winding of slow-release relay 130 and battery, one terminal of which is grounded, and also through its armature 131 to complete a holding circuit for relay 124. Slow-release relay 130 pulls up its armature to apply ground to a circuit including the winding of a relay 132 and battery 133, the other terminal of which is grounded. Relay 132 is thereby operated, its upper inner armature removes ground from the circuit 134, adapted to be controlled by relay 126 when this relay is operated by incoming direct current impulses received over the control circuit due to the operation of the start switch of a sending machine of a remote station of the eastern section, and by its upper outer armature to complete a relay circuit as follows: from ground through lead 135 to this armature, lead 136 to relays 137 and 138, associated with the input and output circuit of filter 115, and relay 139 asso-

ciated with the input or lower transmission path of repeater 112. The winding of relay 137 is energized over the following circuit: from ground 140, battery 141, winding of relay 137, conductor 136, upper armature of relay 132, lead 135 to ground and therethrough to 140. The winding of relay 138 is energized over the following circuit: from ground 142, battery 143, winding of relay 138, conductor 136, lead 135 and through ground to 142. These two relays operate through their upper armatures to connect lead 113 directly to lead 116 via conductor 144, and through their lower armatures to connect lead 114 directly to lead 117 via conductor 145, thereby removing filter 115 from the output circuit, i. e., the upper transmission path of repeater 112. Relay 139 is energized from ground, battery 146, winding of relay 139, conductor 136, lead 135 and through ground to battery 146, to pull up its armatures and thereby short circuit the input circuit, i. e., the lower transmission path of repeater 112. As in the case of the four-wire line, direct current repeaters associated with alternating current line repeaters will be operated by the reversal of direct current supplied to the line to effect certain control functions at these repeaters, and the reversed direct current will operate to effect like results at the successive alternating current station repeaters included in the lines comprising the eastern section, and hence the attendant at the local station, or an attendant at a station of the western section, may broadcast speech or send picture currents over the eastern section, depending upon whether his talking key has been set for broadcasting or his start key has been operated to transmit a picture.

In case two-way telephone conversations are to be effected from a local station or a station of the western section through the central office, no ground is applied to lead 46, and hence relays 137, 138 and 139 are not operated. Both paths through repeater 112 are operative and filter 115 is included in the output or upper transmission, path of this repeater. Filter 115 is provided to prevent singing when two-way repeating is effected through the four-wire two-wire termination connecting the repeater 112 to the east lines, and the slow-release relay of the direct current repeater is provided to prevent irregular operation of the repeaters or terminating apparatus due to undesired current impulses produced in the control circuit. For a complete disclosure of the operation of the repeater described above, reference may be made to R. B. Hearn Patent 2,018,494, issued October 22, 1935.

When the direct current repeater associated with the two-wire four-wire terminating circuit is in normal condition and a similar repeater associated with the line in question has been operated, either by throwing the talking key to the broadcasting position or closing start key of the picture machine at any remote eastern station, control impulses incoming via the composite connection to the upper conductor of the line section east of the terminating point, will flow through the winding of relay 126 to ground. These impulses being of opposite sign to those normally supplied over the upper conductor energize polarized relay 126 which pulls up its armature, thereby disengaging it from its normal contact to open the circuit of relays 123 and 124 and causing it to engage its alternate contact, to apply ground over the inner lower armature of relay 132, conductors 134 and 127 to conductor 45, whereby the direct current repeaters associated with the terminal loops L_1 and L_2 and the lines of the western section are controlled to condition them for broadcasting speech or for picture transmission. Under these conditions, broadcast speech or picture transmission is effected over the conjugate connection, path 121 and the lower transmission path of repeater 112 to the local station and to stations of the western section. While relays 137, 138 and 139 are not operated, the local station output paths and those of the other lines transmitting into the bridges are short circuited.

In case the western section consists of two-wire open-wire lines, the direct current repeater 44 and those associated with other lines of this section would be replaced by a direct current repeater of the type described above for use with two-wire open-wire lines.

By operating splitting key 74, the network of open-wire lines may be split at the central office and both sections may be independently operated as described above, in connection with the four-wire cable network.

A splitting arrangement for use with open-wire lines is shown in Fig. 4. This arrangement will be substituted for the central office of Fig. 1, i. e., for that portion of the last mentioned figure between section lines Y—Y and Z—Z with which are associated four-wire two-wire terminating circuits of the type disclosed in Fig. 3 to effect connection to the various lines W, E, N_1 and N_2.

Bridges 4 and 6 will comprise resistances in each side of the line which are of the lower order mentioned in the Green patent hereinbefore referred to, and the respective input circuits of repeater 5 will include resistances 150 and 151. When the network is used as a complete entity, these resistances are short circuited by armatures 85 and 86, respectively, of relay 82. However, when the splitting key has been operated to apply ground to conductor L, as hereinbefore described, relay 82 will operate to pull up its armatures. Armature 45 will open the control circuit 43, armature 85 will disengage its forward contact to open the short circuit around resistance 150 and engage its back contact to short circuit the connection between this resistance and the lower output path of repeater 5, and armature 86 will disengage its forward contact to open the short circuit around resistance 151 and engage its back contact to apply a short circuit to the connection of this resistance to the upper output path of repeater 5. Thus the lower leads of bridge 4 and the upper leads of bridge 6 are terminated in resistances the impedances of which should be substantially equal to the output impedances of the respective repeater paths of repeater 5 and, each section of the network may be operated independently of each other, in the manner described with respect to Fig. 1.

Operation of relay 126, included in the direct current repeaters of the type shown in Fig. 3, which are associated with the different lines interconnected by the bridges, or of relay 59, included in the direct current repeaters associated with the station loops L_1 and L_2, as hereinbefore described, will cause its armature to short circuit the input of repeater 3, as well as the inputs of repeater 7 and those associated with the north lines.

By virtue of the use of this arrangement, the network may be split without materially affecting the transmission paths of the lines interconnected by bridges 4 and 6.

Bridge arrangements may be connected in series between bridge 4 and the west line or between bridge 6 and the east line to permit the use of additional lines radiating from the splitting station. One or more of these bridges may be associated with the western group or the eastern group or both groups. In the first two cases, when the network is split, either the western or eastern section will include a greater number of lines local to the splitting station than the other, whereas in the latter case the two sections will include the same number of local lines.

What is claimed is:

1. A communication system comprising a transmission network including a central office, a series of lines terminating at said office, a plurality of means for interconnecting said lines in groups, apparatus at said central office for connecting said plurality of interconnecting means together, means at a station local to said central office and at other stations connected to each line for supplying and receiving signal currents to and from said network, control means at any of said stations for conditioning said network for one-way transmission in either direction from one of said lines to said other lines, and means at said local station for controlling said connecting apparatus at said central office for splitting said network into a plurality of independently operable sections.

2. A communicating system comprising a transmission network including a central office, a series of lines terminating at said office, a plurality of means for interconnecting said lines in groups, apparatus at said central office for connecting said plurality of interconnecting means together, a station local to said central office, other stations connected to each of said lines, means at said local and each of said other stations, for supplying signal currents for two-way transmission over said network, means for conditioning said network for one-way signal transmission in either direction from one of said lines to said other lines, and means at said local station for controlling said connecting apparatus at said central office for splitting said network into a plurality of independently operable sections.

3. A communicating system comprising a transmission network including a central office, a series of lines terminating at said office, a plurality of means for interconnecting said lines in groups, apparatus at said central office for connecting said plurality of interconnecting means together, a station local to said central office, other stations connected to each of said lines, two-way alternating current repeaters in each said lines, means at the local station and each of said other stations for supplying alternating signal currents for two-way transmission over said network, means including direct current repeaters, associated with each said alternating current repeaters, for conditioning said network for one-way alternating current signal transmission in either direction from one of said lines to said other lines, means at said local station and each of said other stations for controlling said conditioning means, and means at said local station for controlling said connecting apparatus at said central office for splitting said network into two independently operable sections with either of which the apparatus of the local station may be associated.

4. A communicating system comprising a transmission network including a central office, a series of lines terminating at said office, a plurality of means for interconnecting said lines in groups, apparatus at said central office for connecting said plurality of interconnecting means together, a station local to said central office, other stations connected to each of said lines, two-way alternating current repeaters in each said lines, means at the local station and each said other stations for supplying alternating signal currents for two-way transmission over said network, means including direct current repeaters, associated with each said alternating current repeaters, for conditioning said network for one-way alternating current signal transmission in either direction from one of said lines to said other lines, means at said local and each of said other stations for controlling said conditioning means, means at said local station and each said other stations for supplying alternating signal currents for one-way transmission over said network, means at said local station for controlling said connecting apparatus at the central office for splitting said network into independently operable sections, and control means at said local station for connecting signaling means thereat for simultaneous operation with the respective sections.

5. A communicating system comprising a transmission network including a central office, a series of lines terminating at said office, a plurality of means for interconnecting said lines in groups, apparatus at said central office for connecting said plurality of interconnecting means together, a station local to said central office, other stations connected to each of said lines, two-way alternating current repeaters in each said lines, means at the local station and each said other stations for supplying alternating signal currents for two-way transmission over said network, means including direct current repeaters, associated with each said alternating current repeaters, for conditioning said network for one-way alternating current signal transmission in either direction from one of said lines to said other lines, means at said local and each of said other stations for controlling said conditioning means, means at said local station and each said other stations for supplying alternating signal currents for one-way transmission over said network, means at said local station for controlling said connecting apparatus at the central office for splitting said network into independently operable sections, and control means at said local station for connecting signal transmitting means to one section and signal receiving means to the other section.

6. A communicating system comprising a transmission network including a central office, a series of lines terminating at said office, a plurality of means for interconnecting said lines in groups, apparatus at said central office for connecting said plurality of interconnecting means together, a station local to said central office, other stations connected to each of said lines, two-way alternating current repeaters in each said lines, means at the local station and each said other stations for supplying alternating signal currents for two-way transmission over said network, means including direct current repeaters, associated with each said alternating current repeaters, for conditioning said network for one-way alternating current signal transmission in either direction from one of said lines to said other lines, means at each of said local and other stations for controlling said condition-

ing means, means at said local station and each said other stations for supplying alternating signal currents for one-way transmission over said network, means at said local station for controlling said connecting apparatus at the central office for splitting said network into independently operable sections, and control means at said local station for connecting signal transmitting means to either section and signal receiving means to the other section.

7. A communication system comprising a transmission network including a central office, a series of lines terminating at said office, a plurality of means for interconnecting said lines in groups, apparatus at said central office for connecting said plurality of interconnecting means together, means at a station local to said central office and at other stations connected to each line for supplying and receiving signal currents to and from said network, and means at said central office for conditioning the network for one-way transmission thereover, controllable from each station.

8. A communication system comprising a transmission network including a central office, a series of lines terminating at said office, a plurality of means for interconnecting said lines in groups, apparatus at said central office for connecting said plurality of interconnecting means together, means at a station local to said central office and at other stations connected to each line for supplying and receiving signal currents to and from said network, including devices for respectively repeating alternating signal currents in opposite directions with respect to said central office, and means at said central office for short circuiting the device in the transmission path opposite to the direction of alternating current signal transmission, controllable from each station.

9. A communication system including a series of lines terminating in a central office comprising a plurality of means respectively connecting a plurality of said lines in a group, apparatus connecting said plurality of means together and means associated therewith for rendering said connecting apparatus inoperative, and a station local to said central office including means for controlling the means associated with said connecting apparatus at the central office.

10. A communication system including a series of lines terminating in a central office comprising a plurality of means respectively including conductive paths interconnecting a plurality of said lines, apparatus connecting said plurality of means together and means associated therewith for rendering said connecting apparatus inoperative, and a station local to said central office including means for controlling the means associated with said connecting apparatus at the central office.

11. A communication network comprising a series of lines terminating in a central office having a plurality of means respectively connecting a plurality of said lines, apparatus including a plurality of conductive paths connecting said plurality of means together and means for short-circuiting the respective conductive paths, and a station local to said central office comprising means for controlling said short-circuiting means.

12. A communication network comprising a series of lines terminating in a central office having a plurality of means respectively connecting a plurality of said lines, apparatus including a plurality of conductive paths connecting said plurality of means together and means for short-circuiting the respective paths through a terminating impedance, and a station local to said central office comprising means for controlling said short-circuiting means.

13. A communication system comprising a transmission network having a series of lines terminating in a central office which comprises a plurality of means respectively connecting a plurality of said lines in a group, apparatus connecting said plurality of means together, and means associated therewith for rendering said connecting apparatus inoperative to thereby split the network into sections, and a station local to said central office comprising means for actuating the splitting means at the central office, means for sending and receiving signals, and means for connecting said signal sending and receiving means to the respective sections.

14. A communication system comprising a transmission network including a series of lines terminating in a central office, comprising a plurality of means respectively connecting a plurality of said lines in a group, apparatus connecting said plurality of means together, and means associated therewith for rendering said connecting apparatus inoperative to thereby split the network into sections, and a station local to said central office including means for actuating the splitting means at the central office, means for sending and receiving signals, and means for connecting signaling means to either of said sections.

15. A communication system comprising a transmission network including a central office provided with a plurality of means for interconnecting a series of lines terminating therein, apparatus for connecting said plurality of interconnecting means together, and means for controlling said connecting apparatus to split said network into a plurality of independently operable sections, and a station local to said central office comprising means for actuating the splitting means at said central office, signal sending means, and means for connecting the signal sending means to either of said sections.

16. A communication system comprising a transmission network including a central office provided with a plurality of means for interconnecting a series of lines terminating therein, apparatus for connecting said plurality of interconnecting means together, and means for controlling said connecting apparatus to split said network into a plurality of independently operable sections, and a station local to said central office comprising means for actuating the splitting means at said central office, signal receiving means, and means for connecting said signal receiving means to either of said sections.

17. A communication system comprising a transmission network including a central office provided with a plurality of means for interconnecting a series of lines terminating therein, apparatus for connecting said plurality of interconnecting means together, and means for controlling said connecting apparatus to split said network into a plurality of independently operable sections, and a station local to said central office comprising means for actuating the splitting means at said central office, signal sending and receiving means, and means for simultaneously connecting one of said signalling means to one section and the other of said signalling means to the other section.

18. A communication system comprising a transmission network including a central office

provided with a plurality of means for interconnecting a series of lines terminating therein, apparatus for connecting said plurality of interconnecting means together, and means for controlling said connecting apparatus to split said network into a plurality of independently operable sections, and a station local to said central office comprising means for actuating the splitting means at said central office, signal sending and receiving means, and means for simultaneously connecting said signal sending and said receiving means to the respective sections one at a time.

19. A communication system comprising a transmission network including a central office provided with a plurality of means for interconnecting a series of lines terminating therein, apparatus for connecting said plurality of interconnecting means together, and means for controlling said connecting apparatus to split said network into a plurality of independently operable sections, and a station local to said central office comprising means for actuating the splitting means at said central office, means for sending and receiving signals of different types to and from said sections and means for connecting the means for sending and receiving signals of one type to either one of said sections or for simultaneously connecting such means to the respective sections, or, alternatively, for connecting the means for sending signals of another type to either one of said sections and for connecting the means for receiving signals of this type to another section.

20. A communication system comprising a transmission network including a central office provided with a plurality of means for interconnecting a series of lines terminating therein, apparatus for connecting said plurality of interconnecting means together, and means for controlling said connecting apparatus to split said network into a plurality of independently operable sections, and a station local to said central office comprising means for actuating the splitting means at said central office, signal sending and receiving means, switching means connecting the means for sending and receiving signals of one type to either of said sections or for simultaneously connecting such means to the respective sections, or, alternatively, for connecting means for sending signals of another type to either one of said sections and for connecting means for receiving signals of this type to another section.

21. A communication system comprising a transmission network including a central office provided with a plurality of means for interconnecting a series of lines terminating therein, apparatus for connecting said plurality of interconnecting means together, and means for controlling said connecting apparatus to split said network into a plurality of independently operable sections, and a station local to said central office comprising means for actuating the splitting means at said central office, signal sending and receiving means, a plurality of switching means including switches for connecting the means for sending and receiving signals of one type to either one of said sections or simultaneously for connecting means for sending and receiving signals of this type to the respective sections, and other switches, cooperating with said first named switches, for connecting means for sending signals of another type to either one of said sections and for connecting means for receiving signals of this type to another section.

22. A communication system comprising a transmission network including a central office provided with a plurality of means for interconnecting a series of lines terminating therein, apparatus for connecting said plurality of interconnecting means together, and means for controlling said connecting apparatus to split said network into a plurality of independently operable sections, and a station local to said central office comprising means for actuating the splitting means at said central office, telephone apparatus, picture sending and receiving devices, and means for connecting telephone apparatus to either or both sections, or, alternatively, for connecting the picture sending device or the picture receiving device to either of the sections or simultaneously to respective sections.

ELLIOT M. STAPLES.