Nov. 12, 1935. O. B. JACOBS 2,020,318

SYSTEM INCLUDING REPEATER

Filed March 6, 1934 3 Sheets-Sheet 1

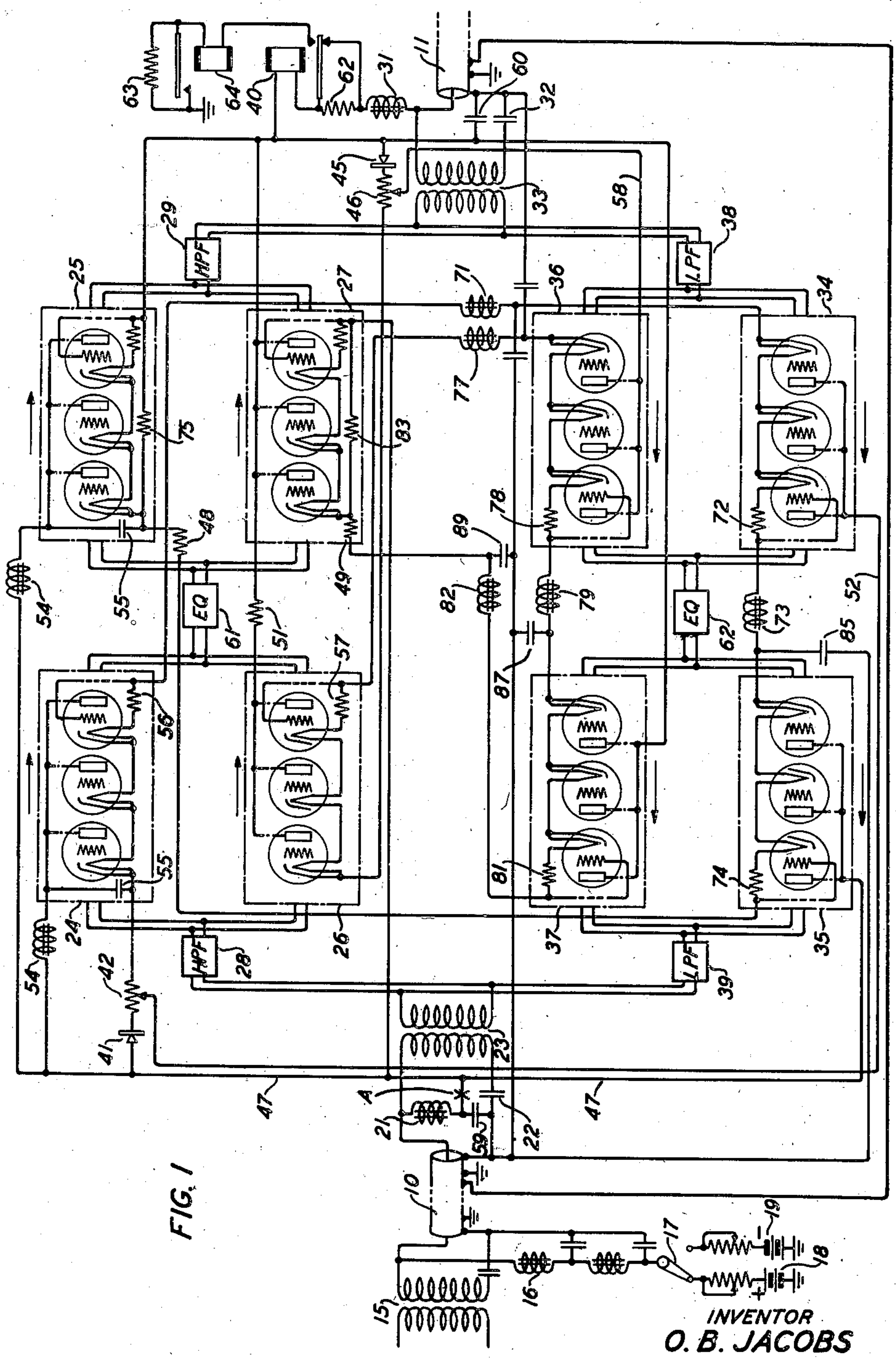

FIG. 1

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3 Sheets-Sheet 2

FIG. 2

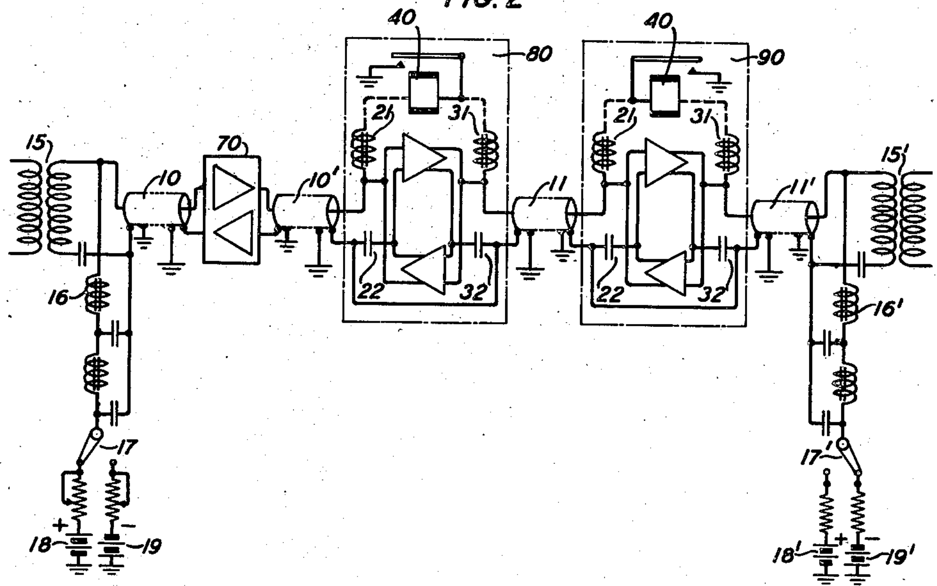
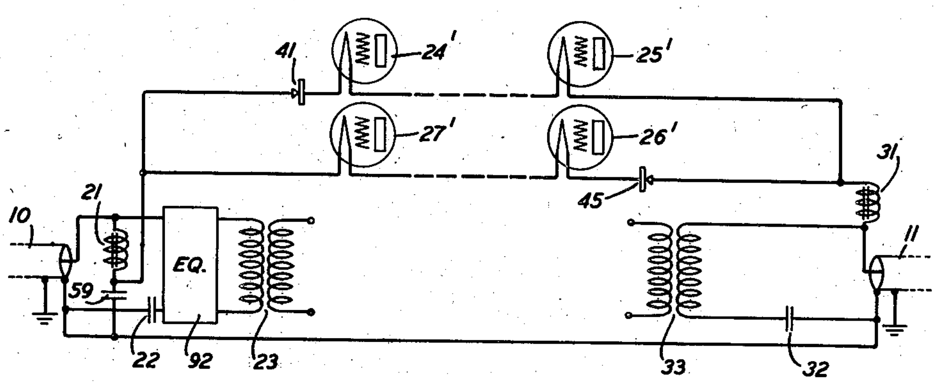


FIG. 3



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Filed March 6, 1934 3 Sheets-Sheet 3

FIG. 4

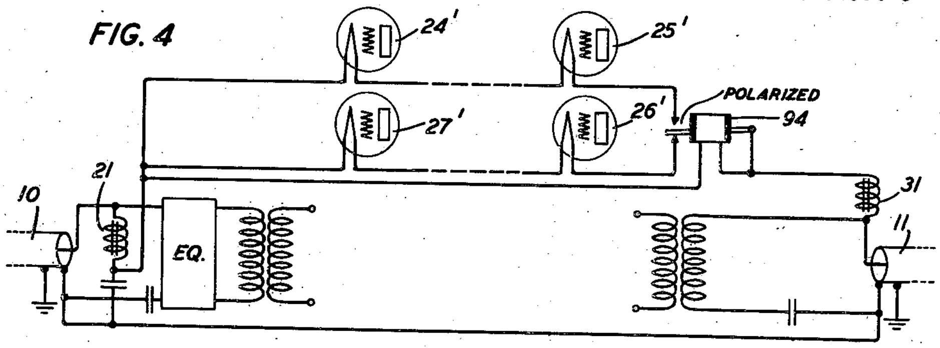


FIG. 5

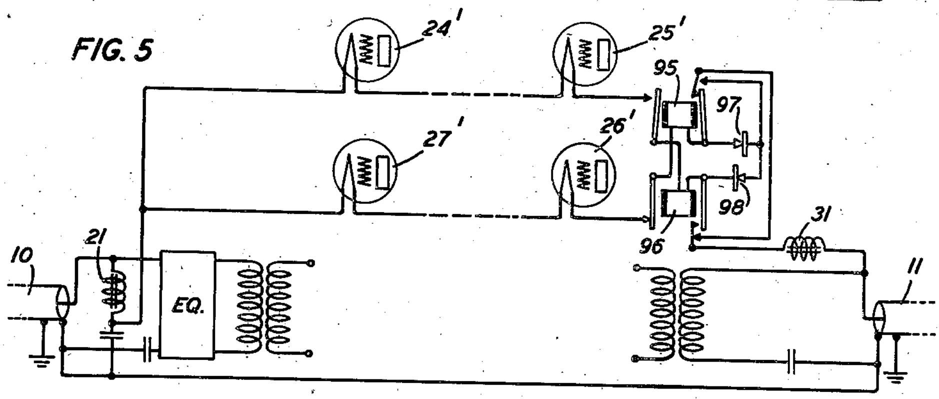
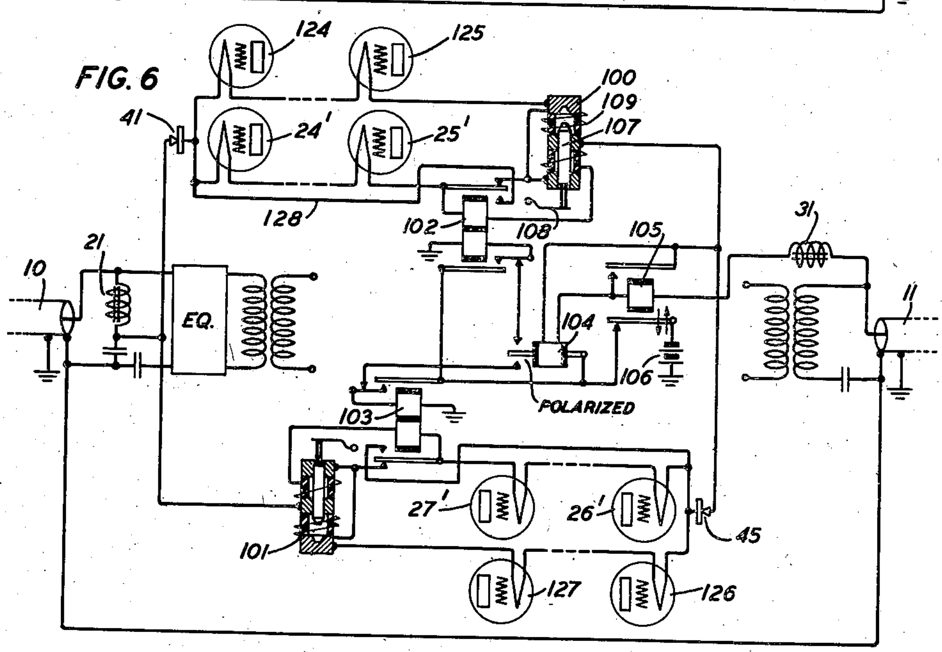


FIG. 6



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Patented Nov. 12, 1935

2,020,318

UNITED STATES PATENT OFFICE

2,020,318

SYSTEM INCLUDING REPEATER

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Application March 6, 1934, Serial No. 714,335

9 Claims. (Cl. 178—63)

The present invention relates to signaling systems containing one or more repeaters between system terminals. It relates particularly to repeaters adapted for location in relatively inaccessible places in that the repeaters can be operated without immediate personal attention for long periods of time.

An object of the invention is a repeater or repeater system capable of continued service for long periods of time without requiring the presence of an attendant at the repeater point or points.

A feature of the invention is the supply of the necessary power for the repeaters by transmitting current from a terminal station, and the control of certain circuit relations of the repeaters by means of the current so supplied. As an example, the supply current can be reversed on the line and the reversal causes the replacement of a repeater by another repeater or performs other switching functions.

The invention will be more fully understood from the following detailed description in connection with the attached drawings in which,

Fig. 1 is a schematic representation of a repeater system according to the invention;

Fig. 2 is a simplified sketch of a line interconnecting terminal stations and including a number of intermediate repeater points; and

Figs. 3 to 6 show alternative ways of substituting amplifiers in a repeater station.

In Fig. 1 there is shown a terminal station at the left connected by a section of line or cable 10 with a repeater station. The repeater station is connected between cable section 10 and another cable section 11. There may be several line sections similar to 10 and 11 with repeater stations between line sections generally similar to the repeater station shown in the drawings. The distant terminal station may be similar to that shown.

The terminal shown will be called the west station and comprises a signal current branch including repeating coil 15 and a direct current branch leading through filter 16 to switch 17 which is connectible to either source 18 or 19 of direct current. The purpose of the direct current is to energize the repeaters at one or more repeater stations on the line.

It will be assumed that carrier currents in an upper group of frequencies are impressed, from suitable transmitting apparatus (not shown), on the line through the signaling branch including repeating coil 15 and that carrier currents in a lower group of frequencies are received from the line by suitable receiving circuits (not shown) through the signaling branch. That is, the higher group is transmitted in the eastward direction over the line and the lower group is transmitted westward. These carrier currents may be speech-modulated to provide a plurality of separate speech channels in each direction.

At the repeater station, a direct current branch leads through retard 21 while a signaling branch is provided by condenser 22 and repeating coil 23. Similar elements 31, 32 and 33, respectively, are provided at the other side of the repeater, where connection is made to line section 11.

The signaling branch connected between repeating coils 23 and 33 includes eastward amplifiers 24, 25, 26 and 27 and westward amplifiers 34, 35, 36 and 37. High pass filters 28, 29 and low pass filters 38 and 39 serve to separate the upper and lower groups of frequencies to their respective repeaters.

In the circuit as shown, amplifiers 24, 25, 34 and 35 are conditioned for operation. Amplifiers 26, 27, 36 and 37 are spare repeaters that may be substituted for those in use by reversal of the line current in a manner to be described.

Two direct current branches are provided between the retards 21 and 31. One branch leads from retard 21 through valve 41, resistance 42, the heaters (or filaments in case filamentary cathodes are used) of amplifier 24, resistance 56, retard coil 71, the heaters (or filaments) of amplifier 34, resistance 72, retard coil 73, the cathodes or heaters of amplifier 35, resistances 74 and 48, the heaters or cathodes of amplifier 25 in parallel with resistance 75, winding of relay 40 to retard 31. The other branch leads from retard 31, winding of relay 40, valve 45, resistance 46, the heaters or cathodes of amplifier 26, resistance 57, retard 77, the heaters or cathodes of amplifier 36, resistance 78, retard 79, the heaters or cathodes of amplifier 37, resistance 81, retard 82, resistance 49, the heaters or cathodes of amplifier 27 and parallel resistance 83 to the terminal of retard 21. On account of the presence of valves 41 and 45, current can flow through only one of these two direct current branches at a time depending on the direction of flow of the line current. These valves may conveniently be copper oxide rectifiers or other suitable unilateral devices.

With the switch 17 in the position shown at the west station, positive battery is connected to the line at that station and it will be assumed that negative battery is connected to the line at the opposite terminal. Under these conditions, the current will flow through filter 16, line section 10, retard 21 and the first of the two direct current branches above traced, that is, through valve 41 to retard 31, line section 11, and so on to the next repeater station (if any) and to the distant terminal. Under these conditions there is no current in the other direct current branch at the repeater station and the amplifiers 26, 27, 36, 37 are inoperative since they are deenergized.

Associated with each of the series retards 71, 73, 77, 79 and 82 is a shunt capacity to ground 84, 85, 86, 87 and 89, respectively, each of which forms, together with its series retard coil, a filter for suppressing the flow of fluctuating current in the respective cathode heating branch.

Anode voltage is derived from the same direct current branch by means of the drop of potential along series resistance in the branch. For the amplifiers 24 and 25, conductor 47 leading from one terminal of retard 21 connects through series retards 54, 54 to the anodes of these respective repeaters. Cooperating with the retards there is in each instance a shunt capacity 55 to the cathode forming, together with the respective series retard, a filter to prevent the backing up of signaling voltages or other fluctuating voltages in the common plate supply lead. Conductor 47 is also shown leading to the anodes of repeater 35 without the interposition of a filter although this could be inserted if desired. Plate voltage for amplifier 34 is derived by conductor 52 from a point intermediate the ends of resistance 42, the plate voltage for this amplifier being relatively small since it is an input amplifier for the lower group and for that reason is assumed to have relatively lower gain and lower output level than the later stages or than amplifiers for the high group. Anode voltage for corresponding repeater 36 is similarly derived from resistance 46 over conductor 58.

It will be observed from the foregoing circuit description that the anode voltage of any given amplifier may be controlled by adjusting the points in the series energizing branch to which its anodes and cathodes are respectively connected. Thus the anode voltage for amplifier 34 is derived as the drop of potential across a portion of resistance 42 and across the heating circuit of amplifier 24 including bias resistor 56 and such additional resistance as may be included in retard 71 and the connecting leads. Amplifier 25, on the contrary, requires a relatively high anode voltage since it is the output amplifier section for the high group for which a high output level is required. For this reason series resistance 48 is connected between its cathode lead and the conductor leading toward retard 21. The presence of resistance 48 makes the cathodes of amplifier 25 more negative, that is, makes the anode to cathode voltage higher, assuming always that the energizing current from the terminal sources is kept constant.

Resistances 75 and 83 are for the purpose of shunting around the cathode heating circuits of amplifiers 25 and 27 the space currents of the amplifiers whose cathode heating circuits are in the same series branch but on the positive side. These space currents become cumulative toward the negative terminal, and resistances 75 and 83 are proportioned with respect to the heating circuits which they shunt to carry this excess current.

With these illustrative uses of cathode lead and anode lead resistances, it will be obvious to control the anode voltage of any of the other amplifiers.

Grid bias may be obtained from cathode lead drop of potential. For example, the final tube of each input amplifier 24, 26 is shown provided with a grid bias resistor 56 or 57. Similar bias resistors are shown for the final tube of each of the other amplifiers. For the other tubes the drop across succeeding tube heaters may be used for grid bias in a manner known in the art.

As described above, reversal of the line current as by throwing switch 17 at each terminal station substitutes amplifiers 26, 27, 36 and 37 for the amplifiers 24, 25, 34 and 35 shown in energized condition in the drawings.

In the drawings and thus far in the description, only the current supply and energizing circuits for the repeaters have been disclosed. The wave transmission paths through the amplifiers may be of any suitable type and preferably are of the type disclosed in British Patent No. 381,831, Fig. 7. That figure discloses a two-way carrier repeater with three stages in the high group repeater and two stages in the low group repeater. While the present application drawings show only two stages in the high group repeater, it will be apparent from what is shown how a third stage may be added as in the British patent and the cathode heaters or filaments of all stages connected in a series circuit and supplied from one or the other direct current branch as herein described.

As in the British patent, Fig. 7, the repeater station herein disclosed is suitable, for example, for use at an outlying point such as Port aux Basques or Grand Bank, N. F., between sections of submarine cable of the lengths and attenuations given in that patent. An advantage of the present invention is that the repeater stations operate without the presence of attendants for long periods of time. Equalizers 61 and 62 correspond respectively to the high group and low group interstage equalizers of Fig. 7 of the British patent.

Relay 40 may be provided at those stations at which it may be desired to have a direct current ground. It may, for example, be provided where there is only one repeater station, or if there are two repeater stations it may be provided at each station. If there are more than two repeater stations it may be used at two of the stations, as will be made plain presently. When direct current of either polarity is sent over the line of sufficient magnitude to energize the repeaters, relay 40 is actuated. At the break of its back contact it opens a shunt around resistance 62, and at the make of its front contact it grounds the direct current branch through resistance 63, which is high enough to prevent a disturbing current surge on the line. Resistance 62 aids in reducing the surge from cable 11 to ground. At the front contact, relay 40 includes the winding of slow operate relay 64 in series with resistances 62 and 63. When relay 64 operates it shunts out resistance 63 and leaves a path to ground through its winding, front contact of relay 40 and resistor 62.

Referring to Fig. 2, a system is shown comprising three repeater stations 70, 80 and 90 in a cable 10, 10′, 11, 11′ connecting west and east terminal stations. Each repeater station 70, 80 and 90 may be identical with that in Fig. 1 except that only two of these stations 80 and 90 are provided with relay 40. For simplicity relay 64 and resistances 62, 63 are omitted in Fig. 2 although they may be used as in Fig. 1. It will be noted that relay 40 at repeater station 90 is connected so as to place a ground on the side of the energizing circuit which is toward station 80. Referring to Fig. 1, this connection is obtained by inserting relay 40 and resistance 62 at point A instead of in the east side of the circuit.

With switches 17, 17' in the positions shown, current flows from positive battery 18 through filter 16, over the line, through the direct current branches poled in that direction at the various repeater stations as described in connection with Fig. 1, through filter 16' at the east station to switch 17' and negative battery 19' and ground. Suitable regulating resistances as shown are provided at both terminal stations.

When current flow is established in this manner over the line, both relays 40 operate and provide a direct shunt to ground at repeaters 80 and 90. The path of the direct current flow from the west station is now from source 18, through switch 17, filter 16, cable sections 10 and 10' including repeater 70, through repeater 80 and thence to ground and by earth return to source 18. Similarly the path of direct current flow from the east station is from source 19' over ground to repeater 90, closed front contact of relay 40 at that repeater, the energizing circuits of the amplifiers as shown in detail on Fig. 1, retard 31, cable 11', filter 16' and switch 17' to negative pole of source 19'. The direct current is thus shunted out of cable section 11. Moreover, the two terminal direct current supply systems now become independent of each other so long as current flows in either half of the line, and the direction of current flow can be reversed at either station by throwing switch 17 or 17' to its alternate position.

When the current is reversed as described a new set of repeaters is substituted for those previously operative. Thus by throwing switch 17 a new set of repeaters is substituted at repeater stations 70 and 80 but not at repeater station 90. Reversal of current by throwing switch 17' substitutes repeaters at repeater station 90.

When switch 17 is opened, relay 40 at station 80 releases, but if relay 40 at station 90 already was operated, it remains so until released by opening switch 17'. When relays 40 at both stations are released a through circuit for direct current exists and the system can be tested by the usual direct current methods so long as insufficient current is sent over the line to cause actuation of relays 40.

Various alternative ways of switching in and out repeaters will now be described in connection with the simplified diagrams of Figs. 3 to 6, inclusive. Fig. 3, for example, shows in simplified from the same method of substituting the repeater as is disclosed in greater detail in Fig. 1. The two tubes 24' and 25' of Fig. 3 correspond to the string of amplifiers of Fig. 1 taken in the order in which energizing current is supplied to them, i. e. amplifiers 24, 34, 35 and 25 while the tubes 26' and 27' correspond to the amplifiers 26, 36, 37 and 27 of Fig. 1. Fig. 3, therefore, as regards the manner of substituting amplifiers can be considered as equivalent to the more complete showing of Fig. 1. Plate and grid bias voltages may be derived as in Fig. 1 or any other suitable manner. For purposes of illustration, in Fig. 3 the equalizer 92 has been inserted between the input filter for separating direct current from the signaling voltages and the input coil 23. Current flow in the direction from cable section 10 to 11, as in Fig. 1, passes through valve 41 and the cathodes of amplifiers 24' to 25', the other amplifiers 26' to 27' being inoperative since their energizing circuit is without current. Current flow in the opposite direction passes through valve 41 and the cathodes of amplifiers 26' to 27' so that these amplifiers are now effectively in circuit while the amplifiers 24' to 25' are effectively removed from the circuit.

Fig. 4 is a circuit diagram similar to Fig. 3, but includes a polarized relay 94 as the means for substituting one set of amplifiers for another instead of the unilateral devices 41 and 45 of the previous figure. Relay 94 has a high resistance winding permanently connected between the retards 21 and 31. Current flow in one direction over the cable sections 10 and 11 causes the relay 94 to make contact with its lower contact thus establishing a path for current flow through the energizing circuits of amplifiers 26' to 27' as illustrated. While the winding of relay 94 is in parallel with the energizing circuits of these amplifiers, the winding is of such high resistance as to consume very little current, most of the current flowing through the amplifier circuit. Current flow in the opposite direction causes the relay to make contact with its upper contact in the drawings thus substituting amplifiers 24' to 25' for those previously in circuit.

In Fig. 5 a pair of neutral relays 95 and 96 together with a pair of valves 97 and 98 control the switching between the different sets of amplifiers. As illustrated, the lower set of amplifiers is in circuit and current flow is assumed to be from cable section 10 toward cable section 11. The path for this current is traceable through retard 21, the energizing circuits of amplifiers 27' to 26', back left-hand contact of relay 96, winding of relay 95, right front contact of relay 95, back right-hand contact of relay 96, retard 31 to cable section 11. The circuit branch through the upper amplifiers 24' to 25' is open at the back contact of relay 95. It will be noted that the above traced circuit does not include either rectifier 97 or 98. That is, when either set of amplifiers is in operation the rectifiers 97 and 98 are cut out of circuit as will be clear presently. Thus, the amplifier energizing circuit is kept free from any variable operation or possible noise which might be involved if the rectifier were connected in the circuit.

If it is desired to switch in the alternate amplifier, the current over the cable is first interrupted allowing relay 95 to restore. Current is then sent in the direction over the cable 11 toward the cable 10, this current passing through retard 31, right-hand back contact of relay 96, right-hand back contact of relay 95, now closed, rectifier 98, winding of relay 96, back left-hand contact of relay 95, now closed, energizing circuits of amplifiers 24' to 25', retard 21 to cable section 10. This current causes relay 96 to energize opening at its left contact the circuit through the lower group of amplifiers and shunting out at its right front contact and thereafter opening the path through the rectifier 98.

Reference will now be made to Fig. 6. In this figure positive current received from cable section 10 passes through retard 21, rectifier 41, the energizing circuits of amplifiers 24' to 25', upper normal contact of relay 102, normal contacts of switch 100, winding of polarized relay 104, winding of battery control relay 105, retard 31 and to cable section 11. The amplifiers 24' to 25' are thus energized and rendered capable of serving as two-way repeaters between the line sections 10 and 11 as in the case of the amplifiers 24 to 25 of Fig. 1.

A digression will be made at this point to describe the switch 100. This is preferably in the form of a sleeve or cylinder comprising an upper, a middle and a lower section of conducting material with insulating material between. A metallic plunger 107 is fitted inside the cylinder and is slidable lengthwise of the cylinder. This plunger 107 is soldered (in the position shown) to the middle and lower portions of the sleeve so as to establish contact between these portions. It is separated, however, from the upper portion so that no contact exists between the middle portion and the upper portion of the cylinder. The cylinder is surrounded by a heating coil 109 adapted, when suitable current is passed through it, to heat up the cylinder and melt the solder. When this is done the spring 108 pushes the plunger 107 upward in the figure so that it passes cut of contact with the lower segment of the cylinder and makes contact with the upper end of the cylinder thus establishing contact between the central portion and the upper portion of the cylinder and breaking contact between the central portion and the lower portion of the cylinder. In order to insure that the plunger will make good fused union with the end of the cylinder the turns of the heating coil 109 are more concentrated toward the closed end of the cylinder so that when the solder is melted and allows the plunger 107 to move, the closed end of the cylinder will be at least as hot as the other portions. As the assembly cools down, the pin 107 is firmly secured in its uppermost position with its ends soldered to the terminals of the cylinder. The switch 101 may be identical with the switch 100 just described.

When current flow was established through rectifier 41 and amplifiers 24′ to 25′, as above described, polar relay 104 was actuated to close its lowermost contact, this relay being of a type biased to central position so that when no current flows through its winding the armature holds both of its contacts open. Whenever the relay 104 is energized by current of proper direction to pass through the rectifier 41, it closes its lower armature and current then flows from local dry battery cells 106 through the back contact of armature 105, contact of relay 104, upper winding of relay 103 to ground causing relay 103 to operate and lock itself over the back contact of relay 105. Relay 105 is slow to operate and slow to release. After a time, under the conditions above described, it attracts its two armatures and opens the holding circuit for relay 103 so that the operation above described of relays 103 and 104 is without effect at this time. At its upper front contact relay 105 closes a shunt around the relatively high resistance of winding 104 so that this winding is removed from the series energizing circuit for the repeater. Under the conditions above described, neither heat coil of switch 100 or 101 receives current since they together with corresponding relays 102 and 103 are shunted out by the normal contacts of the said relays.

If now the current on the line is reversed so that positive current is received from cable section 11, this current passes through retard 31, windings of relays 105 and 104, rectifier 45, energizing circuits of amplifiers 26′ to 27′, normal contact of relay 103, normal contacts of switch 101, retard 21, cable section 10 so that the east and west amplifiers 26′ to 27′, inclusive, are now brought into the circuit in place of the amplifiers 24′ to 25′ previously assumed to be operative. Relays 104 and 105 cause the momentary actuation of relay 102 in the same manner that was described above in connection with relay 103, but this operation is without effect at this time. When relay 105 operates it shunts out the high resistance winding 104 from the series energizing path through the repeater.

The switches 100 and 101 and the relays associated with Fig. 6 provide for two additional substitutions of amplifiers beyond the above-described substitutions that are made by the mere reversal of the line current. For example, assuming that the amplifiers comprising tubes 24′ to 25′, inclusive, have been used and proved unsatisfactory, the circuit of Fig. 6 permits tubes 124 to 125 to be brought into the circuit. Relatively weak positive current is first sent over the line in the direction from cable section 11 to section 10. This causes the relatively sensitive relay 104 to close its upper contact, but relay 105 does not operate on this relatively weak current. Relay 102 is energized by current through its lower winding, upper contact of relay 104 and back contact of lower armature of relay 105, from battery 106. Relay 102 closes a locking circuit for itself independent of relay 104 through the normal contacts and lower armature of relay 105. If the line current is now interrupted, relay 104 restores to its open position, but relay 102 remains locked over the circuit previously traced. Current of normal operating strength is now sent over the cable in the direction from 10 toward 11. This current passes through rectifier 41, conductor 128, upper armature and upper winding of relay 102, heating coil 109, lowermost segment of cylinder of switch 100, plunger 107 to central segment of switch cylinder 100, winding of relay 104, winding of relay 105, retard 31 and cable section 11. This strong current causes relay 105 to energize and attract both of its armatures. At its lower armature it opens the holding circuit through relay 102 while at its upper armature it places a shunt around the winding of relay 104 so that the current no longer needs to pass through the winding of that relay. Although the holding circuit for relay 102 is opened, as described, this relay remains energized on account of the current flowing through its upper winding. The strong current now flowing through the circuit as traced, causes the coil 109 to heat up and raise the temperature of the switch 100. Other things being unchanged, this strong current continues to flow and eventually the temperature of the switch 100 will be raised to a point such that the solder around the plunger 107 fuses and allows the spring 108 to move the plunger to its extreme position where it contacts with the upper closed end of the cylinder of the switch at the same time breaking contact with the lower segment of the cylinder. When this occurs the circuit through upper winding of relay 102 and the heat coil is broken at the lower contact of switch 100 and relay 102 restores without further effect. The current now passes through rectifier 41 and the energizing circuits of amplifiers 124 to 125, upper contact of switch 100, plunger 107 and middle contact of switch 100, armature and winding of relay 105, etc. as before. This current may now be adjusted, if necessary, to the proper operating value for the repeaters 124 to 125. These repeaters and repeaters 26′ to 27′, inclusive, may now be interchanged as often as desired by reversing the current in the normal way.

If it is subsequently desired to replace the amplifiers 26' to 27', inclusive, the amplifiers 126 to 127 may be substituted by first sending weak current over the line in the direction from 10 toward 11 to energize and lock up relay 103 and thereafter sending strong current in the opposite direction over the system and through the heating coil of the switch 101 in a manner entirely analogous to that described in connection with the switch 100. It is thus seen that the circuit of Fig. 6 provides four complete repeater circuits, two of which initially are held in reserve but which may be switched into the circuit separately when it becomes desirable to replace the initial repeaters permanently. It is not possible by the circuit shown in Fig. 6 to actuate the switches 100 and 101 in the opposite direction from the operations that have been disclosed. However, it is assumed that these switches are in the nature of emergency apparatus that would not be called on to operate until after one or both of the repeaters comprising tubes 24' to 25', inclusive, and 26' to 27', inclusive, have proved unsatisfactory in service. After the switches 100 and 101 have been actuated, as described, an attendant may visit the station and manually restore the switches to the position shown in the drawings, in connection with such other servicing as may be necessary.

Various modifications may be made within the spirit and scope of the claims, the circuits that have been described being illustrative of the invention rather than restrictive of the same.

What is claimed is:

1. The combination with a signal transmission line of a terminal station and a distant repeater station on said line comprising a first space discharge repeater and a second space discharge repeater, said repeaters being connected to amplify signals transmitted over said line when conditioned for operation, means to transmit current of either polarity from said terminal to said repeater station, means at said repeater station separate from said repeaters to distinguish the current of one polarity from current of the opposite polarity, one such last means causing current of one polarity to condition said first repeater for operation to amplify signals on said line and another such means causing current of the opposite polarity to condition said second repeater for operation to amplify signals on said line.

2. The combination with a line divided into sections, of a pair of repeaters connected between said sections for repeating signals between said line sections when conditioned for operation, a conditioning circuit for each repeater, each conditioning circuit being responsive to current of one polarity only, means to transmit direct current of either polarity over said line to said repeaters, a pair of unilateral valves connected between said line sections and the respective conditioning circuits for said repeaters, said valves being poled such that current of one polarity conditions one of said repeaters for operation and current of the opposite polarity conditions the other repeater for operation.

3. The combination with a line divided into sections of a pair of amplifying repeaters connected between said line sections for repeating signals from one line section to the next, each repeater comprising a cathode and anode, means to transmit over said line direct current of either polarity, two direct current connections between said line sections, each connection including the cathode and the cathode-anode energizing circuit of a different one of said repeaters, and including also a valve, the valves in said respective connections being oppositely directed, whereby direct current of one polarity on said line energizes the cathode and cathode-anode circuit of one repeater while direct current of opposite polarity on said line energizes the cathode and cathode-anode circuit of the other repeater.

4. In combination, a line having terminal stations and a repeater station intermediate said terminal stations, an amplifying repeater at said repeater station for amplifying signals transmitted over said line, a source of power current at a terminal station for transmission over said line to energize said repeater, the circuit for said power current being initially established from said source over said line to the distant terminal, and current actuated means at the repeater station effective upon establishment of power current flow over said line to shunt the power currents away from the portion of line from said repeater station toward the terminal station remote from said source.

5. In a signaling system, a line connecting terminal stations and divided into sections, a plurality of repeaters in said line connected between respective line sections, a source of current at each terminal station for energizing said repeaters, means initially establishing current flow over said line from the source at one terminal station to the opposite terminal station, means at each of two repeater stations at opposite ends of one line section, operated by said current flow to shunt the current away from said line section whereby each of said two repeaters is thereafter supplied by current from a different terminal source only.

6. In a transmission line system, a line having a normal and a spare repeater, said normal repeater being operatively associated with said line to amplify waves thereon, a polarized relay controlling operative association of said normal repeater and said spare repeater with said line, said relay operating in response to the flow of current of given polarity over said line to dissociate said normal repeater from the line and to operatively associate said spare repeater with said line.

7. In a transmission line system, a line having a normal and a spare repeater, said normal repeater being operatively associated with said line to amplify waves thereon, a relay having its winding in circuit with said line and said normal repeater, a second relay having its winding in circuit with said spare repeater and line, said latter circuit being opened in the energized condition of said normal repeater, said second relay having contacts controlling the energizing circuit of said normal repeater, a valve connected between each relay winding and the line, whereby current of one polarity on the line actuates the first relay to associate the normal repeater with the line and current of opposite polarity operates the second relay to substitute the spare repeater for the normal repeater.

8. In a transmission line system, a normal and a spare repeater, said normal repeater being operatively associated with said line to amplify waves thereon, a movable contact normally establishing operative relation between the line and normal repeater and adapted when moved to its alternate position to dissociate the normal repeater from the line and operatively associate the spare repeater therewith, said contact being

held in normal position by a fusible material, and means responsive to current flow of predetermined characteristic on said line for causing said fusible material to melt and allow said contact to move to its alternate position.

9. In a transmission line system, a line having a ground return, repeaters at intervals in said line supplied with energizing current from a distant source over said line, and means at a repeater controlled from current on said line for grounding the energizing circuit of said repeater.

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