June 27, 1939. E. C. BERTNOLLI ET AL 2,164,185

VOICE OPERATED REPEATER

Filed May 22, 1937 2 Sheets-Sheet 1

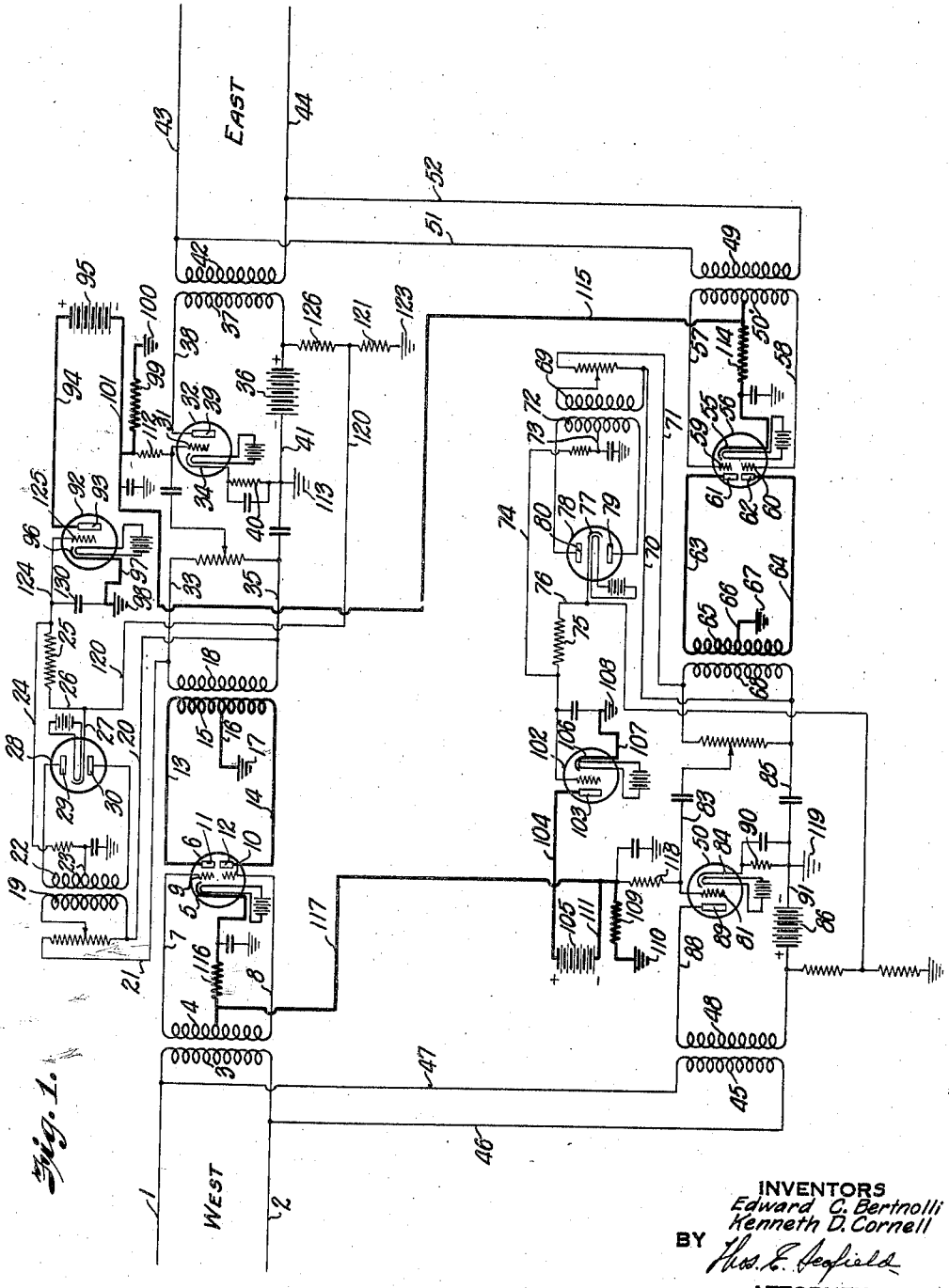


Fig. 1.

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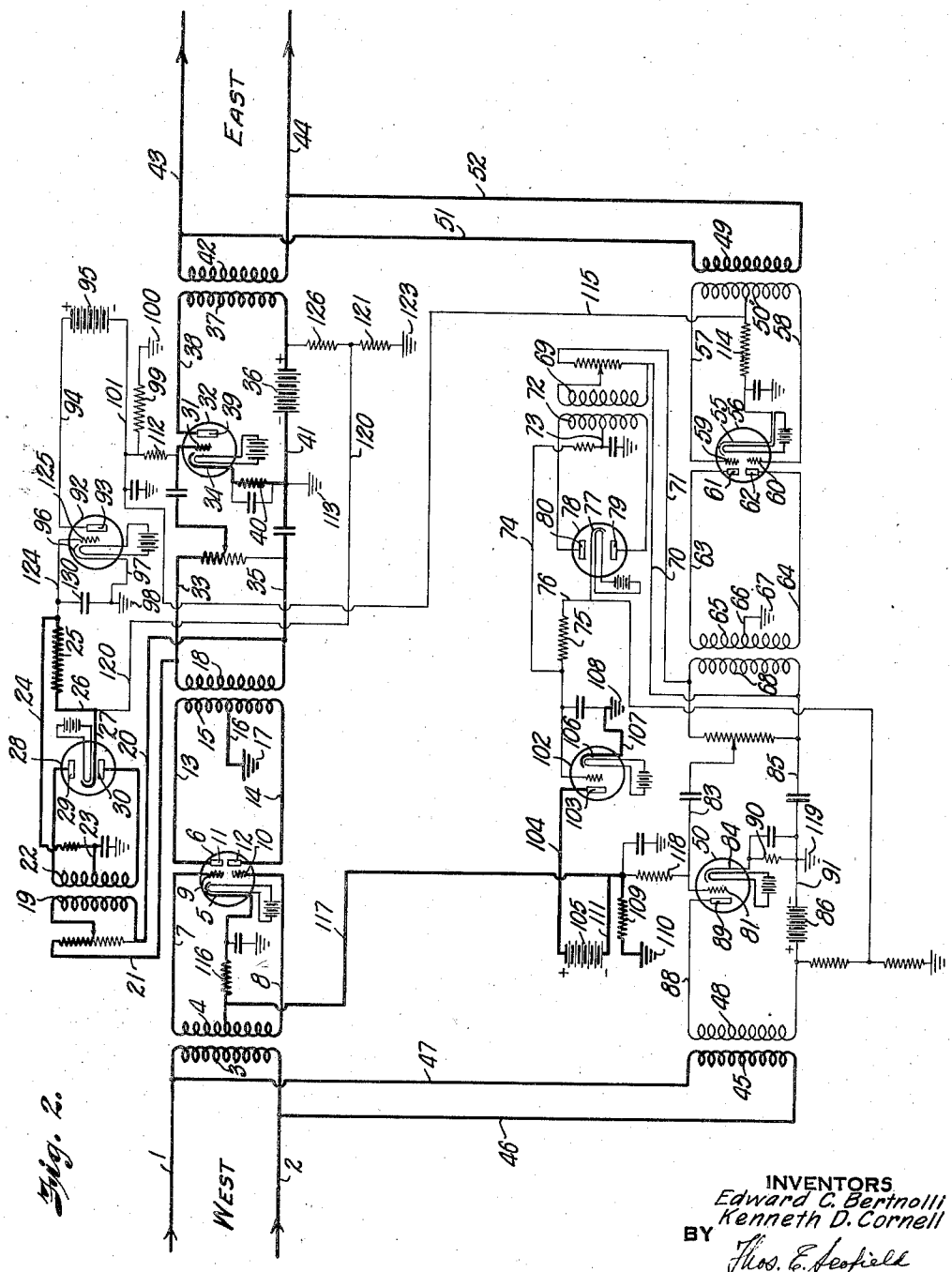


Fig. 2.

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VOICE OPERATED REPEATER

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5 Claims. (Cl. 179—170)

Our invention relates to voice operated repeaters, and more particularly to a two-way transmission circuit containing oppositely directed repeaters which are conditioned for operation one at a time.

In the repeaters or amplifiers now in general use, artificial balancing net works are employed which control the gain output of the amplifier. These networks are used to simulate the line to which the repeater is connected, and are placed in the circuit with a hybrid coil. The gain of the repeater is limited to the balance of the hybrid coil and to the impedance matching of the networks to the actual line. Furthermore, the amplified energy is divided—one-half of it being absorbed by the artificial line, and the other half of the tube output being used as line amplification energy.

Numerous concerns employ field telephones and utilize spur lines between amplifying stations. Under these conditions it is very difficult to get a good network balance and this penalizes amplification.

One object of our invention is to provide an electronic voice operated repeater, in which neither a hybrid coil nor balancing networks are used.

Another object of our invention is to provide a repeater system in which the received signal is amplified directly, enabling any desired gain to be obtained, resulting in better energy quality, as distortion by a mismatched network is eliminated.

A further object of our invention is to improve the operation of a voice operated repeating system, particularly as regards positive directional operation and freedom from internal high frequency circulatory currents or internal oscillation.

In general, our invention contemplates the provision of a two-way repeating system which under the normal or no-voice condition has both the west to east and east to west input sides of the system in operative condition, and the outputs of the west to east and east to west sides standing open or cut off from the line, the repeater being in condition to amplify in either direction without the possibility of setting up an internal high frequency circulatory condition.

When voice or other energy is introduced in either direction, that side is placed in amplifying condition, while the opposite side is automatically blocked out, making it impossible for it to conflict with the operation of the amplifying side.

In the interests of clarity and simplification, our invention will be described with respect to voice operated circuits and two-way transmission, it being understood, however, that the invention is applicable to other types of transmission and to one-way as well as two-way transmission or amplification.

In the accompanying drawings, which form part of the instant specification, and which are to be read in conjunction therewith, and in which like reference numerals are used to indicate like parts in the various views;

Fig. 1 is a diagrammatic view of a voice operated repeater system shown in the normal or no-voice condition, those parts of the circuit carrying current being shown in heavy lines.

Fig. 2 is a diagrammatic view of the system shown in Fig. 1, amplifying signals in the west to east direction, those parts of the circuit carrying current being shown in heavy lines.

More particularly, referring now to the drawings, the line from the west is shown as comprsing conductors 1 and 2, supplying energy to the primary 3 of a transformer, the secondary 4 of which is center tapped to the cathode 5 of thermionic tube 6. The ends of the secondary 4 are connected by conductors 7 and 8, respectively, to grids 9 and 10 of the tube 6. The plates 11 and 12 of the tube 6 are connected by conductors 13 and 14 to the ends of the primary coil 15 of a transformer. The coil 15 is center tapped by conductor 16 and connected to ground 17. The secondary coil 18 is inductively coupled to the primary 15. The primary coil 19 of a transformer is connected across the secondary coil 18 by means of conductors 20 and 21. A secondary coil 22 is inductively coupled with the primary coil 19. Coil 22 is center tapped by conductor 23, which center tap is connected to one end of resistance 25 by conductor 24. The other end of resistance 25 is connected by conductor 26 to the cathode 27 of full wave rectifier tube 28. The ends of secondary 22 are connected to plates 29 and 30, respectively, of the tube 28. The output of the secondary coil 18 is impressed upon the grid 31 of the thermionic tube 32 through conductor 33, the cathode 34 of the tube 32 being connected to the other side of the secondary 18 by conductor 35. The plate current supplied to tube 32 is from battery 36, the plate current flowing from the positive terminal of battery 36 through the primary coil 37 of a transformer, through conductor 38 to the plate 39, to cathode 34, through resistance 40, through conductor 41, to the negative side of the plate battery 36. Variations in the plate current through primary 37 will be inductively reproduced in the secondary coil 42, across which the conductors 43 and 44 of the line are connected. Across the lines 1 and 2, by means of conductors 46 and 47, is also connected the sec-

ondary coil 45 of a transformer, the primary coil, 48, of which is placed in the plate circuit of thermionic tube 50. The primary coil 49, of which coil 50 is the secondary, is connected across lines 43 and 44 by means of conductors 51 and 52. Coil 49 is analogous to coil 3, while coil 50′ is analogous to coil 4. The center of coil 50′ is connected to the cathode 55 of thermionic tube 56. The grids 59 and 60 of tube 56 are connected by conductors 57 and 58 to the ends of coil 50′. The plates 61 and 62 of thermionic tube 56 are connected by conductors 63 and 64 across the primary coil 65 of a transformer, which is center tapped by conductor 66 to ground 67. The coil 65 is inductively coupled to its secondary coil 68, it being understood that coils 65 and 68 are analogous to coils 15 and 18.

The primary coil 69 of a transformer is connected across coil 68 by means of conductors 70 and 71. A secondary coil 72 is inductively coupled to the primary coil 69, and has its center tapped by conductor 73. Center tap 73 is connected by conductor 74 to one side of resistance 75, the other side of which is connected by conductor 76 to the cathode 77 of the full wave rectifier tube 78. Rectifier tube 78 is provided with anodes 79 and 80 connected across the terminals of secondary coil 72. A portion of the output of secondary coil 68 is impressed upon the grid 81 of tube 50, by means of conductor 83, the other side of coil 68 being connected by conductor 85 to cathode 84 of the tube 50. The plate supply for the tube 50 is from battery 86, current flowing from the positive terminal of battery 86 through the primary coil 48 of the transformer, through conductor 88 to the anode 89 of the tube 50, thence, to cathode 84, through resistance 90, through conductor 91 to the other side of the battery 86. A thermionic tube 92 has its anode 93 connected by conductor 94 to the positive terminal of a battery 95. The cathode 96 of the tube 92 is connected by conductor 97 to ground 98. Resistance 99 has one end thereof grounded at 100. The other end of resistance 99 is connected by conductor 101 to the negative terminal of battery 95. Another control tube 102 has its anode 103 connected by conductor 104 to the positive terminal of a battery 105. The cathode 106 of tube 102 is connected by conductor 107 to the ground 108. A resistance 109 is grounded at 110. The other side of resistance 109 is connected by conductor 111 to the negative terminal of battery 105.

In operation, referring now to Fig. 1, which shows the normal or no-voice condition of the system, it will be observed that current is flowing from the positive terminal of battery 95 through conductor 94 to plate 93 to cathode 96, to ground 98, to ground 100, through resistance 99, through conductor 101, to the other side of the plate battery 95. The IR drop of the plate current through resistance 99 creates a voltage across the resistance, that end of the resistance 99 which is connected to cathode being positive and the other end of the resistance being negative. It will be observed that the negative end of resistance 99 is connected by resistance 112 to the grid 31 of tube 32. Since the cathode 34 of tube 32 is grounded through resistance 40 at ground 113, grid 31 will be highly negative with respect to the cathode, thus blocking or biasing out tube 32.

The positive end of resistance 99 is grounded at 100. The center tap of primary coil 65 is grounded at 67, thus impressing a positive potential upon anodes 61 and 62 of tube 56 through conductors 63 and 64. The cathode 55 of tube 56 is connected to resistance 114, and conductor 115 to the negative side of resistance 99. It will be apparent from the foregoing that as long as plate current is flowing through the circuit of tube 92, that tube 32 will be blocked and tube 56 will be in operative or signal receiving position.

Similarly, current will be flowing from the positive terminal of battery 105 through conductor 104, through anode 103, through cathode 106, through conductor 107, to ground 108, to ground 110, through resistance 109, through conductor 111, to the other side of battery 105. The IR drop through resistance 109 will cause a potential difference across the resistance, that side of the resistance which is connected to the cathode being positive. The positive end of the resistance 109, it will be observed, is grounded at 110. The center tap of coil 15 is grounded at 17. Current will flow from the positive side of resistance 109 through ground 110, through ground 17, through both sides of coil 15, through conductors 13 and 14 to anodes 11 and 12 of tube 6 to cathode 5 of tube 6, through resistance 116, through conductor 117, to the negative side of resistance 109.

Similarly, it will also be observed that the negative side of resistance 109 is connected by resistance 118 to the grid 81 of tube 50. The cathode 84 of tube 50 is connected by resistance 90 to ground 119, which is thus connected to the ground 110 and hence to the positive side of resistance 109. It will be clear that grid 81 of tube 50 will be highly negative with respect to the cathode of tube 50 as long as current is flowing through the plate circuit of control tube 102, thus blocking or biasing out tube 50.

In the normal or no-voice condition therefore, as has been just described, the input tube 6 of the west to east amplifier, and the input tube 56 of the east to west amplifier will be in operative condition with the output tube 32 of the west to east amplifier and the output tube 50 of the east to west amplifier in blocked or inoperative condition.

Let us now consider the operation of the system. When a signal is received from the west side of the line, the energy in the line will pass through coils 3, and 45. Since coil 45 is coupled with an output coil 48, which, furthermore, is blocked, nothing will occur. No energy will be transmitted from coil 45 to coil 48. Tube 6 is in operative condition so that the energy will be picked up by the secondary coil 4 and be impressed upon the grids 9 and 10 of the tube 6, being amplified thereby and passed through the plate circuit thereof which includes the primary coil 15. Energy will be picked up by the secondary coil 18 and impressed across primary coil 19, which is coupled to its secondary 22 which is in turn coupled to the full wave rectifier 28. The output of the rectifier tube 28 is connected across resistance 25. The IR drop through the resistance 25 will set up a potential across the resistance, that end of the resistance which is connected to the cathode being positive, and the other end being negative. It will be observed that the positive end of the resistance 25 is connected through conductor 120 through resistance 121, to the ground 123, through ground 98, to the cathode 96 of tube 92. The negative end of resistance 25 is connected by conductor 124 to grid 125 of tube 92, so that the rectified current flowing through resistance 25 will cause grid 125 of tube 92 to become

highly negative with respect to cathode 96, thus blocking the tube 92.

It will also be observed that normally a positive potential from battery 36 is impressed through resistance 126, conductor 120, conductor 26, resistance 25, conductor 124, upon the grid 125 of the tube 92, thus insuring a high plate current through tube 92. The IR drop across resistance 25 is sufficiently high so that this positive potential is overcome and the grid 125 is made sufficiently highly negative to block out tube 92. As soon as the flow of plate current through resistance 99 ceases, the negative bias impressed upon the grid 31 from the resistance 99 is eliminated, and tube 32 is made operative. At the same time the plate potential on tube 56 is eliminated and that tube is made inoperative. It will be seen, therefore, that a portion of the output of secondary coil 18 is rectified in tube 28 and used to block control tube 92, which in turn unblocks output amplification tube 32 and renders input amplifier tube 56 inoperative.

The energy coming from the west then is amplified by tube 32, the amplified energy flowing through the primary coil 37, which is in the plate circuit of the tube 32. The energy is picked up by the secondary coil 42, across which the conductors 43 and 44 of the line are connected.

Howling or oscillatory action is prevented since tube 56 is automatically rendered inoperative whenever tube 32 is rendered operative. It will be seen therefore that whenever energy is being transmitted from west to east, no energy can be transmitted from east to west, since both tubes of the east to west amplifier are in inoperative condition during the passage of a signal from west to east.

The potential across resistance 25 is impressed upon a condenser 130, so that if energy being transmitted from west to east momentarily ceases, the control tube 92 will remain momentarily blocked due to the potential impressed upon the grid thereof from the condenser 130, which has become charged. It will also be observed that one side of condenser 130 is grounded at 98, so that condenser 130 is shunted by resistance 25 and resistance 121. The charge of condenser 130 therefore is adapted to leak off through resistances 121 and 25. Any suitable time interval may be obtained by the value of condenser 130 or by altering the resistance 121. The value of resistance 25 is determined by the IR drop necessary to block tube 92 against the potential of battery 36.

Should a signal be received from the east for transmission to the west, the operation is the same except control tube 102 is biased out by rectified energy from rectifier tube 78 as will be apparent to those skilled in the art.

It will be observed that we have accomplished the objects of our invention. We have provided a voice operated repeater in which neither the hybrid coil nor balancing networks are employed. The received signal is amplified directly to the line and any desired gain may be had. Positive directional operation is obtained and freedom from high frequency circulatory currents or internal oscillation is achieved.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and is within the scope of our claims. It is further obvious that various changes may be made in details within the scope of our claims without departing from the spirit of our invention. It is, therefore, to be understood that our invention is not to be limited to the specific details shown and described.

Having thus described our invention, what we claim is:

1. In a transmission system having an input thermionic tube having a grid and an output thermionic tube having a grid, said input thermionic tube normally being operative and said output tube normally being inoperative, a control thermionic tube having a plate circuit the potential of which is impressed upon the grid of the output thermionic tube to render it inoperative, a rectifier tube, means for rectifying a portion of the output energy of said first thermionic tube, means for impressing said rectified energy upon the grid of said control tube to render it inoperative whereby incoming energy is adapted to render said output tube operative in response thereto.

2. In a repeating system having two one-way transmission channels each comprising an input thermionic tube and an output thermionic tube, a pair of control tubes each adaped to render the input tube of one channel operative and the output tube of the other channel inoperative, and means operated by energy from one of said transmission channels for nullifying the action of the control tube affecting the output tube of said energy receiving channel.

3. In a two-way voice operated repeater system, a pair of one-way transmission channels each having an input tube and an output tube, control tubes for rendering the input tubes of respective channels operative, and for controlling the output power level of respective opposite output tubes, and means responsive to the output of the input tube of one of said channels for controlling the control tube governing the output tube of said channel.

4. In a repeating system having two line sections, a two-way repeating means adapted to repeat signals between line sections comprising two one-way transmission channels, each having an input thermionic tube having a grid and an output thermionic tube having a grid, a pair of control thermionic tubes each having a plate circuit the potential of which is impressed upon the grid of respective output thermionic tubes to render them inoperative, a pair of rectifying tubes, means for rectifying a portion of the output energy of each of said input tubes, means for impressing said rectified energy upon respective grids of control tubes to render them inoperative, the construction being such that incoming energy from one direction is adapted to render the output tube of one of said transmission channels operative and the input tube of the other of said transmission channels inoperative.

5. In a repeating system having two line sections, a two-way repeating means adapted to repeat signals between line sections comprising two one-way transmission channels each having an input thermionic tube having a grid, and an output thermionic tube having a grid, a pair of control thermionic tubes each having a plate circuit, a resistance in said plate circuit, means for connecting said resistance to the plate-cathode circuit of one of said input thermionic tubes to enable the IR drop across said resistance to furnish the plate voltage for said tube, means for connecting said resistance to the grid of the output tube of the opposite transmission channel to apply a blocking voltage to the grid of said tube

whereby rendering it inoperative, the other of said control tubes being similarly provided with a plate circuit having a resistance and means for similarly connecting said resistance to enable the IR drop thereacross to act as the plate potential for the other of said input tubes and the grid blocking potential of the other of said output tubes, a pair of rectifying tubes, means for rectifying a portion of the output energy of each of said input tubes, and means for impressing said rectified energy upon respective grids of said control tubes to render them inoperative.

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