Nov. 21, 1933. W. H. T. HOLDEN 1,935,744

DUPLEX RADIO SYSTEM

Filed Nov. 2, 1932 2 Sheets-Sheet 1

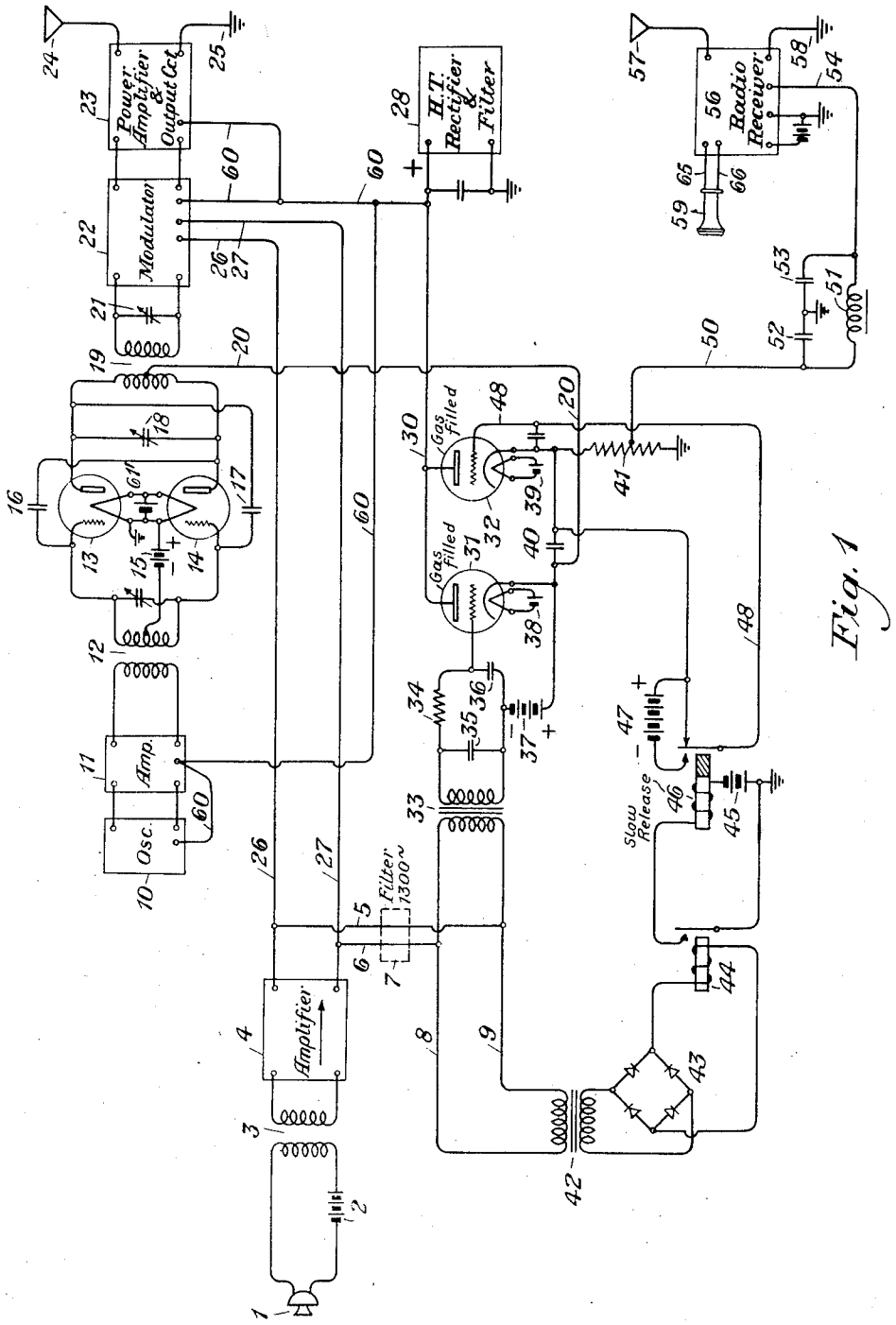


Fig. 1

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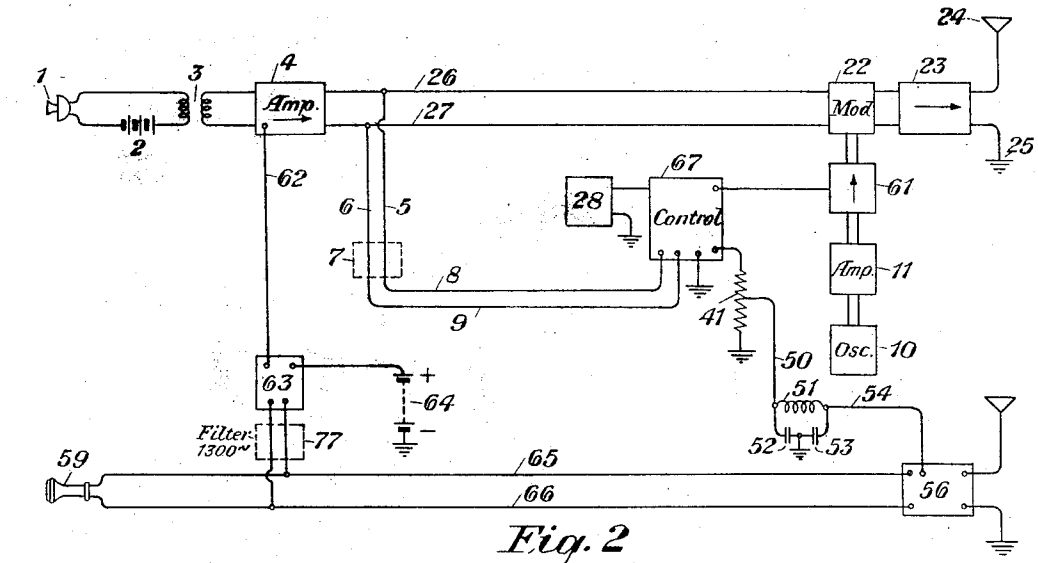


Fig. 2

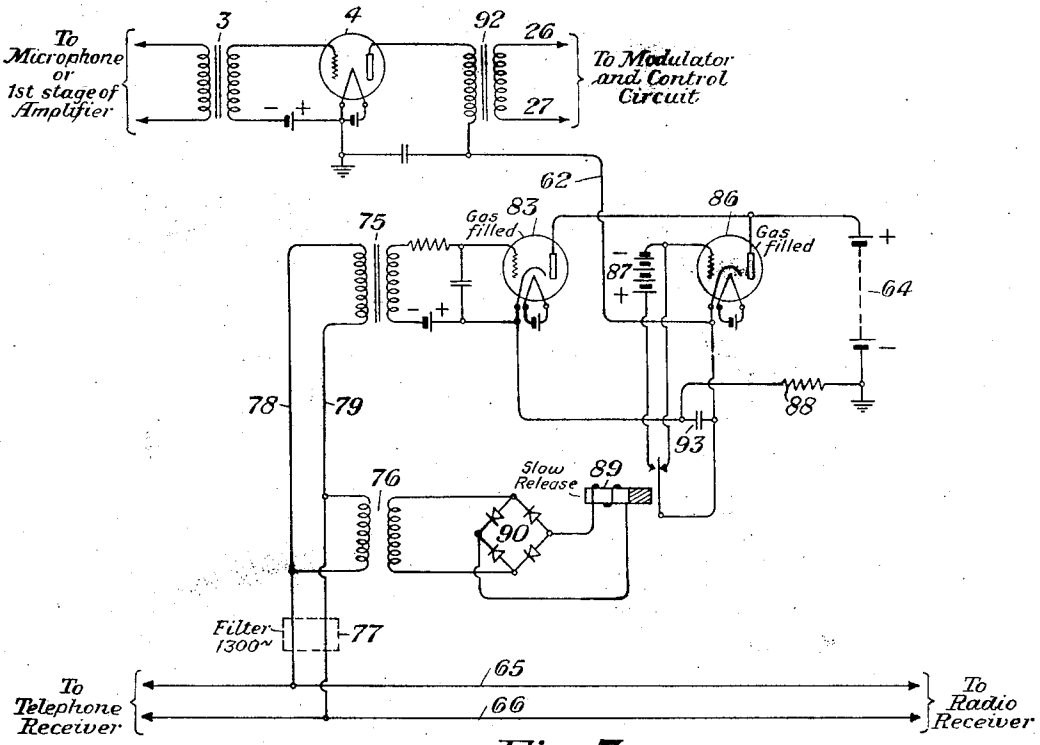


Fig. 3

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DUPLEX RADIO SYSTEM

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Application November 2, 1932. Serial No. 640,897

6 Claims. (Cl. 250—9)

This invention relates to electrical circuits, and more particularly to such circuits for the automatic duplex operation of a radio telephone or telegraph terminal, including a radio transmitter and receiver, in which only one or the other of these devices is operative, at any one time, and in which voice currents control the operation of the switching devices for transferring from "receive" to "transmit" and vice versa.

Many such arrangements have been proposed in the past, which have depended for their operation upon the use either of electromagnetic relays, controlled by vacuum tubes, or upon the use of vacuum tubes as switching elements. The latter have the disadvantage of not cutting off sharply, and of requiring fairly large inputs. The use of vacuum tubes also leads to somewhat complicated circuit arrangements, owing to their limited power capacity. The use of vacuum tubes, however, has a definite advantage over the use of tube controlled relays, as the speed of operation of the vacuum tube device can be made very much higher than the possible speed of relay operation.

One of the objects of this invention is to provide means for accomplishing the switching operation from "receive" to "transmit" and vice versa by the use of gas-filled thermionic discharge tubes. Such tubes have the property of extremely rapid operation, requiring only from one to ten microseconds to pass from the non-conducting to the conducting state. They are also capable of passing considerable arc currents, as compared with vacuum tubes of equal size and cathode consumption, and furthermore pass discontinuously from the non-conducting to the conducting state.

Other objects and features of this invention may be understood more fully from the following description together with the appended drawings, in the Figs. 1, 2 and 3 of which the invention is illustrated.

Figure 1 is a circuit diagram showing a preferred form of the invention. Figs. 2 and 3 are modifications of the invention. Similar reference characters have been used to denote like parts in all of the figures.

Referring to Fig. 1, reference character 1 indicates a telephone transmitter or microphone, which is supplied with current by battery 2, through the primary of transformer 3, the secondary of which delivers the microphone output to amplifier 4. The output of amplifier 4 is connected to modulator 22 over conductors 26 and 27. Conductors 5 and 6 connect conductors 26 and 27 to conductors 8 and 9, through a selective net work 7, tuned to 1300 cycles. This device has been indicated in dotted lines in the drawings, as it is not essential to the operation of the circuit and may be omitted. It is, however, useful in reducing the possibility of false operation due to noise. Conductors 8 and 9 are connected to the primaries of transformers 33 and 42. The secondary of transformer 33 is connected to the grid of gas-filled thermionic tube 31 through current limiting resistance 34. Grid bias to the grid of tube 31 is obtained from battery 37. Condensers 35 and 36 prevent high frequency transients or radio frequency disturbances from reaching the grid of tube 31. The cathode of tube 31 is connected to the plate circuit of the control amplifier comprising tubes 13 and 14 by conductor 20, while the anode of tube 31 is connected to conductor 30 and this is in turn connected to the positive terminal of high tension rectifier and filter 28 of a type well known in the art, which supplies plate voltage over conductor 60 to the vacuum tubes of the radio transmitter apparatus comprising oscillator 10, amplifier 11, modulator 22 and the power amplifier apparatus 23. The anode supply of tubes 13 and 14 will thus be opened if there be no arc in tube 31, and closed if there be an arc in the aforesaid tube 31. The radio transmitter is made up of oscillator 10 which is connected to amplifier 11. Amplifier 11 in turn is connected through tuned transformer 12 to the grids of tubes 13 and 14. Battery 61' supplies filament current to these tubes, while battery 15 furnishes grid bias. This amplifier is neutralized by condensers 16 and 17 in the manner well known in the art. The output of tubes 13 and 14 is connected to the primary of transformer 19, tuned by condenser 18, while the secondary, tuned by condenser 21, delivers the amplified carrier to modulator 22, which in turn delivers modulated carrier to the power amplifier and output circuits 23, and thence to transmitting aerial 24 and ground 25. Evidently, if there be no arc in tube 31, and hence no plate voltage on tubes 13 and 14, no carrier will be supplied from oscillator 10 and hence none radiated.

Incoming signals will be received by antenna 57 and ground 58, and after amplification and detection in receiver 56, the signals will be transmitted to receiver 59. The plate battery supply to the radio receiver is obtained over conductor 50, through the filter composed of inductance 51, and condensers 52 and 53, and over conductor 54 to the receiver. Conductor 50 is supplied with voltage from the tap on potentiometer resistance 41, through which current will flow from rectifier 28 and the arc path of tube 32, when an arc exists therein. When there is no arc in this tube, 32, plate voltage is removed from the radio receiver 56 and the receiving side of the circuit is thus disabled.

It will thus be seen that this combination of transmitter and receiver will be arranged to transmit or receive, respectively, according to whether an arc is established in tube 31 or 32.

The cathodes of these two tubes are interconnected through condenser 40, so that starting of an arc in one will extinguish the arc in the other, due to the voltage surge transmitted through condenser 40, in the manner well known in the art.

The control of tubes 31 and 32 is accomplished in the following manner: Consider first that signals or speech are being received, and that there is no input to microphone 1. An arc exists in tube 32. This represents the normal state of the station. If now speech energy is applied to microphone 1, amplifier speech currents will be applied to conductors 8 and 9 through transformer 3, amplifier 4, conductors 26, 27, conductors 5, 6, through selective circuit 7, if used, to conductors 8 and 9. The first impulse of speech voltage applied to the grid of tube 31 will cause an arc to strike therein, supplying plate voltage to tubes 13 and 14 and starting the transmitter. Owing to the high speed of operation of tube 31, this will not cause any serious or appreciable clipping of the initial syllables. The striking of the arc in tube 31 raised its cathode suddenly to a positive potential only 20 volts or less below that of conductor 30. This surge transmitted through condenser 40 raises the cathode thereof to a high positive potential, reversing the voltage across the tube 32 and stopping the arc therein.

At the same time, speech currents applied to transformer 42 over conductors 8 and 9 will be rectified in rectifier 43 and operate relay 44, which will in turn operate relay 46, and apply the high negative bias from battery 47 to the grid of tube 32, over conductor 48, holding this tube in a non-arcing condition before the charge on condenser 40 has leaked off.

Upon the cessation of the speech or signal input to transformers 33 and 42, relay 44 will release. After a slight delay or "hangover", which has been found desirable in systems of this type, relay 46 will release, removing the bias from the grid of tube 32 and restoring this grid to zero potential with respect to the cathode of the aforesaid tube. An arc will immediately strike therein, and in the same manner will send a positive surge into the cathode of tube 31, suppressing the arc therein, and so stopping the radiation of carrier. Potentiometer resistance 41 maintains the load constant on rectifier 28, avoiding voltage fluctuation, and at the same time plate voltage is reapplied to receiver 56 from the tap of poteniometer resistance 41.

With the arrangements thus far described at both terminals of a radio telephone circuit, automatic duplex operation will be obtained. But if a subscriber at one station attempts to interrupt the subscriber at the other, he will transfer his station to the transmitting condition, while the other station remains in the transmitting condition also, so long as the subscriber thereat goes on talking. The circuit will thus be broken without the knowledge of either subscriber.

This may be avoided by the arrangement indicated in Figs. 2 and 3. Fig. 2 illustrates the arrangements for one terminal with the addition of the transmitter input cut-off unit 63, the details of which are shown in Fig. 3. The same reference characters have been used as in Fig. 1 to indicate the same circuit elements as those in Fig. 1. Reference characters 61 indicates on Fig. 2 the stage of amplification composed of tubes 13 and 14, together with their associated devices, shown on Fig. 1, while reference character 67 refers to the gas-filled tubes 31 and 32 of Fig. 1, together with their associated devices. Fig. 2 differs from Fig. 1 by the addition of control element 63, bridged across conductors 65 and 66, which connect telephone receiver 59 to radio receiver 56. A selective network 77, passing 1300 cycles, may be interposed between conductors 65, 66 and control circuit 63, to reduce the sensitivity of the latter to noise frequencies.

Control circuit 63 is similar to 67, and is arranged to open the circuit by removing plate voltage from one stage of amplifier 4 when speech or signals are being received from radio receiver 56. This prevents speech input to microphone 1 from switching off the receiver and placing the transmitter in operation when signals are being received, but releases, after a short delay or "hangover", when signals are not being received.

The detailed circuit of control device 63 and its associated apparatus is shown in Fig. 3. Conductors 65 and 66 carry the output of the radio receiver. When currents are present in these conductors as when signals are being received, alternating voltage is applied to conductors 78 and 79. Device 77 consisting of a selective network passing only a band of currents having frequencies within a few hundred cycles range, about 1300 cycles as a center, together with an amplifier if required, may be utilized to decrease the sensitivity of the control device to noise or static, while the amplifier may be needed to raise the energy level to a sufficient value if the receiver output is not already at a high level. Conductors 78 and 79 apply alternating voltage to the grid of gas-filled tube 83, through transformer 75, and also to rectifier 90 through transformer 76. When there are no signals being received and hence no input to tube 83 or rectifier 90, relay 89 will be released and there will be no grid bias on the grid of gas-filled thermionic tube 86. An arc will strike in this tube and supply space current to vacuum tube 4, from the positive terminal of anode battery 64, to and through the arc path of tube 86 to conductor 62 to and through the primary of transformer 92 to the plate of tube 4. The input circuit from microphone to modulator will therefore be operative and input to the microphone will operate the circuit previously described to render the receiver inoperative.

If, however, signals are received when the input circuit to the transmitter is not energized, the input to tube 83 as hereinbefore described will cause an arc to strike therein. The positive surge transmitted from the cathode of tube 83 to that of tube 86 when current starts to flow through tube 83 and resistance 88 will raise the cathode potential of tube 86 to such a value that the arc therein will be extinguished, so interrupting the plate supply of vacuum tube 4, preventing speech or signal input from reaching the modulator or the transmitting control circuit. The transmitter circuit is thus rendered inoperative. At the same time, the signal input to rectifier 90 has been rectified therein and caused slow release relay 89 to operate, and this will occur before the charge on condenser 93 has been able to leak off. When relay 89 operates it places a high negative bias from battery 87 on the grid of tube 86, so that this tube will be held inoperative until signals have ceased to be received and relay 89 has had time to release. When this occurs, the grid of tube 86 is reduced to zero bias by the release of relay 89 and an arc strikes in

this tube. This restores plate current to tube 4 and also extinguishes the arc in tube 83, due to the surge sent through condenser 93. It is, therefore, impossible with the complete arrangement shown in Figs. 2 and 3 at both terminals to produce a lockout whereby both receivers are simultaneously disabled.

While this invention has been described with regard to a particular embodiment thereof which is intended for use in radiotelephone systems, it is obviously capable of many other applications, particularly to carrier or voice frequency telephony or telegraphy over wire lines. It is to be understood that this invention is not limited to the specific arrangement described, but includes any and all organizations falling within the scope and spirit of the appended claims.

What is claimed is:

1. A station comprising a radio transmitter and a radio receiver, a circuit for impressing signals on said transmitter, a source of voltage for operating said transmitter and said receiver, a normally operated gas-filled discharge tube, means for extending a circuit from said source to said receiver over the cathode-anode circuit of said normally operated tube, a normally unoperated gas-filled discharge tube connected to said first mentioned circuit and operated by signals transmitted over said circuit to said transmitter, means for extending a circuit from said source to said transmitter over the cathode-anode circuit of said normally unoperated tube when operated, and means controlled by the operation of either of said tubes for deenergizing the other of said tubes.

2. A station comprising a radio transmitter and a radio receiver, a circuit for impressing signals on said transmitter, a source of voltage for operating said transmitter and said receiver, a normally operated gas-filled discharge tube, means for extending a circuit from said source to said receiver over the cathode-anode circuit of said normally operated tube, a normally unoperated gas-filled discharge tube connected to said first mentioned circuit and operated by signals transmitted over said circuit to said transmitter, means for extending a circuit from said source to said transmitter over the cathode-anode circuit of said normally unoperated tube when operated, means controlled by the operation of said last mentioned tube for deenergizing said first tube, and relay means operated by the signals transmitted to said transmitter for maintaining said first tube in a deenergized condition.

3. A station comprising a radio transmitter and a radio receiver, a circuit for impressing signals on said transmitter, a source of voltage for operating said transmitter and said receiver, a normally operated gas-filled discharge tube, means for extending a circuit from said source to said receiver over the cathode-anode circuit of said normally operated tube, a normally unoperated gas-filled discharge tube connected to said first mentioned circuit and adapted to be operated by signals transmitted over said circuit to said transmitter, means for extending a circuit from said source to said transmitter over the cathode-anode circuit of said normally unoperated tube when operated, and a condenser connected between the cathodes of said tubes whereby the discharge of one tube will apply through said condenser to the cathode of the other tube a potential of such valve as to prevent it from discharging.

4. A station comprising a radio transmitter including vacuum tube amplifying apparatus and a radio receiver including vacuum tube amplifying apparatus, a circuit for impressing signals on said transmitter, two gas-filled discharge tubes, the first of said tubes being normally in an operated condition, the second of said tubes being normally unoperated but connected to said first mentioned circuit and adapted to be operated by signals transmitted over said circuit to said radio transmitter, means controlled by the operation of said first tube for applying an operating voltage to the plate circuit of the vacuum tube amplifying apparatus of said receiver, means controlled by the operation of said second tube for applying an operating voltage to the plate circuit of the vacuum tube amplifying apparatus of said transmitter, and means for so interconnecting said tubes that the operation of one will block the operation of the other.

5. A station comprising radio transmitter apparatus and radio receiver apparatus, a local transmitting circuit for transmitting signals to said transmitter, a local receiving circuit for receiving signals from said receiver, a normally operated gas-filled discharge tube and means controlled by said tube when operated for maintaining said receiver in an operated condition, a normally unoperated gas-filled discharge tube and means controlled by said tube when operated for causing said transmitter to be operative, means for connecting said last mentioned tube to said local transmitting circuit whereby said tube may be operated by the signals transmitted thereover, means controlled by the operation of either of said tubes for causing the deenergization of the other, and means controlled by the transmission of signals over said local receiving circuit for disabling said local transmitting circuit.

6. A station comprising radio transmitter apparatus and radio receiver apparatus, a local transmitting circuit for transmitting signals to said transmitter, a local receiving circuit for receiving signals from said receiver, a normally operated gas-filled discharge tube and means controlled by said tube when operated for maintaining said receiver in an operated condition, a normally unoperated gas-filled discharge tube and means controlled by said tube when operated for causing said transmitter to be operative, means for connecting said last mentioned tube to said local transmitting circuit whereby said tube may be operated by the signals transmitted thereover, means controlled by the operation of either of said tubes for causing the deenergization of the other, a second normally operated gas-filled discharge tube, means controlled by the operation of said tube for maintaining said local transmitting circuit in an operative condition and means controlled by the deenergization of said tube for disabling said local transmitting circuit, a second normally unoperated gas-filled discharge tube, means for connecting said last mentioned tube to said local receiving circuit whereby said tube may be operated by the signals transmitted thereover, and means controlled by the operation of either of said two last mentioned tubes for deenergizing the other.

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