

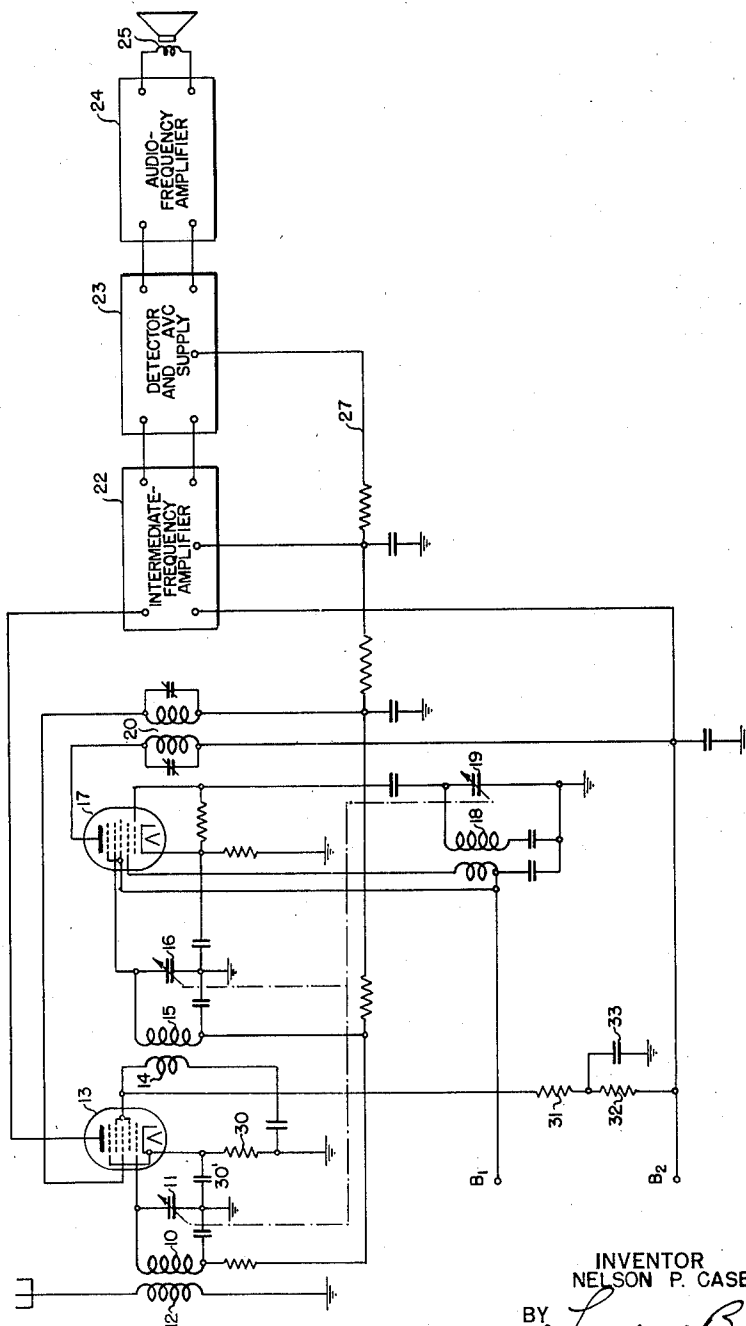
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DUPLEX VACUUM-TUBE REPEATER

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DUPLEX VACUUM-TUBE REPEATER

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This invention relates generally to a duplex amplifier or repeater stage and particularly to such a stage comprising two output circuits, one of which is substantially free from frequency components of one of the signals being amplified or repeated, and is also substantially free from heterodyne sum or difference frequency components of signals being amplified or repeated.

Vacuum-tube repeaters are commonly utilized to repeat or amplify two or more signal inputs having components of substantially different frequencies. Such devices have been utilized to provide a reflex amplification of a signal in a modulated-carrier signal receiver, thus to minimize the number of tubes required to provide a desired gain. Such reflex amplifier stages have been utilized to effect a dual amplification of an audio-frequency signal and a carrier-frequency signal or, in the case of a superheterodyne receiver, to effect an amplification of an intermediate-frequency signal and a carrier-frequency signal or an audio-frequency signal. Such stages of the prior art, however, have had the disadvantage that frequency components of each of the signals amplified, as well as heterodyne sum and difference frequency components of the signals amplified, were present in the output circuit or output circuits of the stage. It has, therefore, been essential in the prior art systems that all components of each of the signals to be repeated or amplified be of a substantially different frequency than all other signal or modulation components, that is, of a sufficiently different frequency so that they can be separated by filters. If the above conditions are not satisfied, it has been impossible to separate the repeated or amplified signals into separate useful channels in the customary manner. These conditions have necessarily placed restrictions on the relationship of frequencies of the signal components which may be successfully amplified in the same stage. Also, since it is impossible to construct a theoretically perfect filter, the operation of all duplex amplifier stages of the prior art has been impaired to some degree.

It is an object of the invention to provide an improved duplex repeater stage.

It is another object of the invention to provide a duplex repeater stage having an output circuit in which are developed only signal components of the frequency of one of the signals being repeated by the stage.

It is a further object of the invention to pro-

vide a duplex repeater in which only the components of one of the signals being repeated need be of a substantially different frequency than the sum or difference frequency components of the two signals being repeated.

In accordance with the invention there is provided a duplex repeater stage comprising a vacuum tube including two repeater sections utilizing the same electron stream derived from the cathode of the tube. The first section includes the cathode, a first signal-input electrode and a first output electrode, while the second section includes a second signal-input electrode and a second output electrode, in the order named, the first output electrode having portions respectively disposed between the cathode and the second signal-input electrode and between the second signal-input electrode and the second output electrode. The stage includes provisions, such as the spacing of the electrode elements, for substantially eliminating the transconductance from the second input electrode to the first output electrode. A circuit is provided for applying a signal comprising frequencies within a predetermined range to the second signal-input electrode and another circuit is provided for applying a signal comprising frequencies within a higher range than the first-mentioned range to the first signal-input electrode, the frequencies of the first-mentioned range being substantially different from the frequencies of the higher range or the heterodyne sum or difference frequencies of said ranges.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following specification taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

The single figure of the drawing is a schematic circuit diagram of a complete superheterodyne receiver employing a duplex amplifier stage arranged in accordance with the invention to effect an amplification of both the radio-frequency signal and the intermediate-frequency signal of the receiver.

In general, the receiver illustrated in the drawing comprises a tunable radio-frequency selector circuit, comprising an inductance 10 and a condenser 11 coupled between an antenna-ground circuit, comprising an inductance 12 and a radio-frequency signal-input grid of a duplex amplifier stage comprising tube 13. The radio-frequency output electrode of tube 13 is coupled through an inductance 14 to a second tunable radio-fre-

quency selector circuit comprising an inductance 15 and a condenser 16. The selector 15, 16 is, in turn, connected to a frequency-changer tube 17 comprising an oscillator section including the frequency-determining circuit 18, 19. The condensers 11, 16, and 19 are provided with a conventional unicontrol mechanism shown schematically by the broken lines interconnecting these elements. The output electrode of frequency changer 17 is coupled through a double-tuned intermediate-frequency transformer 20 to a second signal-input grid of tube 13. The amplified intermediate-frequency output is taken from the anode or second output electrode circuit of tube 13, which is coupled to the input circuit of an intermediate-frequency amplifier 22. Connected in cascade to the output circuit of intermediate-frequency amplifier 22, in the order named, are a signal detector and automatic amplification control or A. V. C. rectifier 23, an audio-frequency amplifier 24, and a loud-speaker 25. An A. V. C. bias derived from unit 23 is applied to the control electrodes of one or more of the tubes 13, 17 and intermediate-frequency amplifier 22 by way of a connection 27 and suitable filter circuits.

In general, the operation of the receiver just described, neglecting the features which constitute the present invention presently to be described, is well understood in the art and a detailed description thereof is, therefore, unnecessary. In brief, however, signals intercepted by the antenna circuit comprising inductance 12 are selected in selector circuit 10, 11, amplified in the inner or radio-frequency amplifier portion of vacuum tube 13, and transmitted by way of selector circuit 15, 16 to frequency changer 17, wherein they are converted to intermediate-frequency signals in a well-known manner. The intermediate-frequency signals are further selected in the selector circuit comprising double-tuned transformer 20 and are amplified by a reflex amplification in the outer or intermediate-frequency amplifier section of tube 13 and passed to intermediate-frequency amplifier 22 wherein they are further amplified. Audio frequencies of modulation are derived in detector 23, are further amplified in audio-frequency amplifier 24, and supplied in the usual manner to loudspeaker 25 for reproduction. The unidirectional-bias voltage developed by the A. V. C. rectifier and detector 23 is applied by way of the connection 27 to both input electrodes of tube 13, tube 17, and one or more of the tubes of intermediate-frequency amplifier 22, thereby maintaining the amplitude of the signal input to detector 23 within a relatively narrow range for a wide range of received signal amplitudes.

Referring now more particularly to the parts of the system involving the present invention, it is seen that the inner or radio-frequency amplifier section of vacuum tube 13 includes the first grid as a signal-input electrode and, as an output electrode, the second and the fourth grids of the tube connected together within the tube. The outer or intermediate-frequency amplifier section of tube 13 includes the anode or second output electrode of the tube as an output electrode, the third grid as a signal-input electrode, and a virtual cathode formed between the second and third grids. A cathode-biasing resistor 30, by-passed for alternating currents by condenser 30', is provided for vacuum tube 13, while suitable operating potentials are supplied for the system through the terminals marked B₁ and B₂, the output electrode comprising the second

and fourth grids of tube 13 being supplied through a network comprising series resistors 31, 32 and shunt condenser 33. The first and third grids of tube 13 which are negatively biased with respect to the cathode, together with the second grid, which is maintained at a positive potential by the source B₂, are effective to form a virtual cathode in the tube between the second and third grids in a manner which is well understood. Tube 13 is so designed that transconductance between the third grid and the second and fourth grids together is substantially eliminated over the radio-frequency range of the receiver shown. It has been found that a type 6L7 tube meets this requirement fairly well.

In considering the operation of the duplex amplifier stage comprising tube 13, it will be seen that, because of the arrangement of the electrodes within the tube and the potentials on the second and third grids with respect to the actual cathode, a virtual cathode, that is, a cloud or mass of slowly or random moving electrons, is formed between the second and third grids. The flow of electrons to the anode or second output electrode of the tube from this virtual cathode is controlled by the third grid. As the potential of the third grid of the tube is varied, the electron current to the second grid, which is connected to the output circuit including inductance 14, varies in a manner opposite to that to the fourth grid, which is also connected to the output circuit including inductance 14. The second and the fourth grids may, therefore, be so related to the third grid that transconductance between the third grid and the composite output electrode comprising the second and fourth grids together is substantially eliminated over the range of frequencies to which the selectors 10, 11 and 15, 16 are tunable. In other words, the second and fourth grids may be said to be a means for eliminating transconductance between the outer signal-input electrode or third grid and the inner output electrode. The automatic volume control bias applied to the first grid is effective to control the amplification of radio-frequency signals as well as intermediate-frequency signals within the tube 13, while that applied to the third grid or second control electrode is effective only to control the amplification of the intermediate-frequency signals. Either may be used separately if desired.

While there has been shown a duplex amplifier in which a radio-frequency signal is amplified in the inner section and an intermediate-frequency signal is amplified in the outer section, it will be understood that the invention can be used as well to amplify a carrier-frequency signal in the inner section and to amplify an audio-frequency signal in the outer section thereof. The output circuit comprising inductance 14 is preferably designed to have a low impedance over the range of frequencies amplified in the outer section of the duplex amplifier in order to prevent the development of any signal voltages within such range in case of any incidental transconductance between the second signal-input grid and the first output electrode. The output circuit of the intermediate-frequency amplifier section of tube 13, that is, the circuit comprising the input circuit of intermediate-frequency amplifier 22, is preferably designed to have a low impedance to signals within the radio-frequency range of the receiver. It will also be understood that the A. V. C. potential applied to the first grid of tube 13 is effective to control

the amplification of each of the signals being amplified within the tube. The duplex amplifier stage of the invention is preferably utilized with the inner section acting as an amplifier of the higher frequency signals in order to prevent a modulation of the high-frequency signal by signal components of the low-frequency signal.

While the invention is of general application, there follow specifications of a particular duplex amplifier stage having amplification characteristics which are particularly satisfactory:

Tube 13.....	Type 6L7
Tube 17.....	Type 6A8
Resistor 30.....	1,000 ohms
15 Condenser 30'.....	0.05 microfarad
Resistors 31 and 32.....	10,000 ohms
Condenser 33.....	8 microfarads
Source B ₁	105 volts
20 Source B ₂	230 volts
Radio-frequency selectors 10, 11 and 15, 16 tunable over a range of frequencies from 0.54 to 1.56 megacycles.	
25 Double-tuned transformer 20 tuned to an intermediate- frequency of 455 kilocycles.	

While there has been described what is at present considered to be the preferred embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A duplex repeater stage comprising a vacuum tube including a first repeater section having a cathode, a first signal-input electrode and a first output electrode, a second repeater section comprising a second signal-input electrode and a second output electrode in the order named, said first output electrode having portions respectively disposed between said cathode and said second signal-input electrode and between said second signal-input electrode and said second output electrode, said portions being spaced with relation to said second signal-input electrode so that transconductance from said second signal-input electrode to said first output electrode is substantially eliminated, a circuit for applying a signal comprising frequencies within a predetermined range to said second signal-input electrode, and a circuit for applying a signal comprising frequencies within a range higher than said first-mentioned range to said first signal-input electrode, the frequencies of said first-mentioned range being substantially different from the frequencies of said higher range or the heterodyne sum or difference frequencies of said ranges.

2. In a modulated-carrier signal receiver of the superheterodyne type, a duplex repeater stage comprising a vacuum tube including a first repeater section having a cathode, a first signal-input electrode and a first output electrode, means

for forming a virtual cathode, a second repeater section comprising said virtual cathode, a second signal-input electrode and a second output electrode disposed in the order named, means for substantially eliminating transconductance from said second signal-input electrode to said first output electrode over the intermediate-frequency range of said receiver, a circuit for applying intermediate-frequency signals to said second signal-input electrode, a circuit for applying radio-frequency signals to said first signal-input electrode, the frequencies of said intermediate-frequency signal being of a substantially different magnitude than the frequencies of said radio-frequency signal or the heterodyne sum or difference frequencies of said signals, and means for effecting an automatic amplification control of each of said signals within said tube.

3. In a modulated-carrier signal receiver of the superheterodyne type, a duplex repeater stage comprising a vacuum tube including a first repeater section having a cathode, a first signal-input electrode and a first output electrode, means for forming a virtual cathode, a second repeater section comprising said virtual cathode, a second signal-input electrode and a second output electrode disposed in the order named, means for substantially eliminating transconductance from said second signal-input electrode to said first output electrode, a circuit for applying intermediate-frequency signals to said second signal-input electrode, a circuit for applying radio-frequency signals to said first signal-input electrode, the frequencies of said intermediate-frequency signal being of a substantially different magnitude than the frequencies of said radio-frequency signal or the heterodyne sum or difference frequencies of said signals, and means for effecting an automatic volume control of each of said signals within said tube by a single bias applied to one of said electrodes.

4. In a modulated-carrier signal receiver of the superheterodyne type, a duplex repeater stage comprising a vacuum tube including a first repeater section having a cathode, a first signal-input electrode and a first output electrode, means for forming a virtual cathode, a second repeater section comprising said virtual cathode, a second signal-input electrode and a second output electrode disposed in the order named, means for substantially eliminating transconductance from said second signal-input electrode to said first output electrode, a circuit for applying intermediate-frequency signals to said second signal-input electrode, a circuit for applying radio-frequency signals to said first signal-input electrode, the frequencies of said intermediate-frequency signal being of a substantially different magnitude than the frequencies of said radio-frequency signal or the heterodyne sum or difference frequencies of said signals, and means for effecting an automatic amplification control of only said intermediate-frequency signals within said tube by a bias applied to one of said electrodes.

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