

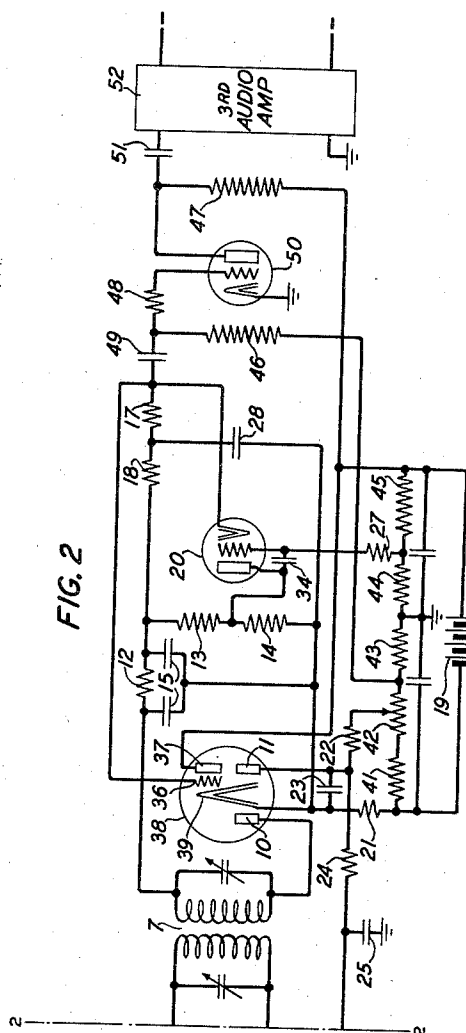
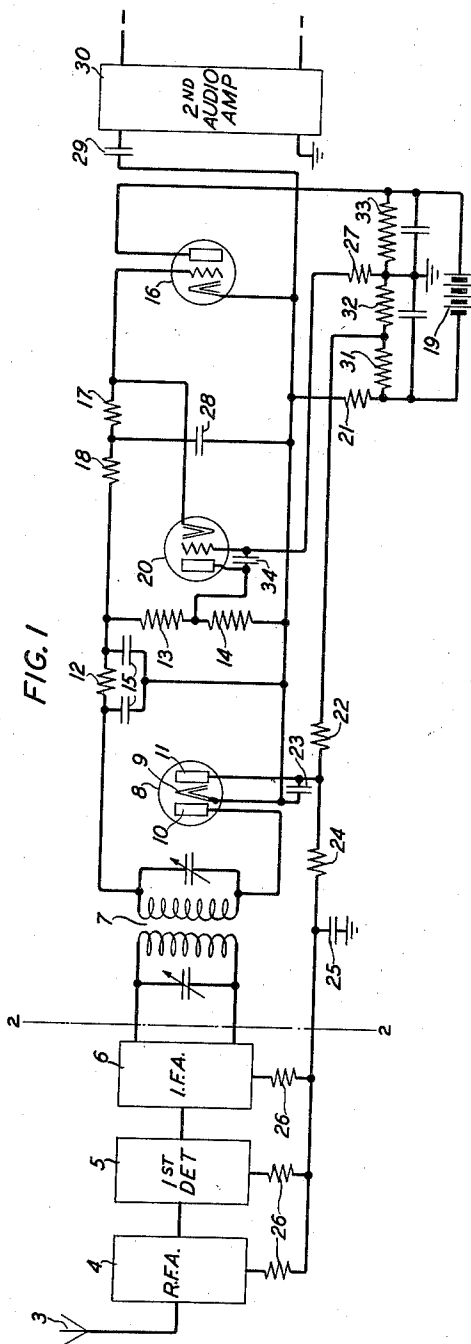
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RADIO RECEIVER

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RADIO RECEIVER

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This invention relates to radio receivers, and particularly to circuits for suppressing disturbances or noise in connection with the operation thereof.

Two important types of disturbances encountered in the operation of radio receivers are those occurring in the absence of a received carrier and those due to sharp crashes or other noise impulses of short duration when a signal is being received. The first is particularly troublesome with receivers employing automatic volume control in which case the amplification is greatly increased when no carrier is being received, either due to interruption of the carrier at the transmitter or when during the tuning process the set is not tuned to a carrier frequency. As a result noise is greatly amplified so as to produce highly objectionable disturbances in the output of the receiver.

An object of the invention is to provide a simple and effective means of eliminating the troublesome effects of these two types of disturbances.

In a specific preferred embodiment of the invention, the space path of a triode vacuum tube is connected in series in the audio circuit of a radio receiver. The grid of the tube is normally biased negatively so that the space path is non-conducting. A circuit is provided so that in the presence of a received carrier, this blocking bias will be removed. Other circuit means are provided for biasing the anode positively by detected signals so that the tube will conduct signals of normal amplitude. This circuit is given such a time constant that impulses of high amplitude and short duration will have the effect of rendering the tube non-conducting by the removal of positive bias from the anode.

The invention may be more readily understood by reference to the following detailed description in connection with the drawing in which Fig. 1 is a schematic circuit diagram of a radio receiver including one embodiment of the invention and Fig. 2 is a schematic circuit diagram of a modification of that portion of the circuit of Fig. 1 to the right of the dash-dot line 2—2.

The radio receiver of Fig. 1 comprises an antenna 3, connected to the input of a radio frequency amplifier 4. The output of the amplifier 4 is fed to the input of the first detector or converter circuit 5—5 where the received radio frequency is modulated by oscillations of a local oscillator and the resultant beat frequency is fed to the intermediate frequency amplifier 6. These portions of the receiver are of the conventional

type and for the sake of simplicity have been represented merely by boxes.

Connected in the output of the intermediate frequency amplifier 6 is a tuned intermediate frequency transformer 7, the secondary winding of which is connected to a diode detector circuit. There is provided a duplex diode tube 8 which has a cathode 9, an anode 10 which is used for detection, and a second anode 11 which is used as the delay control diode of a well-known type of automatic volume control circuit, as will be described later. One terminal of the secondary of the intermediate frequency transformer 7 is connected to the anode 10. The other terminal is connected through a filter resistor 12 to the detector load resistor comprising the series connected resistors 13 and 14. The latter resistor 14 is connected to the cathode 9 to complete the circuit for the detector. Filter capacitors 15 are provided for eliminating the high frequencies and giving the detector circuit the desired impedance.

There is provided a triode vacuum tube 16 which operates as a direct current amplifier amplifying both the audio and direct current output components of the detector. The grid of the tube 16 is connected through the resistors 17 and 18 to the upper terminal of the detector load resistor 13. This grid is also connected to the junction of the resistors 13 and 14 through the space path of the triode tube 20, the grid of tube 16 being connected to the cathode and the junction of the resistors 13 and 14 to the anode. The anode circuit of the tube 16 includes the plate battery 19 and the load resistor 21 in series between the anode and cathode.

The tube 16 acts as an amplifier for both the direct current and audio components of the detected wave. The direct current component of the detected wave is initially supplied to the grid of the tube 16 through resistors 18 and 17. After tube 20 becomes conducting the direct current component and the audio frequency component are supplied through the space path of the tube 20. Since the condenser 28 has a large capacity (for example of the order of .1 microfarad) the path through the resistors 18 and 17 is effectively short-circuited for audio frequency.

The amplified audio frequency voltages appearing across the load resistor 21 are supplied to the input of the final audio frequency amplifier 30 through the blocking condenser 29.

When no carrier voltage is present in the tuned circuit 7, the grid of the tube 16 is substantially at the same potential as the cathode being con-

nected thereto through resistors 17, 18, 13 and 14. As a result the space current of the tube and consequently the voltage drop in resistor 21 is a maximum.

When carrier voltage is being received, the voltage in the secondary of the transformer 7 is rectified in that space path of the duplex diode 8 which includes the anode 10, producing a voltage across the resistors 13 and 14 such that the upper terminal of resistor 13 is negative with respect to the lower terminal of resistor 14. This will make the grid of the detector tube 16 negative, reduce its space current, and consequently the voltage across resistor 21.

The other half of the twin diode 8 including the anode 11 is used as a control diode for the A. V. C. circuit. The anode 11 is connected to the junction of resistors 31 and 32 of the voltage divider 31—32—33. A by-pass condenser 23 is connected between the anode 11 and the cathode to keep those electrodes at the same audio voltage. The initial bias of the grids of the controlled tubes is provided by the voltage drop across the resistor 32. The controlling bias is supplied through the filter comprising resistor 24 and condenser 25 and the individual filter resistors 26 to the grids of the controlled tubes, the cathodes of which are grounded.

In the absence of a signal and at low signal levels, the voltage drop across the resistor 21 is larger than that across resistor 31 so that the anode 11 is negative with respect to its cathode and the only voltage supplied to the controlled tubes is the voltage across resistor 32. When sufficiently strong signals are received, the voltage drop across resistor 21 will be reduced to a point where the voltage across resistor 31 is the larger and the anode 11 will draw space current through the resistor 22. The resulting voltage will be added to the initial voltage across the resistor 32 and applied to the grids of the controlled tubes. Further increases in signal voltage produce further increases in this voltage giving the desired automatic volume control action.

The operation of tube 20 for suppressing noise in the absence of received carrier will now be explained. As pointed out above, when no carrier wave is being received, no voltage is developed across the detector load resistors 13, 14 and as a result, the voltage drop in resistor 21 is a maximum. If no noise were present under such conditions, the cathode and anode of the tube 20 would be at the same potential. However, the effect of noise being received or developed in the set may be such as to produce some voltage across resistors 13 and 14, making the anode somewhat positive with respect to the cathode.

However, the grid of tube 20 is connected through a resistor 27 to the junction of resistors 32 and 33. Since the voltage divider is so designed that under the condition of no carrier input, the algebraic sum of the voltage across the resistor 21 and that across resistors 31 and 32 is sufficiently negative that the grid of tube 20 is so negative with respect to the cathode as to bias the tube 20 to cut-off. Thus the coupling circuit for audio frequency voltages between the detector and the amplifier 16 is effectively opened and noise voltages will not be supplied to the amplifier, the condenser 28 having such a large capacity that the path through resistors 18 and 17 is effectively short-circuited for voltages of such frequencies.

Thus, for example, if at the no-signal condition the voltage drop across resistor 21 is 120 volts,

and the bleeder current produces a drop of 90 volts across resistors 31 and 32, it is evident that the grid of the tube 20 is at a potential of -30 volts with respect to the cathode which is sufficient to drive the grid to the cut-off point and to block the space path of the tube 20.

Now if a carrier voltage is received in the transformer 7, a resulting rectified voltage will appear across the detector load resistors 13 and 14 to which the grid of tube 16 is connected through the resistors 17 and 18. The voltage thus produced by the rectified carrier will be in such direction as to make the grid of tube 16 negative with respect to its cathode. This reduces the space current of tube 16 and consequently the voltage drop across resistor 21. On the basis of the figures assumed above, this may be such as to reduce the voltage across resistor 21 to perhaps 80 volts. The bias on the grid of tube 20 will then be less negative or on the basis of the above figures even 10 volts positive with respect to its cathode so that the tube is no longer cut-off and the space path becomes conductive. This will permit audio voltages to be supplied to the grid of the tube 16 through the space path of tube 20. For all audio frequency variations, the potential of the grid of the tube 20 will be maintained at such a point as not to block the space path of the tube.

The resistor 27 connected to the grid of the tube 20 is of comparatively high resistance and is provided to prevent the grid from drawing appreciable current even when it goes positive. There is connected between the grid and plate of the tube 20 a condenser 34 of comparatively high capacity so as to tie the two electrodes together for alternating current voltages and consequently prevent the tube from acting as an amplifier therefor.

The action of the tube 20 for suppressing disturbances due to static or other noise impulses of high amplitude and short duration will now be described. In the presence of a rectified signal across the detector load resistors 13 and 14, the condenser 28 will become charged. If the resistors 17 and 18 are equal, as is preferable, the condenser 28 will charge to a voltage equal to the voltage across the resistor 14 plus one-half the voltage across resistor 13. This charge will then maintain the cathode of the tube 20 negative with respect to the anode, the voltage difference between these electrodes being the difference between the voltage across condenser 28 and that across resistance 14. For the values given this will be one-third of the voltage across condenser 28. In this way the cathode is permitted to follow the superimposed audio voltage up to this value. For such audio voltages across the resistance 14, the tube will be conductive and the audio component will be impressed on the grid of tube 16 for amplification.

However, if there occurs a noise impulse which produces a voltage across resistance 14 which is higher than this value, the negative voltage of the anode will become greater than the charge on condenser 28. The space path will therefore be non-conductive and such noise peaks are prevented from being transmitted to the amplifier 16.

During such intervals there will, of course, be a tendency for the condenser 28 to charge through resistor 18 to the increased voltage across resistors 13 and 14. However, the time constant for the circuit including resistor 18 and condenser 28 is made such that this action cannot take place during the period of ordinary static impulses.

The circuit is therefore very effective in eliminating static or other noise impulses of short duration.

Fig. 2 discloses a modification of the invention in which the noise suppressor tube is included in the coupling to the grids of two successive audio amplifier stages. This circuit is a modification of that portion of the radio receiver of Fig. 1 to the right of the line 2—2 and similar reference symbols are used for similar elements.

In this circuit the function of tubes 8 and 16 of Fig. 1 have been combined in a single tube 38 of the duplex diode-triode type. This tube, which is a well-known commercial type, has a single cathode 39 associated with two diode anodes and triode amplifier electrodes. It can readily be employed in this type of circuit as it will be observed that in the circuit of Fig. 1 the cathodes of tubes 8 and 16 are at the same potential.

Since the circuit arrangement and operation of Fig. 2 is essentially the same as that of Fig. 1 up to and including the first audio amplifier which consists of the triode section 36—37 of tube 38 (corresponding to tube 16) only the modifications will be described in detail.

The battery 19 or other equivalent source of voltage is shunted by a voltage divider comprising resistors 41, 42, 43, 44 and 45, the connection from the control diode anode 11 through resistance 22 is made to an adjustable tap on resistor 42. This permits a control of the sensitivity of the receiver by an adjustment of the initial bias for the controlled tubes, namely the voltage across resistor 43 and the right-hand portion of resistor 42.

The grid of the noise suppressor tube 20 is connected through resistor 27 to the junction of resistors 44 and 45. The voltage across resistors 41, 42, 43 and 44 serves the same purpose as that across resistors 31 and 32 of Fig. 1, the grid of tube 20 being biased with respect to the cathode by the algebraic sum of this voltage and the voltage drop in the load resistor 21.

A triode vacuum tube 50 is provided for the second audio amplifier stage; the grid of this tube is not connected directly to the load resistor 21 of the first audio frequency amplifier as in the circuit of Fig. 1. Instead the grid of tube 50 is connected through resistor 48 and blocking condenser 49 to the cathode of tube 20. In this way the space path of the tube 20 is connected not only in the audio frequency coupling path to the grid 36 of the first amplifier but also in the audio frequency coupling path to the grid of the tube 50. In this way the effectiveness of tube 20 in blocking the path for noise is greatly increased. While this type of circuit introduces a small amount of negative feedback, such an effect can readily be compensated for and is far outweighed by the increased effectiveness of the tube 20 for eliminating noise both in the absence of a received carrier and noise and static impulses during the reception of a signal.

Grid biasing voltage for the tube 50 is supplied by a connection through resistor 46 to the junction of resistors 42 and 43. The output of the tube 50 is connected through coupling resistor 47 and the blocking condenser 51 to the input of the third audio amplifier 52.

In the interest of simplification of the circuit diagrams, the cathode heating circuits have been omitted from both figures.

What is claimed is:

1. In a receiver for signal modulated carrier waves, an electric discharge device having a cathode and a plurality of cold electrodes, a signal

circuit including said device, means for so biasing one of said cold electrodes in the absence of received waves below a predetermined amplitude that the signal current has a high attenuation but responsive to received waves above said predetermined amplitude to substantially reduce the attenuation of said signal circuit, and means for so biasing another of said cold electrodes that the signal circuit has a low attenuation in the presence of signal voltages below a definite amplitude, and a high attenuation in the presence of voltages of short duration above said predetermined amplitude.

2. In a receiver for signal modulated carrier waves, an electric discharge device having a cathode and a plurality of cold electrodes, a signal circuit including the space path of said device in series therein, means for so biasing one of said cold electrodes as to render the space path normally non-conductive but responsive to received signals for rendering the space path conductive, and means for so biasing another of said cold electrodes as to render the space path conductive to signal voltages below a definite amplitude but non-conductive for voltages of short duration above said definite amplitude.

3. In a radio receiver, a detector including a load impedance, an electric discharge amplifier having an anode, a cathode and a control electrode, connections from said load impedance to the cathode and control electrode of said amplifier, said connections including the space path of an electric discharge device having a cathode, an anode and a control electrode, a circuit having resistance and capacity for biasing the anode of said device with respect to the cathode from the voltage drop in said load impedance, the time constant of said circuit being such that said anode is maintained positive with respect to the cathode for voltages across said load impedance below a definite value while for voltages above said definite value and of short duration the anode is rendered negative, a load resistance in the anode-cathode circuit of said amplifier, and means including said load resistance for biasing the control electrode of said electric discharge device to render the space path thereof non-conductive in the absence of received signals.

4. In a radio receiver, an electric discharge device connected in the signal frequency path, means for so controlling the conductivity of said device as to block the path for input voltages of short duration and of amplitude above a definite value, a control electrode for said device, and means for so biasing said control electrode as to render said device non-conductive in the absence of a received carrier.

5. In a radio receiver, a detector, a load impedance therefor, a signal circuit, an electric discharge device connected in series between said load impedance and said signal circuit, means for so biasing said device that it is conductive for signal voltages while non-conductive for voltages of short duration, and other means for so biasing said device that it is non-conductive in the absence of a received signal wave.

6. In a radio receiver, a detector and load impedance therefor, a signal frequency circuit and electric discharge device, a connection between said load impedance and said signal frequency circuit including the space path of said device, a resistance-capacity circuit for so biasing said device from the voltage drop in said load impedance as to render it conductive for voltages below a definite value, the time constant of said

circuit being such that for higher voltage impulses of short duration said device is non-conductive, and means for rendering said device non-conductive in the absence of received signals and responsive to a received signal for rendering said device conductive.

7. In a radio receiver, an electric discharge device having a cathode, an anode and a control electrode, a signal path including the space path of said device in series therein, means responsive to input voltages of normal level for maintaining said anode and said control electrode at such voltages with respect to the cathode that the space path is conducting, means acting in the absence of signals of a definite minimum normal level for establishing such a voltage on said grid that the space path is non-conducting, and means responsive to input voltages above a definite maximum normal level for establishing such a voltage on said anode that the space path is non-conducting.

8. In a radio receiver, a detector, a load impedance for said detector, a plurality of audio amplifiers, an audio coupling circuit including in series therein the space path of an electric discharge device, a circuit comprising resistance and capacity for biasing the anode of said device from the voltage across said load impedance and having such a time constant that for high voltages of short duration the space path is rendered non-conductive, and connections for including said coupling circuit between said load impedance and the input of one of said audio amplifiers and between the output of said one audio amplifier and the input of another of said audio amplifiers.

9. In a radio receiver a detector, a load impedance for said detector, an amplifier tube having a cathode, an anode and a control electrode, a resistor in the anode-cathode circuit of said

amplifier tube, a coupling circuit from said load impedance to the control electrode-cathode circuit of said tube including a series resistor and a shunt condenser of such constants that said coupling circuit is substantially opaque at signal frequencies while conductive for direct current, a second coupling circuit from said load impedance to said control electrode-cathode circuit including an electron discharge tube having a cathode, an anode and a control electrode, and connections including said resistor for biasing the control electrode of said electron discharge tube so that said second coupling circuit is opaque at signal frequencies for voltages across said load impedance below a predetermined value.

10. A combination according to claim 9 and a second amplifier tube connected to the output of said first amplifier tube through said second coupling circuit.

11. In a radio receiver, a detector, a load impedance therefor, an amplifier tube having a cathode, an anode and a control electrode, a resistor in the anode-cathode circuit of said amplifier tube, a coupling circuit for direct current voltage from said load impedance to the control electrode-cathode circuit of said amplifier tube, said coupling circuit including a shunt connected condenser of such capacity as to substantially prevent the transmission of signal frequency voltages, a second coupling circuit from said load impedance to said control electrode-cathode circuit, said second coupling circuit including in series therein the space path of an electron discharge device having a cathode, an anode and a control electrode, and circuit connections including said resistor for biasing said control electrode so that said space path is blocked for voltages across said load impedance below a predetermined value.

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