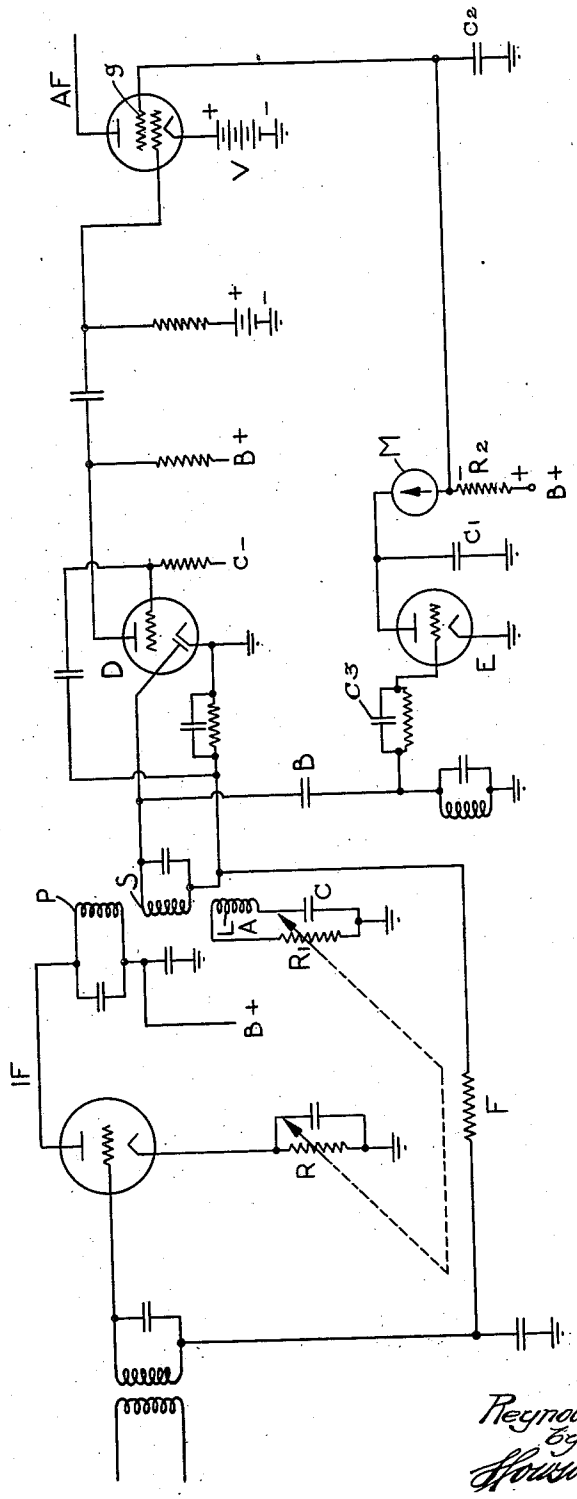
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INTERCARRIER NOISE SUPPRESSOR

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INTERCARRIER NOISE SUPPRESSOR

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This invention relates to radio receivers and has for its principal object the provision of a novel inter-carrier noise suppressor. The invention is useful particularly in a system such as that disclosed and claimed in the copending application of Andrew P. Montgomery for High fidelity radio receiver, Serial No. 20,473, filed May 8, 1935. In that application, there is disclosed a superheterodyne radio receiver embodying means for broadening the fidelity curve or response characteristic of the receiver to give a desired substantially rectangular response curve, and to eliminate sideband cutting, and also embodying a tuning indicator circuit connected to the main circuit so as to derive a portion of the incoming energy therefrom. The present invention is very well adapted for use in conjunction with such a system and it will, therefore, be described herein with reference to this specific adaptation, although it will be understood that the invention is not thus limited but is capable of application in any desired and suitable manner.

The main feature of the invention comprises the use of a resistor which has developed thereacross a unidirectional potential which varies in accordance with the various signal strengths received during the tuning of the receiver. This variable potential is applied to an amplification control element in one of the circuits of the audio frequency amplifier of the main circuit, thus placing a variable bias on the said control element and effecting gain control of the audio frequency amplifier. There is thus provided an inter-carrier suppressor which allows functioning of the receiver only when it is properly tuned to the carrier frequency. In the absence of this suppressor, it would be difficult to properly tune the receiver by ear as the receiver would respond to the same extent even when tuned considerably off the carrier frequency. The resistor above mentioned has developed across it a negative biasing potential which is of such value as to cut off the audio frequency amplifier excepting when the receiver is tuned to the carrier.

A further feature of the invention resides in its particular adaptation for use in connection with automatic volume control. By this feature, objectionable characteristics of the conventional audio volume control action are eliminated, as will be fully explained hereinafter.

The invention may be fully understood by reference to the accompanying drawing, the single figure of which is a diagrammatic illustration of a portion of a superheterodyne receiver of the type above mentioned embodying the features of this invention.

Referring to the drawing, there is shown an intermediate frequency amplifier IF such as commonly employed in the intermediate frequency stages of the superheterodyne receiver and while only one such amplifier is shown, it will be understood that the receiving system may comprise a plurality of intermediate frequency stages, as is well known. The intermediate frequency amplifier shown is coupled to a detector D, which constitutes the usual second detector of the system, by means of the inductively associated transformer coils P and S. The detector D is coupled to an audio-frequency amplifier AF in conventional manner, it being understood that there may be a plurality of audio-frequency amplifier stages as is well known. Automatic volume control may be embodied in the system in any manner, for example, by deriving a control voltage from the leak resistance of the detector D and applying such voltage through a filter resistor F to the control grid of amplifier IF in conventional manner.

In the system shown, following the teaching of the above-mentioned copending application, there is provided a variable grid biasing resistor R which is interposed in the cathode lead of the intermediate frequency amplifier and there is also provided a series resonant circuit A which includes a variable resistor R_1, these two resistors being preferably adapted for joint or simultaneous manual operation, as indicated by the broken-line representation. The circuit A also includes a condenser C and an inductance coil L which is overcoupled with respect to S. This device functions to increase the fidelity range of the receiver, while maintaining the over-all gain uniform, as fully described in the said copending application. Inasmuch as this subject matter does not form a part of the present invention, it is unnecessary to describe it in further detail herein.

As also taught by the said copending application, there is provided a branch circuit B which is preferably connected to the main circuit of the intermediate stage IF and the detector D as illustrated. This circuit preferably takes the form of a sharply tuned circuit which has connected thereto a rectifier E preferably in the form of a grid-leak detector as illustrated. Unless the grid condenser C_3 is so large that audio frequency waves will not occur across it as a result of demodulation of the carrier, other means must be used to prevent such audio frequencies from dis-

turbing the audio amplifier. In the output of detector E, there is provided a tuning indicator or meter M and a suitable filter condenser C_1.

In operation, the branch circuit B derives a portion of the incoming energy and such energy is detected or rectified by the grid-leak detector E in the usual manner of operation of such a device. The output current of this detector flowing through the indicator or meter M varies in accordance with the tuning of the receiver and the meter therefore indicates the proper tuning of the system. With the receiver adjusted for high fidelity reception, it is difficult to properly tune it by ear due to the fact that even though the receiver is not properly tuned, reception will nevertheless take place but at a loss of quality. However, since the detector E is in a sharply tuned circuit, it will be energized sufficiently to operate the meter M only when the receiver is properly tuned. Thus the meter indicates at all times the correct tuning of the receiver, even when the correct tuning cannot be determined conveniently by ear.

In accordance with the present invention, there is provided in the output circuit of the detector E and in series with the tuning indicator or meter M a resistor R_2, one extremity of which is connected to a screen-grid g of the audio frequency amplifier AF. There is also provided a suitable filter condenser C_2, as illustrated. By virtue of the output current flow through resistor R_2, there is set up across this resistor a unidirectional potential or voltage having the polarity indicated. It will be noted that the negative side of the resistor is connected to the screen-grid g_1 of the audio frequency amplifier.

The cathode of one or more of the tubes AF may be biased above ground by a battery V having the polarity indicated or this voltage may be supplied by a circuit in the plate supply. It will be noted that the screen-grid-to-cathode circuit of this tube is shunted by the series circuit comprising the tuning meter M and the internal plate-to-cathode circuit of the detector tube E and that both of these tubes are energized through the resistor R_2. The condensers C_1 and C_2 are preferably provided as filter condensers and serve to reduce the ripple in unidirectional current supplied to the meter M and screen-grid g. It will also be noted that when the grid of the detector tube E has no bias, corresponding to zero carrier signal, the plate-to-cathode resistance of the tube E will be small. Hence the major portion of the voltage drop in the circuit will be across R_2. By virtue of the bias V on the cathode of tube AF, the screen-grid bias of said tube may be very small or even negative with respect to its cathode and as the amplification is roughly proportional to the screen-grid bias for low bias values, the gain in the amplifier AF under these conditions may be reduced to zero; in other words, the tube may be cut off. But as the grid of the detector tube is made negative due to an increase in applied signal voltage, its plate current will decrease and hence the voltage drop across the resistor R_2 will decrease and the positive screen-grid voltage of the amplifier tube AF will increase. It will be noted that when the detector tube E is unbiased and consequently draws full current, it is the controlling factor in determining the voltage applied to the screen-grid g_1; but when the detector tube is biased so as to have little current, then the screen voltage is determined largely by the current which the grid g draws per se and the relatively small plate current for the detector tube E will have little or no effect. Hence the circuit may be designed so that for zero or very small signals on the detector tube, the amplifier is substantially cut off; but for signals above some predetermined minimum value, the gain of the amplifier is not affected.

By properly designing the resistor R_2 in relation to the amplifier AF, the device may thus be caused to operate as an inter-carrier suppressor. Since it is characteristic of a grid-leak detector that the output or plate current decreases with increase of input voltage, the output current of the detector E will be a minimum when the receiver is tuned to a carrier wave and a maximum when no signal is applied. Therefore, the negative voltage across resistor R_2, which is applied to the amplifier AF, will be a minimum when the receiver is properly tuned to a carrier wave. With proper design, the amplifier AF may be caused to transmit signals only when the signal input to detector E is above a predetermined minimum value; or, in other words, when the receiver is properly tuned to a carrier wave. A decrease in detector input signal below this minimum value due to a change in the tuning of the receiver or for any other reason, will cause the plate-to-cathode current of detector E to become sufficiently large to cause cut-off or blocking of the amplifier AF so that the amplifier will not function when the receiver is detuned. Thus, the device may be made to function effectively as an inter-carrier suppressor.

It will be noted that the present invention has important advantages in connection with automatic volume control. The automatic volume control action is controlled by energy derived from portions or circuits of the system which are broadly resonant to the frequency of received signal and its side bands, and the automatic volume control action causes the output energy to cut off rather gradually at the end regions of the broad frequency range over which it is effective, which causes noisy response in these regions. As is well known, this defect is inherent in receivers with automatic volume control, but can be overcome to some extent by the use of a carefully designed inter-carrier noise suppressor. The suppressor of this invention, however, is controlled by energy derived from portions or circuits of the system which are sharply resonant to the frequency of the received signals and, therefore, the suppressor cuts off the audio amplifier before the said noisy regions can be reached and while a large amount of automatic volume control action is still present, thereby eliminating the undesirable noisy operation. The suppressor action is at all times sharper than the automatic volume control action under any condition of adjustment of the fidelity of response. The relatively broad frequency response characteristics of the automatic volume control will maintain the voltage supplied to the branch circuit B substantially constant over the small range of frequencies to which the response of the inter-carrier noise suppressor is limited by the sharply tuned input circuit of detector E. As the voltage supplied to it is not reduced by the automatic volume control, the inter-carrier noise suppressor is not critical with respect to voltage.

Only such portion of the receiving system as is necessary to illustrate a simple embodiment of the invention has been illustrated, it being unnecessary to illustrate or describe the conventional receiver in further detail. It will be understood

that various modifications, including those above mentioned, may be made without departing from the invention.

I claim:

1. In a superheterodyne radio receiver, an intermediate frequency amplifier for amplifying modulated intermediate frequency carrier signals, a branch circuit comprising at least one sharply tuned circuit energized by said intermediate frequency amplifier, rectifying means energized by said intermediate frequency amplifier for demodulating said modulated signal, an audio frequency amplifier comprising at least one space discharge device having an anode, a cathode and two control elements, means for supplying said demodulated signal to said cathode and one of said control elements, a second rectifying means connected to said branch circuit and having an output circuit wherein there is obtained a signal dependent upon said carrier signal amplitude, and means including filter means for supplying said last named signal to said cathode and said other control element so as to reduce the amplification of said audio frequency amplifier when said carrier signal amplitude is less than a predetermined value.

2. In a superheterodyne radio receiver, an intermediate frequency amplifier for amplifying modulated intermediate frequency carrier signals, a branch circuit comprising at least one sharply tuned circuit energized by said intermediate frequency amplifier, rectifying means energized by said intermediate frequency amplifier for demodulating said modulated signal, an audio frequency amplifier comprising at least one space discharge device having an anode, a cathode and two control elements, means for supplying said demodulated signal to said cathode and one of said control elements, a second rectifying means comprising a grid-leak detector having an input circuit, a cathode and an anode, means for supplying said detector input circuit with signals from said branch circuit, a resistance connected to said detector anode and to a voltage source, a connection between said detector cathode and said voltage source, a condenser connected to said detector anode and to said voltage source, a conductive connection between said detector anode and the other of said control elements of said discharge device, and a conductive connection between said cathode of said discharge device and said cathode of said grid-leak detector.

3. In a superheterodyne radio receiver, an intermediate frequency amplifier having a substantially rectangular frequency response characteristic for amplifying modulated intermediate frequency carrier signals, automatic volume control means controlled by said intermediate frequency amplifier, a branch circuit comprising at least one sharply tuned circuit energized by said intermediate frequency amplifier, rectifying means energized by said intermediate frequency amplifier for demodulating said modulated signal, an audio frequency amplifier comprising at least one space discharge device having an anode, a cathode and two control elements, means for supplying said demodulated signal to said cathode and one of said control elements, a second rectifying means connected to said branch circuit and having an output circuit wherein there is obtained a signal dependent upon said carrier signal amplitude, and means including filter means for supplying said last named signal to said cathode and said other control element so as to reduce the amplification of said audio frequency amplifier when said carrier signal amplitude is less than a predetermined value.

4. In a superheterodyne radio receiver, an intermediate frequency amplifier for amplifying modulated intermediate frequency carrier signals, a branch circuit comprising at least one sharply tuned circuit energized by said intermediate frequency amplifier, rectifying means energized by said intermediate frequency amplifier for demodulating said modulated signal, an audio frequency amplifier comprising at least one space discharge device having an anode, a cathode and two control elements, means for supplying said demodulated signal to said cathode and one of said control elements, a second rectifying means connected to said branch circuit and having an output circuit wherein there is obtained a signal dependent upon said carrier signal amplitude, a tuning indicator in said output circuit, and means including filter means for supplying said last named signal to said cathode and said other control element so as to reduce the amplification of said audio frequency amplifier when said carrier signal amplitude is less than a predetermined value.

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