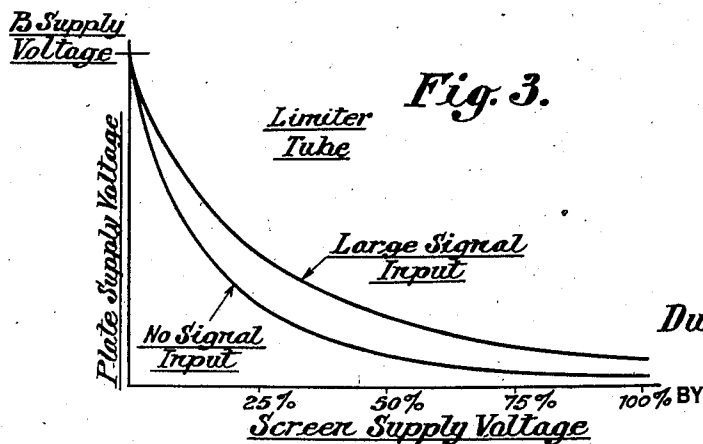
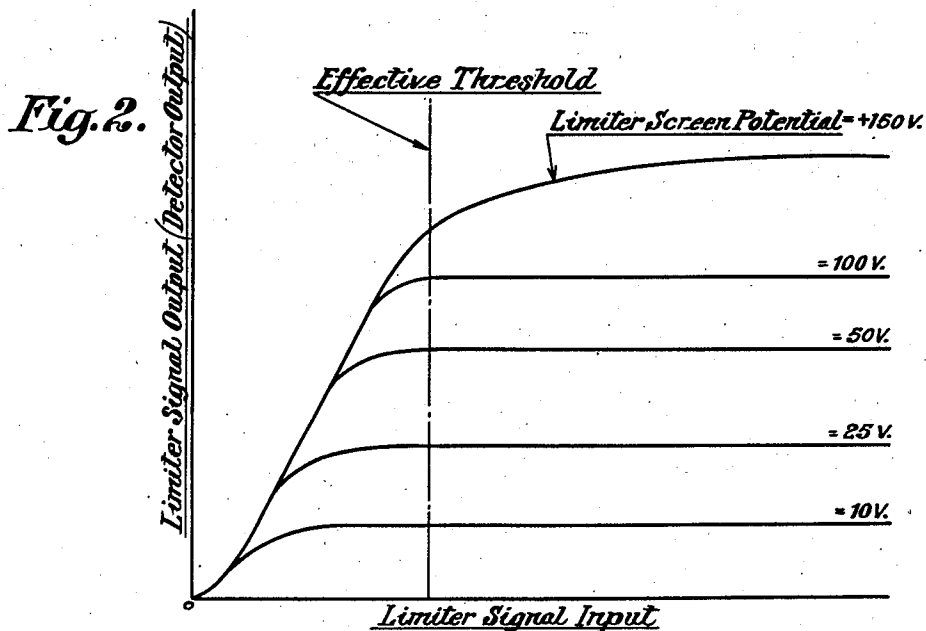
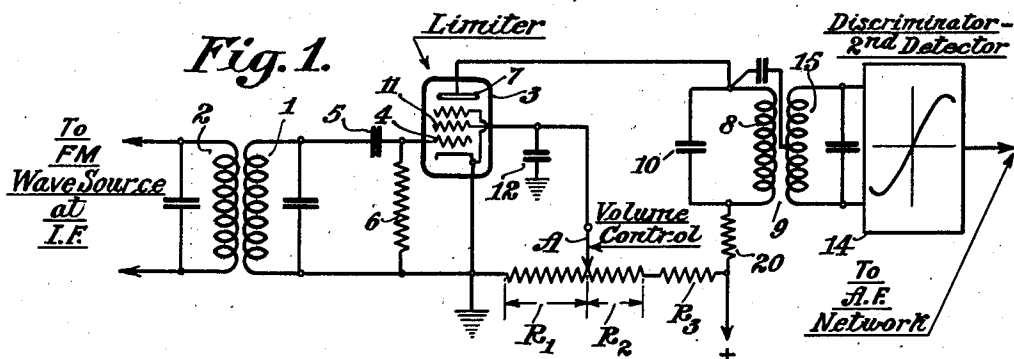


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LIMITER OUTPUT CONTROL

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## LIMITER OUTPUT CONTROL

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Our present invention relates to volume control devices for frequency modulated (FM) carrier wave receivers, and more particularly to a device for adjusting the limiter output level of an FM receiver.

One of the main objects of our invention is to provide a device for varying the limiter output of an FM receiver thereby to secure gain control action, and at the same time maintaining the limiting action.

Another important object of the invention is to provide a volume control for an FM receiver; the control essentially comprising a device for adjusting the limiter tube input-output characteristic over a family of characteristics.

Another object of our invention is to provide a manual volume control instrumentality for an FM receiver, wherein the limiter tube screen potential may be varied in such a manner as to produce a variation in the effective threshold value of the limiter characteristic.

Still other objects of the invention are to improve generally the simplicity and efficiency of gain controls for FM receivers, and more especially to provide a highly simple type of volume control device which is economically manufactured and assembled in an FM receiver.

The novel features which we believe to be characteristic of our invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which we have indicated diagrammatically a circuit organization whereby our invention may be carried into effect.

In the drawing:

Fig. 1 shows an embodiment of the invention,

Figs. 2 and 3 graphically illustrate the functioning of the invention.

Referring now to the accompanying drawing, there is shown in detail the limiter stage of an FM receiver of the superheterodyne type. Let it be assumed that the receiver is constructed to receive signals in the 43 to 50 megacycle (mc.) band of FM reception, and that it uses an intermediate frequency (I. F.) of 2.175 mc. The networks preceding the limiter input circuit 1 may comprise the customary signal collector feeding into one or more tunable radio frequency amplifiers, and a tunable local oscillator feeding local oscillations to the first detector along with the amplified FM signals from the amplifiers.

The FM signals at I. F. value may be passed through one or more I. F. amplifiers each operating at the 2.175 mc. frequency. The circuit 2, tuned to the I. F. value, may be considered as in the plate circuit of the last I. F. amplifier tube. Circuit 1 is reactively coupled to circuit 2, and is also tuned to the I. F. energy center frequency. The limiter functions to insure the transmission to the second detector of solely FM signals, no amplitude modulation effects being transmitted. Those skilled in the art are fully acquainted with the circuit details of the networks prior to the limiter, and hence they need not be described in any further detail.

The limiter stage itself comprises a tube 3 which may be a pentode tube, say of the 6SJ7 type. The signal grid 4 may be coupled to the high potential side of the input circuit 1 by the condenser 5, the grid leak resistor 6 connecting the grid end of condenser 5 to the grounded cathode.

The plate 7 of the limiter tube is connected to a source of positive potential through the primary winding 8 of I. F. transformer 9. The winding 8 is shunted by a condenser 10 which resonates it to the operating I. F. value. The screen grid electrode 11 of the limiter tube is connected to a predetermined point on the voltage supply bleeder which comprises a plurality of resistor sections arranged in series between the plate potential supply terminal and the grounded cathode. The bleeder sections consist of a potentiometer  $R_1$ — $R_2$  which is adjustable and a section  $R_3$  of constant magnitude. The screen grid 11 is by-passed to ground for intermediate frequency currents by the condenser 12. There is applied to screen grid electrode 11 a positive potential which is of a predetermined magnitude.

When the magnitude of  $R_1$  is decreased, then the magnitude of  $R_2$  is increased. The potentiometer arm A connects the screen lead to  $R_1$ — $R_2$  so as to vary the magnitudes of said sections in inverse senses. The arm A is designated as "Volume control," and it will be understood that adjustment of arm A results in variation of the signal output level at circuit 10—8. Before describing in detail the manner in which adjustment of resistor sections  $R_1$  and  $R_2$  results in variation of the limiter signal output level, it is first pointed out that the network following the limiter output circuit may consist of any desired type of discriminator-second detector network. For example, the numeral 14 designates a rectangle within which is shown the typical S-shaped characteristic curve of an FM

discriminator-second detector network. Those skilled in the art are fully acquainted with the various types of networks that may be employed between the first audio frequency amplifier and the limiter output circuit 10—8.

It is sufficient for the purpose of the present application, since the invention is confined to the limiter stage, to point out that the input circuit 15 of discriminator-second detector 14 is tuned to the operating I. F. value, and the entire network may follow the teachings disclosed by S. W. Seeley, in U. S. Patent 2,121,103, patented June 21, 1938. In this type of circuit there is produced across opposed load resistors of a pair of rectifiers rectified voltages in polarity opposition. The substantially S-shaped characteristic curve which relates carrier frequency deviation as abscissae to rectified output voltages as ordinates is shown within the rectangle 14. Of course, there may be employed in place of the Seeley type of network a pair of rectifiers which have input circuits oppositely and equally mistuned from the center frequency of the FM signals. As stated previously, those skilled in the art are fully aware of the construction of such discriminator-second detector networks, and they all function to produce in the output circuit the modulation voltage components which correspond to the frequency deviations of the FM carrier. The audio frequency voltage developed in the output circuit of the second detector may be impressed upon one or more stages of audio frequency amplification, and such stages may be followed by any desired type of audio reproducer.

Returning now to the limiter stage, it is first pointed out that the stage provides a certain amount of gain over the range of frequency represented by the I. F. peak and the maximum frequency deviation. The primary function of the tube is to act in the manner of an amplifier which is very easily overloaded. That is, grid current is caused to flow and plate current saturation is produced on one half of the signal cycle, and plate current cut-off is created on the other half of the cycle. The essential purpose of the tube is to wipe out all amplitude variations present in the output of the I. F. amplifier network ahead of the limiter, and to pass on to the discriminator a constant amplitude-variable frequency signal. The amplitude variations may be created by noise impulses, fading or by the selectivity characteristics of the resonant circuit preceding the limiter tube. The method of creating the required operating conditions for the limiter tube is by a combination of constants. When using a tube of the 6SJ7 type, which is a sharp cut-off tube, there is employed comparatively low values of screen and plate voltage, and no initial control grid bias, so that the tube will overload relatively easily and plate current cut-off is quickly reached. The operating point is established at the center of the linear portion of the plate current-grid voltage curve by the application of the correct operating potentials. Under proper conditions signals of a comparatively small amplitude will swing the grid voltage into that zone which causes plate current cut-off and plate current saturation thereby limiting the magnitude of signal plate current variations in the plate circuit. The tube does not function in any way to limit the frequency deviation of the modulated I. F. signal.

If there are a number of noise peaks included in the FM signal the limiting action of the tube will result in clipping off those peaks which have

an amplitude exceeding the saturation point of the tube characteristic. Hence, it is seen that by virtue of the limiting action of the tube any signal or noise voltage in excess of that required to drive the grid of the tube to plate current cut-off in the negative region, and to plate current saturation in the positive region, will not cause corresponding changes in the plate current. Hence, the signal and noise peaks to the left of the cut-off point, and to the right of the saturation point, are effectively wiped out of the output signal, which, though it corresponds in frequency to the input signal, does not vary in amplitude. The limiter behaves somewhat in the fashion of an automatic volume control circuit. That is, the output signal of the limiter remains practically constant for any increase in the amplitude in the input signal above that required for limiting action. Therefore, the output of the limiter is substantially independent of input, and the signal voltage fed to the discriminator-second detector will be of constant amplitude for all signal voltages above the limiting threshold.

The actual signal level which may occur in the limiter output circuit is dependent upon the changes in plate current. This output level can be raised or lowered by increasing or decreasing the operating voltages of the limiter tube. The effect of increasing the magnitude of the screen voltage would be equivalent to moving apart the points of plate current cut-off and plate current saturation, and, therefore, increasing the spread between the threshold limits in the negative and positive regions of the plate current-grid voltage characteristic of the tube. This would call for a signal of greater amplitude to produce the limiting action, but it would also result in a correspondingly larger signal output. On the other hand, if the limiter tube screen voltage were reduced the plate current cut-off and plate current saturation points would be brought closer together. In such a case a signal voltage of much less amplitude would suffice to produce the limiting action, but the signal output of the limiter would be correspondingly reduced.

In Fig. 2 there is shown a family of limiter signal input signal output characteristics. It will be realized, of course, that the limiter signal output is equivalent to the output existing at the output circuit of the second detector. The curves show the change which occurs in the limiting action of the tube as the limiter screen potential is changed from +10 volts to +150 volts. It will be observed that as the screen potential is raised the signal output level at the limited output circuit is similarly raised, but that the effective threshold point is also increased.

In a limiter of the screen grid type the plate current cut-off value is largely dependent on the screen potential, and, hence the detector output for a given deviation is a function of the limiter screen potential. This is well shown in Fig. 2. For any given screen potential value, then, the detector output may be made substantially independent of input signal. Consequently, the adjustment of screen potential in the limiter tube may be used to control the output from the detector while at the same time maintaining the limiting action unimpaired. In Fig. 2 the frequency deviation is assumed constant for all curves. Signals below the limiter threshold value are usually so marred by noise impulses as to lack entertainment value. There is some shift in threshold value with screen voltage adjustment, but most signals which are listened to are above

the threshold value for even the higher voltages. Hence, the dotted vertical line in Fig. 2 has been indicated as "Effective threshold."

It is desired that the detector output, for a given frequency deviation, be affected only by the setting of the screen potential control arm A, and not by any variation in signal level for signals above the threshold value. Changes in signal level affect the limiter grid bias, and, hence, the screen current. In order that this variation in screen current be prevented from affecting the screen potential materially the screen should be fed from a source of good regulation. For example, such a source, as shown, is a potential divider which carries current appreciably larger than the maximum screen current. If the screen potential is too great then limiting action would be impaired. The resistor section  $R_3$  is ordinarily chosen so that the maximum screen potential obtainable by adjustment of the volume control does not exceed the value for satisfactory limiting action. This is necessary to prevent the maximum current that may be drawn by the screen from exceeding the safe maximum rating. Some trace of this effect is illustrated in the curve representing +150 volts applied to the screen. For still higher screen voltages, with the circuit parameters assumed, the limiting action will be still less effective, so it is desirable to limit the maximum screen potential.

A plate dropping resistor 20 of about 100,000 ohms may be inserted in the plate lead of the limiter tube. With zero signal applied to the grid 4 the plate voltage is of the order of 10 volts. The plate voltage rises to some 70 volts as signal is applied, and depends, of course, on the relative magnitude of the signal. This, also, depends upon the potential applied to screen grid 11. Fig. 3 indicates the manner of variation of plate potential as screen potential is varied in the limiter.

While we have indicated and described several systems for carrying out our invention into effect, it will be apparent to one skilled in the art that our invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of our invention, as set forth in the appended claims.

What we claim is:

1. In combination with an electron discharge tube having signal input and output circuits, means for applying to said input circuit a signal of variable frequency and variable amplitude, said tube comprising at least a cathode, a signal grid, a screen grid and an output electrode, means for applying signals in said input circuit to said signal grid, means for connecting said output electrode to said output circuit, means for applying to said output electrode and screen grid positive direct current potentials, said screen potential being so chosen that said tube functions as a limiter thereby to remove from said variable frequency signal amplitude variations above a predetermined threshold value, and a manual volume control means comprising a device for varying the magnitude of the screen grid potential over a wide range of positive values without impairing the limiting action of the tube at selected screen grid potentials.

2. In combination with an electron discharge tube having signal input and output circuits, means for applying to said input circuit a signal of variable frequency and variable amplitude, said tube comprising at least a cathode, a signal grid, a screen grid and an output electrode,

means for applying signals in said input circuit to said signal grid, means for connecting said output electrode to said output circuit, means for applying to said output electrode and screen grid positive direct current potentials, said screen potential being so chosen that said tube functions as a limiter thereby to remove from said variable frequency signal amplitude variations above a predetermined threshold value, and a manual volume control device for varying the magnitude of the screen grid potential without impairing the limiting action of the tube at selected screen grid potentials, said device comprising a potential divider connected with said potential applying means, said divider including at least two series resistors, and means for varying the magnitudes of said resistors in opposing senses thereby to vary the screen potential over a wide range of positive values.

3. In combination with an electron discharge tube having signal input and output circuits, means for applying to said input circuit a signal of variable frequency and variable amplitude, said tube comprising at least a cathode, a signal grid, a screen grid and an output electrode, means for applying signals in said input circuit to said signal grid, means for connecting said output electrode to said output circuit, means for applying to said output electrode and screen grid positive direct current potentials, said screen potential being so chosen that said tube functions as a limiter thereby to remove from said variable frequency signal amplitude variations above a predetermined threshold value, and a manual volume control device for varying the magnitude of the screen grid potential over a wide range of positive values without impairing the limiting action of the tube at selected screen grid potentials, said varying device comprising a potential divider included in said potential applying means, said divider consisting of a resistor section of constant value in series with a resistor of adjustable magnitude, and the screen being connected to the variable resistor.

4. In combination with the limiter tube of a frequency modulation receiver having signal input and output circuits, means for applying to said input circuit a signal of variable frequency and variable amplitude, said tube comprising at least a cathode, a signal grid, a screen grid and an output electrode, means for connecting said signal grid to said input circuit, means for connecting said output electrode to said output circuit, means applying to said output electrode and said screen grid positive direct current potentials, means for maintaining said signal grid at a relatively small bias with respect to the cathode, said screen potential being so chosen with respect to said grid bias that said tube functions as a limiter thereby to remove amplitude variations above a predetermined threshold value from said signals, and volume control means for the receiver comprising a device for varying the magnitude of the screen grid potential over a wide range of positive values without impairing the limiting action of the tube at selected screen grid potentials.

5. In combination with an electron discharge tube having signal input and output circuits, means for applying to said input circuit a signal of variable frequency and variable amplitude, said tube comprising at least a cathode, a signal grid, a screen grid and an output electrode, means for applying signals in said input circuit to said signal grid, means for connecting said output electrode to said output circuit, means for

applying to said output electrode and screen grid positive direct current potentials, said screen potential being so chosen that said tube functions as a limiter thereby to remove from said variable frequency signal amplitude variations above a predetermined threshold value, and a manual gain control device for varying the magnitude of the screen grid potential over a wide range of positive values without impairing the limiting action of the tube at selected screen grid potentials and said potential applying means comprising a potential divider between said output electrode and cathode, said divider including at least two resistors of adjustable magnitude, and said control device varying the magnitudes of said resistors in opposing senses.

6. In combination with an electron discharge tube having signal input and output circuits, means for applying to said input circuit a signal of variable frequency and variable amplitude, said tube comprising at least a cathode, a signal grid, a screen grid and an output electrode, means

for applying signals in said input circuit to said signal grid, means for connecting said output electrode to said output circuit, means for maintaining said output electrode at a positive direct current potential, means for maintaining said screen grid at a positive direct current potential, means for maintaining said signal grid at a bias close to the cathode, and said screen potential being so chosen with respect to said grid bias that said tube functions as a limiter thereby to remove amplitude variations from said variable frequency signal above a predetermined threshold value, and said screen grid potential applying means including a gain control means, the latter comprising a device for varying the magnitude of the screen grid potential over a wide range of positive values without impairing the limiting action of the tube at selected screen grid potentials.

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