July 26, 1949. J. D. REID ET AL 2,477,391

RADIO RECEIVING SYSTEM

Filed Nov. 24, 1944 2 Sheets-Sheet 1

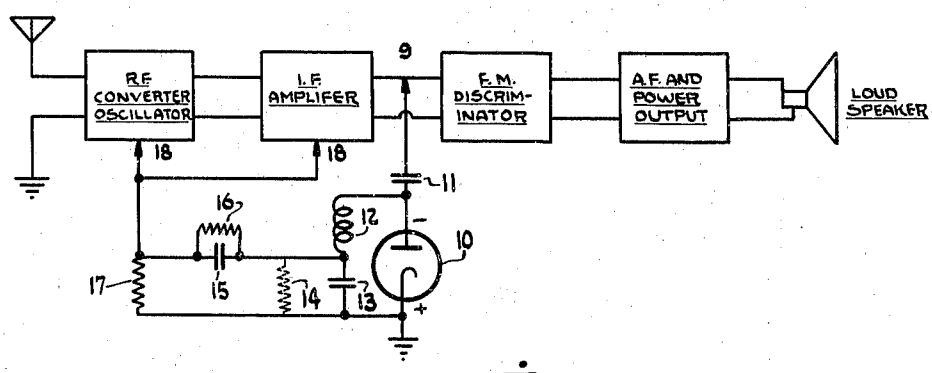


Fig. 1

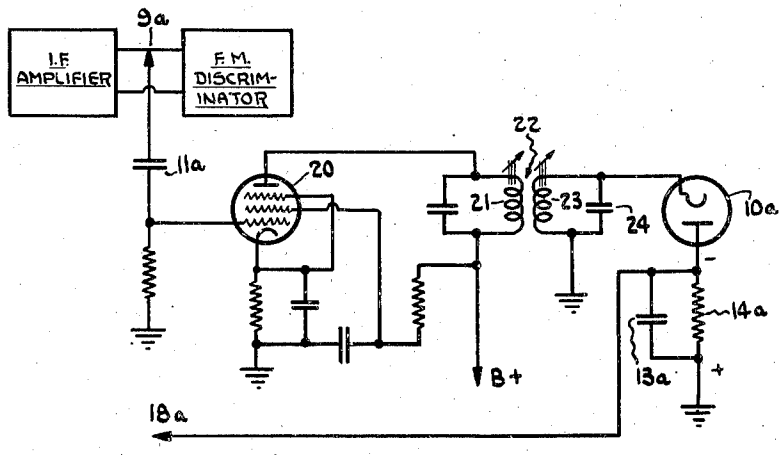


Fig. 2

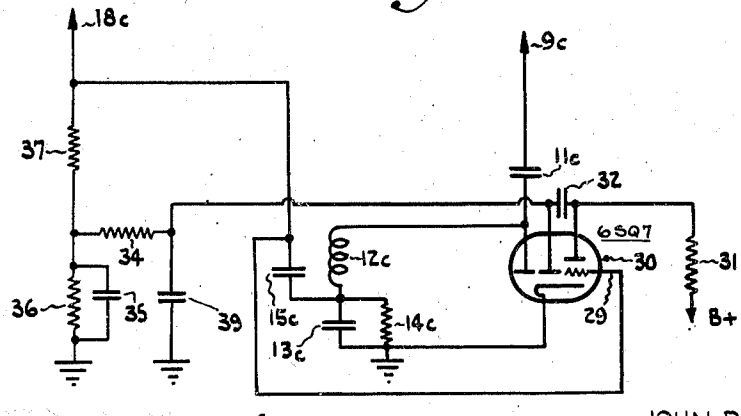


Fig. 4

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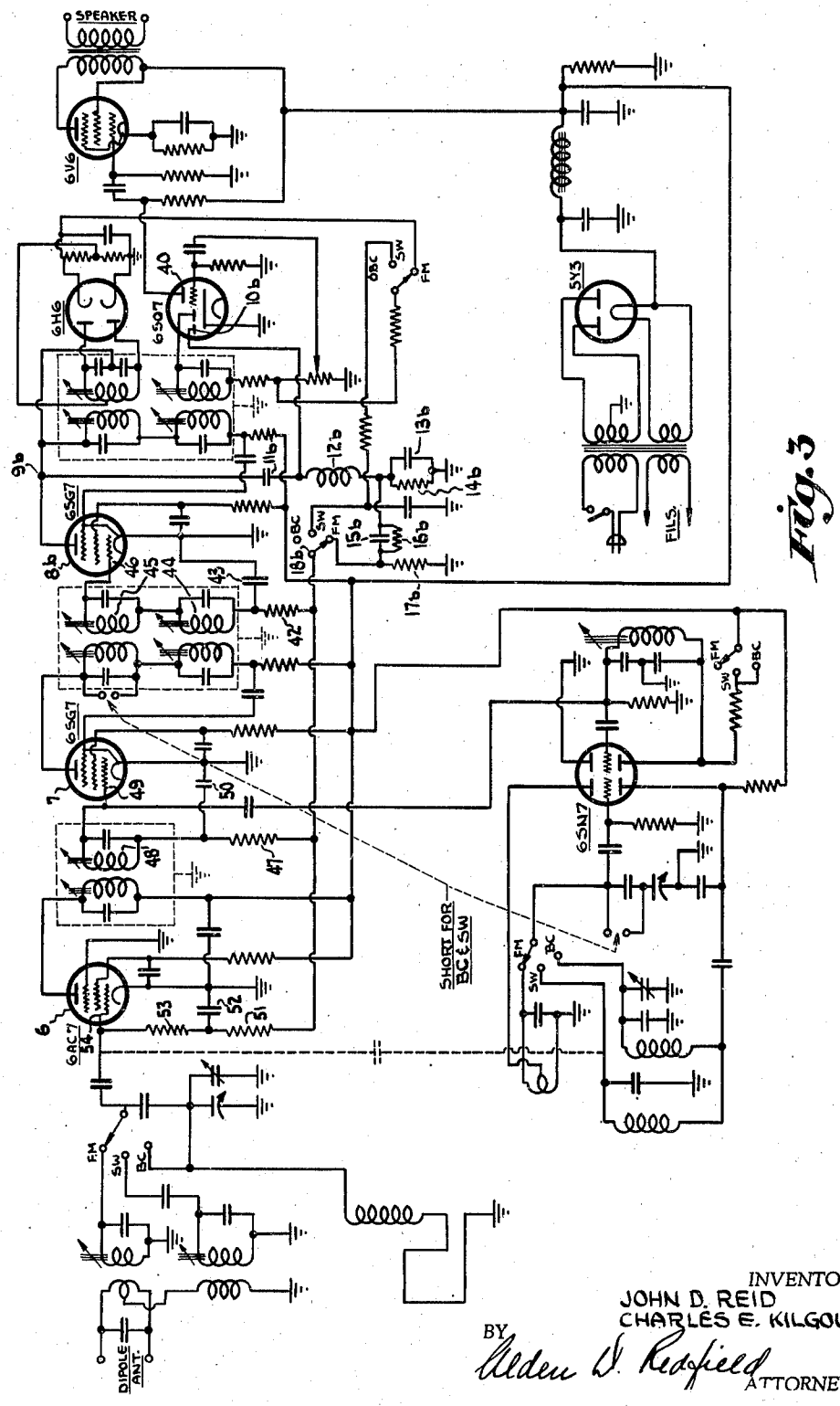


Fig. 3

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RADIO RECEIVING SYSTEM

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3 Claims. (Cl. 250—20)

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This invention relates to a radio receiving system for receiving frequency modulated carrier waves so that the effect of amplitude modulations is reduced or avoided without using conventional limiting circuits.

As is well known in the art, limiting is accomplished by overloading a vacuum tube, viz., by operating it under conditions such as after a certain input voltage is reached, the output remains constant. This is disadvantageous in that it entails a loss of selectivity and results in a low effective sensitivity. An object of the present invention is to reduce amplitude modulations such as caused by interference or "noise" without the use of the conventional limiting circuits and without impairing selectivity. Further objects are to provide amplitude modulation reducing means that are more sensitive than those that have heretofore been used, to simplify the manufacture of frequency modulation receivers and to reduce the cost thereof.

The novel features that we consider characteristic of our invention are set forth in the appended claims; the invention itself, however, both as to its organization and method of operation, together with additional objects and advantages thereof will best be understood from the following description of specific embodiments when read in conjunction with the accompanying drawings in which—

Fig. 1 is a block diagram showing how our invention may be utilized in a receiver for frequency modulated waves.

Fig. 2 is a circuit diagram of a modification of our invention, showing an amplifier stage used in conjunction therewith.

Fig. 3 is a circuit diagram of a complete receiver for standard broadcast, short wave and FM.

Fig. 4 is a circuit diagram showing how amplitude modulated waves may be amplified and rectified for obtaining additional bias.

Briefly described, our invention comprises amplifying and uniformly rectifying a frequency modulated radio frequency carrier, deriving a voltage therefrom to bias the control grids of the amplifiers toward cutoff according to the amplitude of the signal envelope, and substantially independent of the frequency variation of the carrier, and simultaneously applying a portion of the direct current voltage developed during rectification to such grids, thereby preventing overloading. The audio frequency voltage derived from the carrier is applied to the control grids of amplifying stages in conjunction with capacitance and

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resistance of such time constant that a rapid control may be effected.

Fig. 1 is a block diagram of a superheterodyne receiver for frequency modulated waves, showing the stages of converting the incoming signal to an intermediate frequency, amplifying the intermediate frequency, discriminating the frequency modulation that is impressed on the incoming carrier, amplifying the same and converting it to sound waves. A diode 10 is connected at 9 between the high side of the intermediate frequency output and ground by coupling capacitance 11. A voltage is developed across diode 10 which corresponds to the amplitude modulated envelope of the carrier and appears across capacitance 13. An audio voltage corresponding to the amplitude modulation on the carrier is then applied through audio coupling capacitance 15 to the control grids of preceeding amplifiers at 18, thus automatically biasing them, in a sense tending to reduce the amplitude modulation of the carrier. Resistors 16 and 17 act as a voltage divider, dividing the D. C. components of the rectified voltage, the resultant of which is also applied to the preceding amplifiers through an audio pass filter network as shown in detail in Fig. 3. This controls the gain of the amplifiers and thus prevents overloading.

The amount of D. C. applied may be controlled by selecting appropriate values for resistances 16 and 17. If resistance 17 is made ten or more times as large as resistance 16, substantially the full D. C. voltage developed will be applied for control purposes. Conversely, if resistance 17 is made one-tenth of the value of resistance 16, then slightly less than one-tenth of the developed D. C. voltage will be applied for control purposes. If no D. C. is desired to be applied for control purposes, resistor 16 may be omitted and resistor 14 shown in dotted lines may be connected across capacitance 13 as indicated in Fig. 1.

A choke coil 12 is inserted between the diode plate and the high side of capacitance 13 for the purpose of completing the D. C. circuit without appreciably reducing the intermediate frequency voltages applied to the diode plate and for the purpose of coupling the diode to the I. F. amplifier without appreciable selectivity over the I. F. pass band so as to obtain uniform rectification of the FM modulated carrier.

Fig. 2 shows a modification incorporating an additional stage of amplification between the signal channel and our control means. An amplifier 20 is connected to the signal channel at 9a through coupling capacitance 11a. The output of the amplifier is transformer coupled to our

control device by a double permeability tuned transformer 22 having primary 21 and secondary 23, and a pass band substantially the same as the I. F. amplifier. The radio frequency output of this transformer is connected between the cathode of diode 18a and ground as shown. Between the plate of the diode and ground is included a load resistance 14a, shunted by intermediate frequency bypass capacitance 13a. The desired audio control voltage corresponding to the amplitude modulation on the carrier is developed across the load resistor 14a. This audio control voltage together with the full D. C. component is applied to the control grids of the amplifiers desired to be controlled. Of course, any part of this control voltage may be used, different amounts may be used on different tubes, the control bias may be applied to tubes preceding or following point 9a in the signal channel, and as described in connection with Fig. 1, circuits may be used to obtain different ratios of D. C. to audio voltage.

In Fig. 3 is a circuit diagram of a combined standard broadcast, short wave and FM receiver. On the standard broadcast and short wave band, the receiver functions as a triple detector or double superheterodyne, but on the FM band it operates as a single superheterodyne. The first I. F. stage operates at approximately 8.25 megacycles and the second I. F. stage operates at either 8.25 megacycles or 245 kc. As shown in Fig. 3, the receiver is connected for FM reception. The tube 40 relating to the present invention is a duplex diode triode of the 6SQ7 type, the diode plate 10b being connected to the signal channel at 9b through capacitance 11b. Connection 9b is in the output of the last I. F. amplifier designated as 8b.

In Fig. 3 the elements corresponding to Fig. 1 are shown with the letter suffixes "b." In addition, other components connecting to the control grids of the I. F. amplifiers and first detector are indicated by suitable reference characters. As an illustrative embodiment, these components may conveniently have the following values:

11b—10 micromicrofarads
12b—100 microhenries
13b—100 micromicrofarads
14b—100,000 ohms
15b—.5 microfarad
16b—1 megohm
17b—2 megohms
42—10,000 ohms
43—.001 microfarad
47—10,000 ohms
50—.001 microfarad
51—10,000 ohms
52—.001 microfarad
53—2 megohms

Control voltages of the type previously described are communicated from the point 18b; to the control grid 46 of I. F. amplifying tube 8b through resistor 42 and the secondary 44 of the 245 kc. I. F. transformer and the secondary 45 of the 8.25 megacycles I. F. transformer. Capacitance 43 completes the intermediate frequency circuit to the cathode of tube 8b.

Control voltages are also communicated through point 18b to control grid 49 of I. F. amplifier 7, through resistor 47, and through the secondary 48 of the 8.25 megacycle I. F. transformer. Capacitance 50 is connected to the cathode of tube 7 for the purpose of completing the I. F. circuit. These control voltages are also applied to the control grid 54 of the first detector 6 through resistors 51 and 53. Capacitance 52 is connected between the cathode of the first detector and the junction point of resistors 51 and 53 for the purpose of bypassing this junction to ground with respect to R. F. and I. F. potentials.

A further embodiment of our invention is shown in Fig. 4, in which amplitude modulation components are amplified, rectified and applied in order to provide additional D. C. control bias in excess of the audio frequency control bias. This is of advantage in order to prevent the controlled tubes from drawing grid current. This is accomplished by providing a duplex diode-triode 30 such as a standard 6SQ7, and connecting into the signal channel at 9c, in the manner previously described through a capacity 11c. Components corresponding to those indicated in the other figures are denoted by the suffix "c." One plate of the diode section of the tube 30 is connected through inductance 12c to load resistance 14c shunted by capacitance 13c. Voltage components appear across load resistor 14c as described in connection with the other figures. An audio voltage corresponding to the amplitude modulation is applied through capacitance 15c to one or more of the control grids in preceding amplifier stages through connection 18c. The D. C. component is not utilized in this embodiment. In order to obtain additional bias corresponding to the intensity of the amplitude modulation the audio signal is also applied to the grid 29 of the triode section of tube 30. This amplified voltage appears across the load resistor 31 and whatever voltage thus appears is connected through capacitance 32 to the other diode of the tube 30 and again rectified. The rectified voltage appears across capacitor 39. The voltage appearing across this capacitor is applied through filter network 34, 35, 36 and 37, to the control grids of the amplifiers by the connection shown at 18c. The constants of this low pass filter network are such that substantially all audio components of the rectified voltage are removed.

It will be observed that with circuits constructed in accordance with the foregoing embodiments it is possible to utilize the voltage derived from the amplitude modulations on the carrier to bias the control grids of the amplifiers in a sense tending to reduce the effect of said amplitude modulations. Furthermore, it is possible to utilize all or part of a D. C. voltage corresponding to the signal strength to exercise a further control upon the amplifiers so as to prevent overloading with its attendant loss of sensitivity.

It should also be noted that the amplitude modulation reducing means is effective and will operate at relatively low levels of signal at the discriminator. One or two volts of intermediate frequency signal at the input of the discriminator will be effective when applied through the described amplitude modulation reducing means. With conventional frequency modulation receivers embodying a limiter, one or two volts of intermediate frequency are required at the grid of the limiter, which is the last I. F. amplifier tube, before any amplitude modulation reduction is obtained. Accordingly, the effective sensitivity (the sensitivity at which amplitude modulation reduction is effective) of our system is increased by the gain of the last intermediate frequency amplifier which may be 50 or more. This obviates the necessity of an additional amplifying stage, simplifies receiver design and reduces cost.

Having thus described our invention, we claim:

1. In a receiver for angular velocity modulated waves comprising an amplifier for amplifying the modulated carrier and a discriminator for detecting the desired modulations, an auxiliary detector connected therebetween and coupled thereto by means no more selective than the amplifier, said auxiliary detector comprising a diode and a load circuit connected thereto, whereby it may rectify both the signal carrier and undesired amplitude modulations thereof, and selective means comprising an audio pass filter network connecting said load circuit to said amplifier, said filter network including a direct current voltage divider whereby substantially all the audio voltage derived from said auxiliary detector and a portion of the direct current voltage derived therefrom is applied to said amplifier.

2. In a receiver for angular velocity modulated waves comprising an amplifier for amplifying the modulated carrier and a discriminator for detecting the desired modulations, an auxiliary detector connected therebetween and coupled thereto by means no more selective than the amplifier, said auxiliary detector comprising a diode and a load circuit connected thereto whereby it may rectify both the signal carrier and undesired amplitude modulations thereof, and selective means comprising an audio pass filter network connecting said load circuit to said amplifier, said filter network including a direct current voltage divider whereby selected portions of audio and direct current voltages are applied to said amplifier.

3. In a receiver for frequency modulated waves having amplifiers a diode for uniformly rectifying the FM carrier, means including a load circuit for deriving a voltage therefrom corresponding to the amplitude modulation on said carrier, means comprising a coupling capacitance and an audio pass filter network for applying a portion thereof to the control grid of said amplifier, additional means comprising an amplifier and a rectifier for deriving an amplified direct current voltage proportionately to the average value of said amplitude modulations and a low pass filter network for applying a portion of said direct current voltage to said first amplifier.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,093,548	Chittick	Sept. 21, 1937
2,194,552	Hunt	Mar. 26, 1940
2,207,905	Weagant	July 16, 1940
2,251,382	Sziklai	Aug. 5, 1941
2,253,338	Lewis	Aug. 19, 1941
2,264,724	Schonfeld	Dec. 2, 1941
2,276,488	Hershey	Mar. 17, 1942
2,390,502	Atkins	Dec. 11, 1945