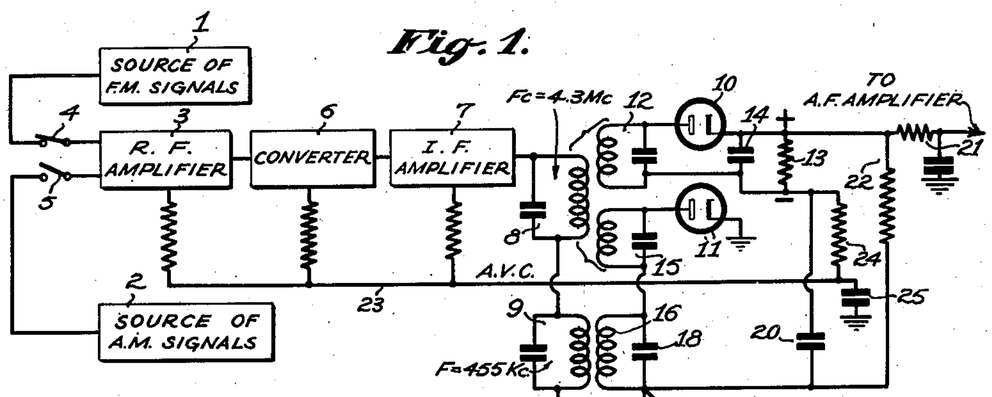
June 7, 1949. W. R. KOCH **2,472,301**

FREQUENCY MODULATED-AMPLITUDE MODULATED RECEIVERS

Original Filed Feb. 5, 1945 2 Sheets-Sheet 1

Fig. 1.



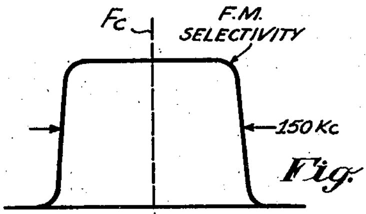


Fig. 1a.

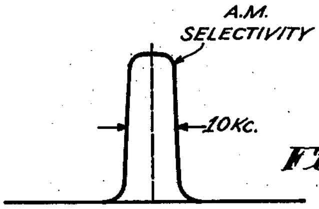


Fig. 1b.

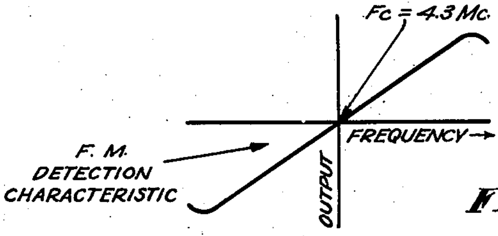


Fig. 1c.

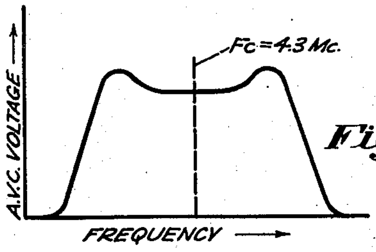


Fig. 1d.

INVENTOR.
WINFIELD R. KOCH
BY H. S. Grover
ATTORNEY

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FREQUENCY MODULATED-AMPLITUDE MODULATED RECEIVERS

Original Filed Feb. 5, 1945 2 Sheets-Sheet 2

Fig. 2.

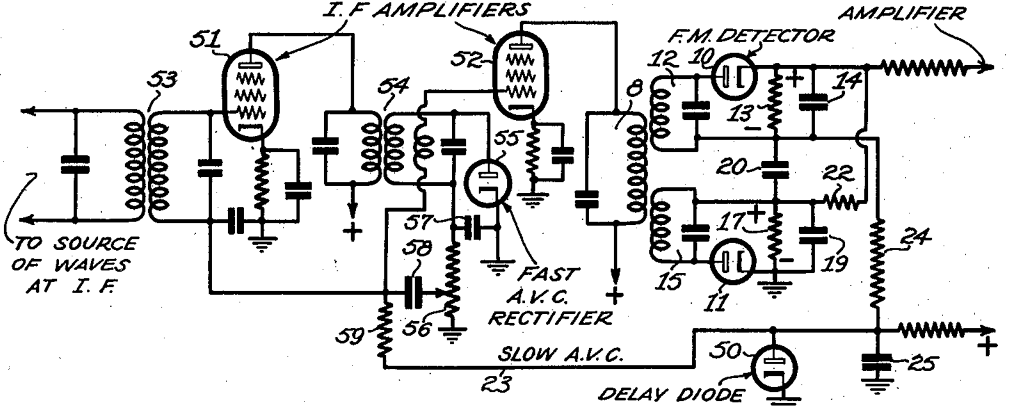
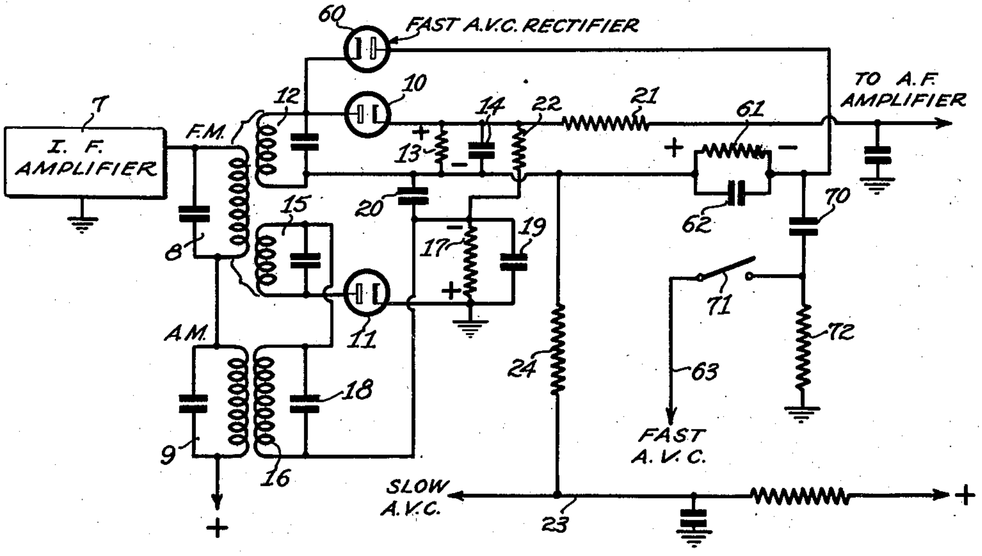


Fig. 3.



INVENTOR.
WINFIELD R. KOCH
BY
H.S. Grover
ATTORNEY

UNITED STATES PATENT OFFICE

2,472,301

FREQUENCY MODULATED-AMPLITUDE MODULATED RECEIVER

Winfield R. Koch, Haddonfield, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Original application February 5, 1944, Serial No. 521,193. Divided and this application March 2, 1945, Serial No. 580,683

4 Claims. (Cl. 250—20)

My present invention relates to receivers of frequency modulated (FM) or amplitude modulated (AM) carrier waves, and more particularly to novel and improved receivers of FM or AM carrier waves. This application is a division of my application Serial No. 521,193, filed February 5, 1944, now Patent No. 2,429,726.

In his U. S. Patent No. 2,296,092, granted September 15, 1942, M. G. Crosby has disclosed a differential detector circuit adapted to receive FM and/or AM carrier waves. In his detector circuit Crosby provides automatic volume control (AVC) voltage at the detector output in response to either FM or AM reception. The AVC voltage is derived from the separate rectified voltages of the balanced rectifiers added in aiding phase, while the modulation signal corresponding to the frequency modulation of a carrier wave is derived from the rectified voltages added in phase opposition. While Crosby showed a common signal input network for feeding the FM or AM signals to the detector, it is often desirable to provide separate and independent FM and AM signal channels to the detector and yet be able to provide the same output voltages as in the Crosby system. When receiving FM signals with a receiver having a substantially flat-topped selectively characteristic and no amplitude limiter used, it is desirable to provide AVC voltage from the opposed diodes of the discriminator-detector circuit. Again, where such a receiver is provided with a separate signal channel for AM broadcast reception, it is desirable to use one of the opposed diodes for AM detection and AVC rectification without switching. It is an important object of my invention to provide such an FM-AM receiver with minimum circuit components and maximum detected voltage output.

In the customary limiter, or fast-acting AVC, used in FM receivers slow variations in carrier amplitude are controlled along with rapid variations. It is another object of my present invention to improve the receiver performance by providing separate slow-acting AVC and fast-acting AVC for the receiver; the slow-acting AVC voltage being derived from the FM detector circuit, and the fast-acting AVC voltage being taken from a point prior to the discriminator network.

Still another object of my invention is to provide an FM-AM receiver wherein for FM reception separate slow-acting and fast-acting AVC voltages are taken off from the discriminator-rectifier load circuit, whereas for AM reception the fast-acting control is removed leaving the slow-acting control operating.

Other objects of my present invention are to improve generally the efficiency of FM-AM receivers, and more especially to provide economical detector circuits for such receivers.

Still other features will best be understood by reference to the following description, taken in connection with the drawings, in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings:

Fig. 1 shows, in partial schematic form, an FM-AM receiver employing one embodiment of my invention;

Fig. 1*a* shows an ideal selectivity characteristic of the FM signal channel;

Fig. 1*b* shows an ideal selectivity characteristic of the AM signal channel;

Fig. 1*c* illustrates the FM detection characteristic;

Fig. 1*d* shows the "Frequency vs. AVC voltage" characteristic for FM reception;

Fig. 2 is the circuit diagram of an FM signal channel using separate slow-acting and fast-acting AVC; and

Fig. 3 shows a modification of the circuit of Fig. 2 applied to an FM and AM receiver.

Referring now to the accompanying drawings, wherein like reference characters in the different figures designate similar circuit elements, Fig. 1 shows an illustrative receiving system embodying a demodulator network adapted to provide audio voltage and AVC voltage in response to FM or AM signal reception. The receiver circuits prior to the demodulator are schematically represented. Those skilled in the art of radio reception are well acquainted with the nature of the circuits customarily employed in multi-band receivers. While my invention is readily adapted for FM and AM reception on respective bands of 42 to 50 megacycles (mc.) and 550 to 1700 kilocycles (kc.), it is to be clearly understood that the invention is not limited to such frequency bands. The 42 to 50 mc. band is presented by way of illustration, since it is the FM broadcast band presently assigned to such transmission. The 550 to 1700 kc. band is the present AM broadcast band assigned to transmission of AM signals.

It will further be understood that in the following description and claims the generic expression "angle modulated" is intended to include frequency modulation, phase modulation or hybrid modulations possessing characteristics common to either form of modulation. From a very general viewpoint my invention relates to a demodulator network having separate input circuits for carrier waves of different frequencies and of different modulation characteristics.

The numerals **1** and **2** in Fig. 1 denote respectively different sources of modulated carrier waves. Source **1** may be the usual signal collector, such as a dipole, employed for collecting FM waves. The FM waves are transmitted from FM transmitters at a mean, center or carrier frequency assigned to the particular transmitter. In the assumed FM band of 42 to 50 mc. the radiated carrier wave frequency would be in that range, and would be a wave of variable frequency and substantially uniform amplitude. As is well known, the frequency modulation of the carrier wave would be in accordance with the modulation signals at the transmitter. The extent of frequency deviation of the carrier frequency is a function of the modulation signal amplitude, while the rate of frequency deviation is dependent upon the modulation signal frequencies per se. The permissible extreme frequency deviation in the FM band of 42 to 50 mc. is 75 kc. to either side of the carrier frequency; the allotted FM channels are 200 kc. wide. These values are purely illustrative.

Source **2** may be the customary grounded antenna circuit employed in AM broadcast reception. The allotted channels are **10** kc. wide in this band. In AM transmission the carrier wave is modulated in amplitude in accordance with the modulation signals. The carrier frequently is maintained constant in value at the transmitter. The numeral **3** designates a tunable radio frequency amplifier having suitable signal selector circuits for FM or AM reception. Switching devices **4** and **5** respectively provide separate connection of the sources **1** and **2** to respective selector circuits of amplifier **3**. It will be understood that when switch **4** is in closed position, collected FM signal energy will be applied to selector circuits of amplifier **3** capable of selectively amplifying the FM signals over a band at least 150 kc. wide. Upon closing of switch **5** and opening switch **4** the same amplifier **3** will have the FM selector circuits thereof operatively replaced by AM selector circuits. These latter circuits will select the collected AM signals and permit amplifier **3** to amplify the same over a 10 kc. band. Multi-band selector circuits and switching devices for suitable change-over are well known to those skilled in the art of radio communication. Switching devices **4** and **5** affect the demodulator circuit only in so far as they determine the character of the modulated wave to be delivered to the demodulator.

Assuming the system is of the superheterodyne type, as is the usual practice at present, the converter **6** and intermediate frequency (I. F.) amplifier **7** will also be provided with suitable FM and AM signal selector circuits. At the converter **6** the FM signals will have the mean or center frequency thereof reduced to a value which may be chosen from a range of 1 to 20 mc., as for example 4.3 mc. The AM signals are reduced to an I. F. of 455 kc., as an illustrative frequency value, the latter being a commonly employed frequency in AM broadcast receivers of the superheterodyne type. The I. F. amplifier **7**, which may consist of one or more separate stages of amplification, will have an ultimate output circuit from which may be derived, at separate points thereof, the amplified FM signals or AM signals.

The selective circuits **8** and **9** are to be understood as being arranged in series in the plate circuit of the last I. F. amplifier tube. Each of circuits **8** and **9** is resonated to its respective operating I. F. value for FM or AM reception. Thus, circuit **8** is tuned to 4.3 mc., while circuit **9** is tuned to 455 kc. There will be developed across tuned circuit **8** the FM signals at the 4.3 mc. mean frequency when switch **4** is closed, and all FM selector circuits of amplifier **3**, converter **6** and I. F. amplifier **7** are in operative electrical connection. Conversely, when switch **5** is closed, and switch **4** is open, and all AM selector circuits are in operative electrical connection, there will be developed across circuit **9** AM signals at the I. F. value of 455 kc. The impedance of circuit **9** is negligible at 4.3 mc.; therefore, the insertion of circuit **9** in series with circuit **8** will not affect the development of FM signal voltage across circuit **8**. Similarly, the impedance of circuit **8** is negligible at 455 kc., and circuit **8** will not affect development of AM signal voltage across circuit **9**.

The demodulator comprises but two electron discharge devices, shown as diodes by way of illustration. The electrodes of the pair of diodes may be housed within a common tube envelope, or they may be in separate envelopes. By way of specific illustration the diodes **10** and **11** are shown as being separate tubes. The diode **10** is provided with a resonant input circuit **12** which is inductively coupled to the circuit **8**. The anode of diode **10** is connected to one side of the input circuit **12**, while the cathode of diode **10** is connected to the opposite side of input circuit **12** through the load resistor **13**. Resistor **13** is bypassed by condenser **14** for high frequency currents.

Diode **11** has its cathode established at ground potential, while its anode is connected to the high alternating potential side of its resonant input circuit **15**. Circuit **15** is also inductively coupled to the circuit **8**. The low potential side of circuit **15** is connected to ground through the coil **16** and load resistor **17**. Coil **16** is magnetically coupled to circuit **9**, and condenser **18** shunts coil **16** to provide a resonant circuit **16**—**18** tuned to 455 kc. Condenser **19** shunts resistor **17** to bypass high frequency currents.

The input circuits **12** and **15** of diodes **10** and **11** respectively are oppositely and equally mistuned with respect to the operating I. F. value for FM reception. In other words, if the FM signals developed across circuit **8** have a center frequency of F_c (4.3 mc.), then circuits **12** and **15** will be detuned in opposite senses by equal predetermined frequency values relative to F_c. It will be recognized that circuits **8**, **12** and **15** provide the well known discriminator network of Conrad U. S. Patent No. 2,057,640. The action of this form of discriminator circuit is well known to those skilled in the art. It functions to translate FM high frequency signals into corresponding AM high frequency signals.

At the 4.3 mc. frequency used for FM reception the impedance of circuit **16**—**18** is negligible, and hence the load resistor **17** is effectively in series with input circuit **15** and diode **11**. The upper end of resistor **17** is coupled to the lower end of resistor **13** through the condenser **20**. Condenser **20** has a low impedance for the modulation frequencies developed during detection of the FM signals, but has a high impedance to high frequency currents. In other words, condenser **20** is a modulation frequency coupling condenser.

Assuming that the modulation signals on the received FM waves are of audio frequency, then the audio frequency amplifier of the receiver will have its input lead connected to the cathode end of load resistor 13. As already known, a deemphasis network 21 may be employed in the audio frequency output connection in order to compensate for pre-emphasis of higher audio frequencies at the transmitter. In accordance with well-understood principles of FM signal detection, the alternating current components in the rectified signal voltage across each of resistors 17 and 13 will be combined in phase opposition due to the connection of the anode end of resistor 17 to the anode end of resistor 13 by coupling condenser 20.

The differential voltage resulting from the phase-opposed voltages corresponds to the audio modulation signal voltage originally applied to the FM carrier wave at the FM transmitter. At the same time there is provided a conductive connection between the negative or anode end of resistor 17 and the cathode or positive end of resistor 13. This conductive connection includes resistor 22. Considered relative to ground the direct current voltage components of the rectified voltages appearing across resistors 13 and 17 are added in phase-aiding sense. In other words, the direct current voltage components of rectifiers 10 and 11 are combined in additive manner during FM signal reception, while the alternating current (audio) outputs of rectifiers 10 and 11 are combined in phase-opposed relation.

An AVC connection 23 is provided between the gain control electrodes, as for example the signal grids, of the various tubes in networks 3, 6 and 7 and the negtive end of resistor 13. The AVC connection 23 includes a filter resistor 24, whose lower end is bypassed to ground by an audio frequency condenser 25, so as to prevent alternating current components from being transmitted over the connection 23. Network 24—25 therefore acts as a time constant network to produce "slow" AVC action.

The function of the AVC connection is well known to those skilled in the art. Should there be any carrier amplitude variation at the input terminals of each of rectifiers 10 and 11, such amplitude variation will be translated into a corresponding change in direct current voltage across the corresponding load resistors 13 and 17. The AVC voltage applied over connection 23 to the controlled tubes will reduce the gain of the tubes to counteract undesired carrier amplitude increase.

During AM signal reception the I. F. signal energy produced in the circuit 9 will be transferred to input circuit 16—18. Each of circuits 9 and 16—18 is tuned to the operating I. F. value of 455 kc. The circuit 15 and diode 11 are both included in a series circuit with tuned circuit 16—18 and load resistor 17. The circuit 15, resonant close to 4.3 mc., has no appreciable effect on the series circuit, since it acts as an extremely low impedance connection at the 455 kc. value. The modulation voltage component of the rectified I. F. energy developed across bypassed load resistor 17 is applied through condenser 20 and resistor 13 to the common modulation signal output circuit. The direct current voltage component across resistor 17 is applied over AVC path 23 to the prior tubes. The AVC line 23 connects to the ungrounded end of resistor 17, through a series path consisting of resistor 24, resistor 13 and resistor 22. Here, again, the network 24—25 acts to introduce time delay into the AVC action.

In Fig. 1*a* I have shown the form of selectivity characteristic which is preferred for use during FM signal reception. The curve is idealized, and represents a flat-topped characteristic at least 150 kc. wide. The characteristic represents the ideal pass band of the receiver circuits up to the opposed rectifiers 10—11 during FM reception. The flat-topped selectivity characteristic, if the FM carrier is correctly centered on it, insures against production of amplitude modulation on the FM wave as the latter passes through the cascaded resonant circuits to the FM detector circuit, and lessens the importance of the use of an amplitude limiter stage in FM reception. The AVC circuit acts effectively to reduce the gain of the receiver tubes in response to increases in amplitude of the FM carrier.

By way of contrast to Fig. 1*a* I have shown the AM selectivity characteristic in Fig. 1*b*. This curve is idealized, and represents the flat-topped 10 kc. pass band of the receiver circuits up to the rectifier during AM signal reception. This enables faithful AM reception and permits the AVC action to function in the well understood manner. Fig. 1*c* shows the FM detection characteristic of opposed rectifiers 10 and 11 and their associated input circuits 12 and 15. It is desirable to have the spaced peaks of the ideal curve separated by a frequency value in excess of the 150 kc. band width. Further, the curve should be as linear as possible between the peaks thereof.

With a detection characteristic as shown in Fig. 1*c*, the "AVC voltage vs. Frequency" characteristic durinng FM reception will be substantially of the form represented in Fig. 1*d*. It will be noted that the AVC (negative in polarity) voltage, with changes in carrier frequency but not in amplitude, becomes a maximum at spaced peaks of the curve with a decrease towards the center frequency F_c. In other words, the AVC bias will be a maximum on each side of F_c thereby providing an audible aid in differentiation between exact tuning of the receiver and off-center tuning thereof.

In Fig. 2 I have shown a receiving system of the type schematically represented in Fig. 1, but arranged to receive FM signals only. For this reason the circuits shown in Fig. 2 omit the AM signal receiving circuits. The FM detector circuit is substantially the same as that shown in Fig. 1 for receiving FM signals. It will be seen that the AVC line 23 is connected through filter resistor 24 to the anode end of resistor 13, and therethrough to the anode end of resistor 17 through resistor 22. The time constant circuit 24—25 provides slow-acting AVC action. In order to secure a measure of delay there is employed a well known delay device consisting of a diode 50 whose cathode is grounded, but whose anode is connected to the lead 23. A permanent positive bias is applied to the anode of diode 50 thereby effectively establishing the lower end of resistor 24 at ground potential until the diode 50 is rendered non-conductive. The diode 50 becomes non-conductive upon the negative potential at the anode end of resistor 13 assuming a sufficient negative value relative to ground to overcome the positive bias on the anode of diode 50. From that point on the AVC bias will be supplied over line 23 to the control grids of the various controlled tubes. This form of delayed AVC action is well known.

Only the I. F. amplifiers preceding the discriminator network are shown, since it is to be understood that the slow-acting AVC circuit 23 may be connected to one or more of the transmission tubes preceding the I. F. amplifier tubes **51** and **52**. The tuned I. F. transformers **53** and **54** will, of course, be constructed so as to pass the required frequency swing of the FM signals. It will be seen that the I. F. amplifier stages shown in Fig. 2 are of well known form, and hence they need no further explanation. The input electrode of amplifier **52** is magnetically coupled to the resonant secondary circuit of I. F. transformer **54**, and, therefore, derives its signal energy therefrom.

A diode rectifier **55** has its electrodes coupled to the opposite sides of the secondary circuit of I. F. transformer **54**. The resistor **56**, bypassed by condenser **57** for I. F. currents, is connected between the grounded cathode of diode **55** and the low potential side of the secondary circuit of transformer **54**. Alternating current components of the rectified voltage developed across resistor **56** are applied to the control grids of amplifiers **51** and **52** by connecting the grid circuits of these tubes to any desired point on resistor **56** by means of an audio coupling condenser **58**. The feedback to the amplifier control grids from across resistor **56** is performed degeneratively so as to compensate for undesired relatively fast amplitude variations of the FM signals. This action will be referred to hereinafter as control of fast variations or fast AVC. It will be noted that the slow-acting AVC lead **23** is also connected to the grids of tubes **51** and **52** through a filter resistor **59**.

No amplitude limiter stage per se is employed prior to the discriminator network. Furthermore, it will be observed that there is utlized separate control by diodes **55** and **10—11** respectively of fast variations and slow variations in carrier amplitude. In the familiar and customary form of limiter, or fast-acting AVC, slow variations in carrier amplitude are controlled along with the rapid variations. The customary limiter circuit of necessity must reduce the average amplification of the receiver in order to be able to increase and decrease the overall gain to compensate for rapid variations of amplitude. By using a separate slow-acting delayed AVC circuit, together with fast AVC, the average amplification of the receiver will not be cut for weak signals. However, variations in the carrier amplitude, for example as the carrier is swung across a round-top selectivity curve, will be compensated for by the amplitude correction device. Hence, weak signals will be received with less distortion.

Since the gain of a special limiter stage is usually low, because it is usually operated with low screen and plate voltages, there is another advantage secured by the circuit of Fig. 2. By using the separate controls high gain amplification is obtained. It will be noted that the slow-acting AVC voltage is derived from the discriminator-detector output circuit as explained in connection with Fig. 1. This AVC voltage is considerably larger than can be secured in the case where a limiter stage precedes the discriminator thereby giving better regulation and having less likelihood of overloading preceding stages.

The fast-acting AVC rectifier applies its rectified voltage to points prior to, and following, the point from which it derives its signal energy. This insures a substantially flat gain control action. The slow-acting AVC voltage is applied to many tubes in addition to the tubes to which the fast-acting AVC bias is applied. By virtue of the combined AVC actions of Fig. 2 the response characteristics of the coupling transformers between stages need not be ideally flat, since the AVC circuit will tend to compensate for any curvature in the response characteristics.

In Fig. 3 I have shown a further modification wherein the fast-acting AVC voltage may be secured from the discriminator network. This has the advantage that the control voltage obtainable is much greater, and is, therefore, more effective. It will be recognized that in Fig. 3 the FM-AM networks feeding the diodes **10** and **11** are very similar to those shown in Fig. 1. Assuming first that FM signals are being received, the load resistors **13** and **17** develop thereacross audio voltages which are combined in phase opposition and the resultant voltage is transmitted through resistor **21** to the subsequent audio amplifier. The direct current voltage components across resistors **13** and **17** are combined in additive phase through resistor **22**. The slow-acting AVC connection **23** goes through resistor **24** to the negative end of resistor **13**. The AVC action is delayed by connecting the lead **23** to a source of positive bias. Instead of using the diode **50** of Fig. 2 for the delaying action, however, the resistor **59** of Fig. 2 may be omitted and the control grids of the various tubes to be controlled may be permitted to draw grid current thereby rendering the AVC circuit ineffective until the negative voltage at the anode end of resistor **13** becomes sufficiently negative to overcome the positive bias. This is, also, a well-known means for securing delayed AVC action.

The fast-acting AVC action is secured by means of an auxiliary diode rectifier **60** whose cathode is connected to the same side of circuit **12** as the anode of diode **10**. The anode of diode **60** is connected to the opposite side of circuit **12** through a resistor **61** bypassed by condenser **62**. The resistor **61** functions as the load resistor for diode **60**, and the condenser **62** bypasses only the I. F. currents. The fast-acting AVC connection **63** utilizes the alternating current voltage components of the rectified voltages across resistor **61** and resistor **17**. Since the positive end of resistor **61** is connected through the audio coupling condenser **20** to the negative end of resistor **17**, it will be seen that the audio voltages across resistors **17** and **61** are combined in additive phase for transmission through the audio coupling condenser **70** to connection **63** when switch **71** is closed. Switch **71** is provided to selectively connect or disconnect connection **63** from the condenser **70**. Condenser **70** and resistor **72**, the latter having its lower end grounded, remove the direct current components from the voltage and provide the fast time constant network for connection **63**.

It is contemplated that during FM signal reception the AVC connection **63** will be made to at least the prior I. F. amplifier **7**, and will act degeneratively as described in reference to Fig. 2. The slow-acting AVC connection **23** will also be made to one or more of the transmission tubes preceding stage **7**. For AM reception the switch **71** may be opened thereby removing the fast-acting AVC circuit. In this case the AVC lead **23** is connected through resistor **24**, resistor **13** and resistor **22** to the negative end of resistor **17**. In other words the direct current voltage component across resistor **17** is still used for the slow AVC action. In AM reception the audio voltage component across resistor **17** is applied to the audio output connection through the path comprising condenser **20** and resistor **13**. It will, therefore, be appreciated that in Fig. 3 I have provided a circuit wherein both slow-acting AVC and fast-acting AVC derive their voltages from the combination of rectified voltages in additive phase and in response to FM signal reception. For AM reception only one of the three rectifiers need be employed with its associated load resistor. In this way distortionless AM reception can be secured with only the slow-acting AVC circuit operating.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my 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 my invention.

What I claim is:

1. In a frequency modulation receiver, a frequency discriminator including a pair of load resistors across which direct current voltages appear as a result of detection, conductive means for connecting said resistors in series-aiding relation with respect to said voltages, a slow-acting circuit for applying the resultant of the voltages to a portion of the receiver as a first gain control voltage thereof, means for deriving from the received frequency modulated signal a second control voltage which is representative of relatively fast amplitude variations of the signal, means coupled to said resistors for deriving a detected modulation voltage representative of the frequency modulation of the received signal, and a fast-acting circuit for applying said second control voltage to a portion of the receiver as a second gain control voltage.

2. In a frequency modulation receiver, a frequency discriminator including a pair of load resistors across which direct current voltages appear as a result of detection, a conductive impedance element for connecting said resistors in series-aiding relation with respect to said voltages, a slow-acting circuit for applying the resultant of the voltages to a portion of the receiver as a gain control voltage thereof, means for deriving from the received frequency modulated signal a modulation voltage which is representative of relatively fast amplitude variations of the signal, and a fast-acting circuit for applying said modulation voltage to a portion of the receiver as a gain control voltage, means for connecting said resistors in series-opposing relation with respect to the modulation voltages thereacross representative of desired frequency modulation thereof, and means for utilizing the resultant of the series-opposed modulation voltages.

3. In a frequency modulation receiver provided with an amplifier, a frequency discriminator coupled to the amplifier providing a pair of signal voltages whose relative magnitudes are dependent on the frequency variation of received waves, a pair of rectifiers each having an input electrode separately coupled to said discriminator

to have a respective one of the pair of signal voltages applied thereto, a separate load impedance in circuit with each rectifier, a circuit connected across said load impedances deriving a modulation voltage in response to the added rectified voltages developed across said load impedances, a conductive impedance element connecting opposite polarity ends of said load impedances in series relation, a first gain control connection to similar polarity ends of said impedances for deriving from said impedances in additive polarity sense slow-acting rectified voltages developed thereacross, means to apply the additive voltage to said amplifier, an auxiliary rectifier having an input electrode coupled to said discriminator and including a third load impedance in circuit therewith, means of low impedance to modulation currents connecting opposite polarity ends of one of said first two impedances and said third impedance, a second gain control connection between said amplifier and one end of the third impedance for deriving from said third impedance and said one impedance in additive polarity sense the fast-acting rectified modulation voltages thereacross and for impressing them on said amplifier.

4. In a frequency modulation receiver, a frequency discriminator including a pair of load resistors across which direct current voltages appear as a result of frequency discrimination, a conductive impedance element for connecting said resistors in series-aiding relation with respect to said voltages, a slow-acting circuit for applying the resultant of the voltages to a portion of the receiver as a first gain control voltage thereof, means for deriving from the received frequency modulated signal a second control voltage which is representative of relatively fast amplitude variations of the signal, a circuit connected to said resistors for deriving a detected modulation voltage representative of desired frequency modulation of the received signal, said means for deriving comprising a rectifier in circuit with said discriminator, a third load resistor in circuit with the rectifier, means connecting one of the two load resistors and one terminal of the third resistor in series-aiding relation with respect to said second control voltage, and a fast-acting circuit connected to the other terminal of the third resistor.

WINFIELD R. KOCH.

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