June 21, 1938. D. E. FOSTER 2,120,974

AUTOMATIC FREQUENCY CONTROL CIRCUITS

Filed April 3, 1936 2 Sheets-Sheet 1

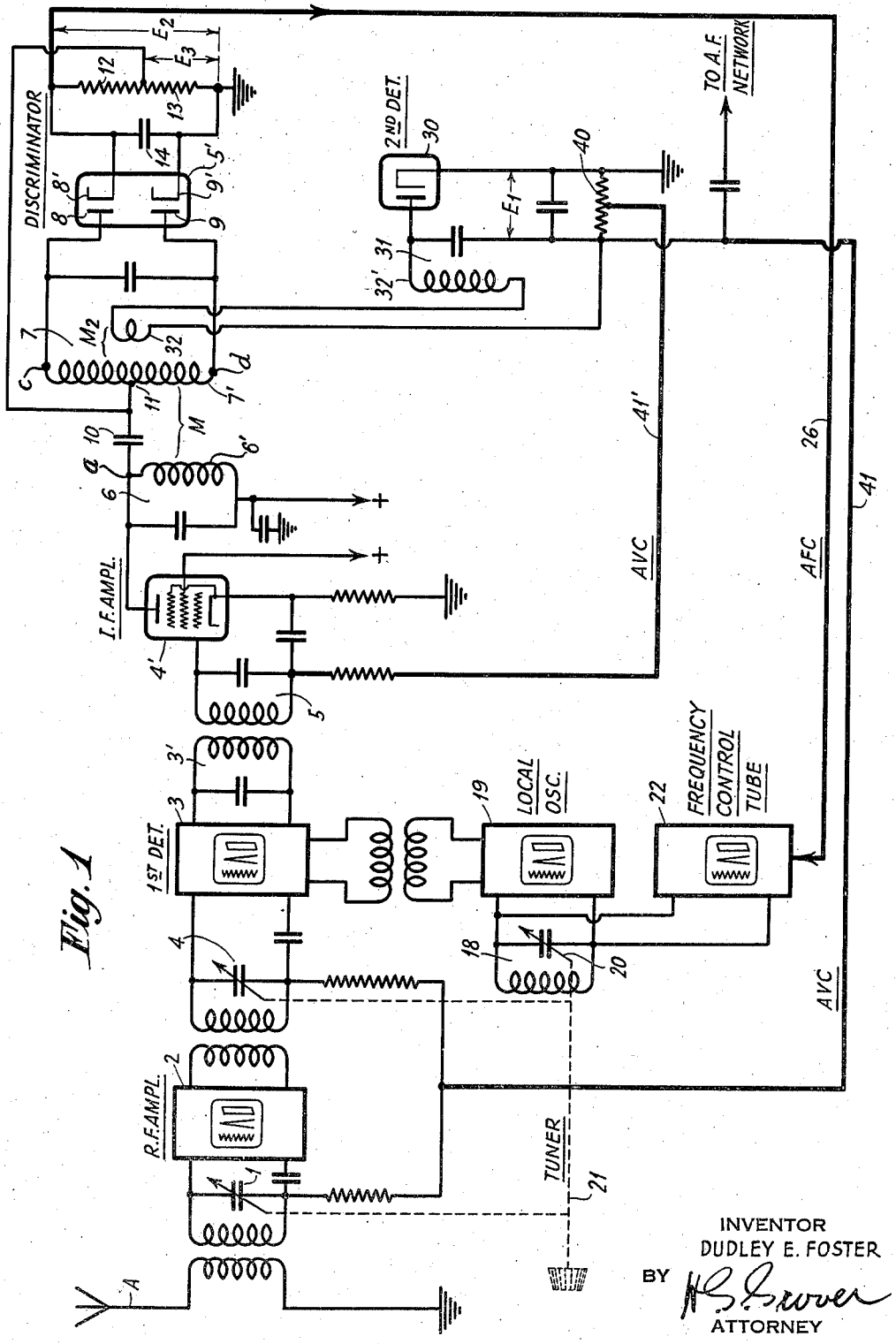


Fig. 1

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Fig. 2

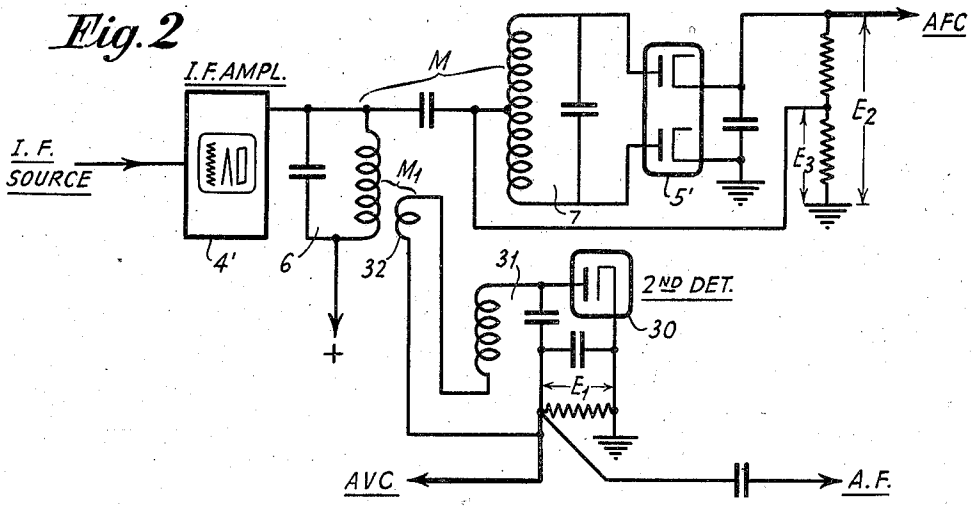


Fig. 3

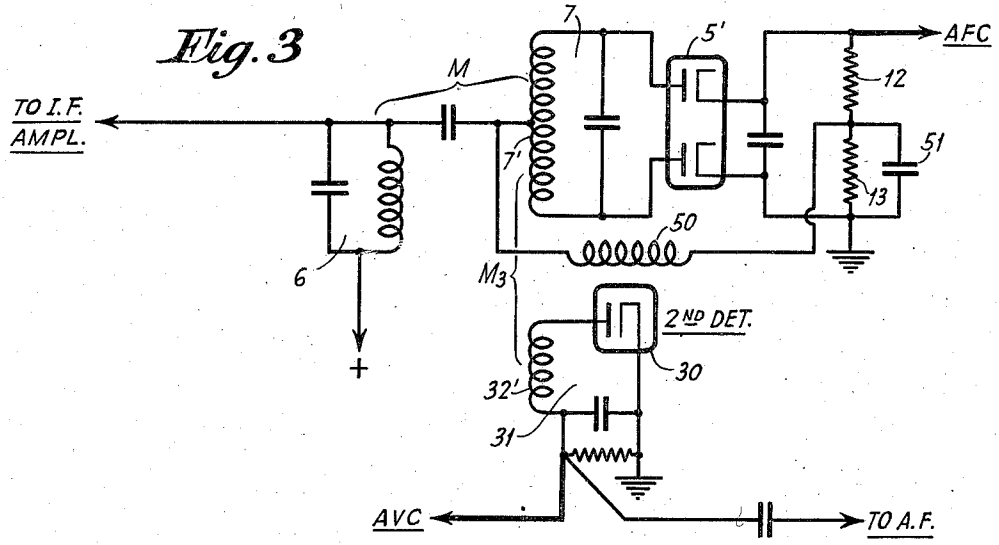
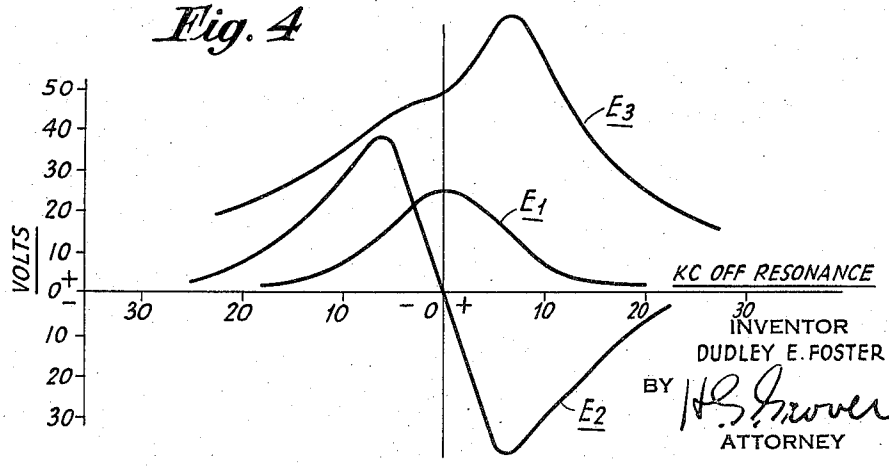


Fig. 4



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UNITED STATES PATENT OFFICE

2,120,974

AUTOMATIC FREQUENCY CONTROL CIRCUITS

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Application April 3, 1936, Serial No. 72,495

8 Claims. (Cl. 250—20)

My present invention relates to automatic frequency control circuits for superheterodyne receivers, and more particularly to improved and efficient discriminator and demodulation networks for automatic frequency control circuits used in superheterodyne systems.

In my application Serial No. 55,749, filed December 23, 1935, there has been disclosed an automatic frequency control system of a practical and efficient type. Generally, such a system comprises a double diode rectifier discriminator network adapted to produce from the IF energy, direct current voltage for AVC and AFC purposes, as well as audio voltage for the audio network of the receiver. Heretofore the use of AFC has been recommended only on superheterodyne receivers having more than one stage of IF amplification because of selectivity limitations of the discriminator system using a two-winding transformer.

It may be stated that it is one of the important objects of my present invention to provide an AFC system for a superheterodyne receiver wherein the frequency discriminator network employs three winding transformers with which the signal selectivity is not reduced, but instead is increased; it being pointed out that it is one of the essential characteristics of the present improvement to utilize an independent diode rectifier for the production of the AVC and audio voltages.

Another important object of this invention is to provide an AFC system in a superheterodyne receiver equipped with a single stage of IF amplification, satisfactory selectivity being secured in such a receiver by the use of a third winding on the discriminator transformer, which winding feeds a diode rectifier functioning to produce audio voltage.

Another object of the invention may be stated to reside in the provision of a superheterodyne receiver of the type employing AFC, and the discriminator of the control system comprising a pair of coupled resonant circuits each tuned to the operating IF, and a third resonant circuit, tuned to the operating IF, being coupled to the second of the discriminator circuits and feeding a demodulator diode.

Still other objects of my present invention are to improve generally the efficiency of AFC systems for superheterodyne radio receivers, and more especially to provide frequency control systems in a manner such that they may be economically and readily embodied in commercial broadcast receivers.

The novel features which are believed to be characteristic of my invention are set forth in particularity in the appended claims; the invention itself, as to both its organization and method of operation, will best be understood by reference to the following description, taken in connection with the accompanying drawings in which I have indicated various circuits whereby my invention may be carried into effect.

In the drawings:

Fig. 1 schematically shows a circuit diagram embodying a preferred form of the invention,

Fig. 2 is a circuit diagram of a portion of the receiving circuit of Fig. 1, and showing another embodiment of the invention,

Fig. 3 illustrates a further embodiment, and

Fig. 4 graphically shows the operation of the discriminator network illustrated in Fig. 1.

Referring now to the accompanying drawings, wherein like reference characters in the different figures designate similar circuit elements, attention is first directed to Fig. 1, which shows in a purely schematic manner a superheterodyne receiver embodying AFC. Since the functioning of the present invention is not dependent in any way upon the particular construction of the superheterodyne receiver, or the specific frequency control tube circuit employed therewith, it is believed sufficient for the purposes of this application to point out a typical superheterodyne receiving system which can be utilized in conjunction with the novel discriminator and audio demodulator construction of my present invention. The receiving system shown in Fig. 1 is a conventional representation of a system shown in Fig. 1 of my aforesaid copending application. Attention is further directed to Fig. 4 of application Serial No. 45,413, filed Oct. 17, 1935 by S. W. Seeley, for a detailed circuit diagram of a receiving system whose general construction is similar to that shown in Fig. 1.

It will be sufficient for those skilled in the art briefly to describe the main elements of a superheterodyne receiving system which is provided with AFC. The usual signal carrier energy collector A is coupled to the tunable input circuit of the radio frequency amplifier of the receiver. The tunable input circuit usually comprises a variable tuning condenser 1, and it is to be clearly understood that the numeral 2 may designate one or more stages of RF amplification, each of which stages may be tunable by a variable condenser. In order to preserve simplicity of disclosure and drawings, the numeral

3 designates the first detector, and its variable tuning condenser is designated by the numeral 4.

The output circuit 3' of the first detector is resonated to the operating IF, and the latter may have a value chosen from a range of 175 to 465 kc. The IF amplifier 4' has its input circuit 5 resonated to the operating IF, and is coupled to the first detector output circuit 3'. The IF amplifier 4' is followed by a double diode tube 5', and this tube may be of the 6H6 type. This type of tube is provided with independent diode electrodes, and the common resonant input circuit 7 has one side thereof connected to the diode anode 8, while the opposite side of the circuit is connected to the diode anode 9. The high alternating potential side of the output circuit 6, of the IF amplifier 4', is connected through condenser 10 to the midpoint of the secondary coil 7' of input circuit 7. The midpoint 11 is connected to the junction of resistor portions 12 and 13; one side of resistor 12 being connected to the cathode 8' of the diode 8—8', and one side of resistor 13 being connected to the cathode 9' of the diode 9—9'.

The condenser 14 is connected between cathodes 8' and 9', and the cathode 9' is grounded. The input circuit 7 is tuned to the operating IF, and is reactively coupled to the circuit 6 as designated by the reference letter M. The AFC network involves the tunable tank circuit 18 of the local oscillator 19. As is well known to those skilled in the art, the variable tuning condenser 20, in the tank circuit 18, has its rotors mechanically uni-controlled with the rotors of the variable tuning condensers of the tunable signal circuits feeding the first detector. The dotted line 21 represents such mechanical uni-control. Of course, the oscillator 19 is tuned at any setting of the tuning mechanism 21 to a frequency which differs from the frequency of the signal circuits by the operating IF. Those skilled in the art are, also, fully aware of the manner of employing padding condensers in the tank circuit 18 for maintaining the operating IF constant in value as the tuner 21 is varied through the operating frequency range, and the latter may be the broadcast range of 500 to 1500 kc. It may even be in the short-wave bands where the receiver is of the multi-range type.

The locally produced oscillations are impressed on the first detector 3 in any desired manner, as by impressing them on the cathode circuit of the first detector. Of course, it is not essential to this invention to employ separate tubes 3 and 19 for the mixer and oscillator functions. For example, a pentagrid tube of the 2A7 type may be employed, in any well known manner, in a composite oscillator-mixer stage. In any case, there is electrically associated with the tank circuit 18 a frequency control tube 22. The electrical connections between the plate circuit of tube 22 and tank circuit 18 are such that an inductive reactance is reflected across the tank circuit.

Since it is not important for the purposes of the present invention to know of the construction of the frequency control tube, it is not believed necessary to go into any detailed discussion of the specific electrical connections between the frequency control tube 22 and the tank circuit 18. In my aforementioned application such a detailed explanation is given; and the same is equally true of the aforesaid Seeley application. In general, it may be said that the tube 22 may be connected to the tank circuit 18 so as to produce an effective inductance across the tank circuit 18. The magnitude of this effective inductance is, of course, a function of the mutual conductance of tube 22. The AFC connection 26 is made from the control grid of tube 22, through an appropriate alternating current filter element not shown, to the cathode side of resistor 12. The mutual conductance of tube 22 is varied in dependence upon the magnitude of the direct current component of the differential rectified IF energy. The magnitude and polarity of the potential at the cathode side of resistor 12 determines the sense of magnitude variation of the effective inductance reflected across tank circuit 18 by control tube 22. The reference letter E_2 denotes that AFC voltage applied through lead 26 to the frequency control tube 22.

The theoretical basis for the production of the AFC voltage E_2 resides in the following considerations. The potentials at either end of coil 7', with respect to the center tap 11, are 180 degrees out of phase. Hence, if the center tap 11 is connected to the primary circuit 6, a potential is realized which maximizes above the resonant frequency of circuit 6 and 7, and a second potential is realized which maximizes below this common resonant frequency. If these two potentials are applied to a pair of rectifiers, such as the diodes in Fig. 1, and the resulting direct current voltages are added in opposition, the sum will be equal to zero. The output load of the two diodes comprises the resistors 12 and 13 which are of like magnitude, and the latter are connected in series between the cathodes 8' and 9'.

In the type of discriminator network shown in Fig. 1 the primary and secondary circuits 6 and 7 are so connected that two vector sum potentials of the primary and secondary voltages may be realized. Point *a* of circuit 6 is at the same alternating potential as point 11 due to the connection through the large condenser 10. At IF resonance the phase of point *a* with respect to ground potential is zero; point 11 is, therefore, at zero phase. The current distribution about point 11 is equal; at any given instant point *c* is as much positive as point *d* is negative. The voltages impressed on the diode rectifiers are therefore equal, but opposite in phase. Since the rectifiers are in series opposition the potential E_2 is zero at resonance. If now the signal energy departs from resonance, a phase shift of 90 degrees (approximately) occurs in the circuit. The voltages induced in the two halves of coil 7' are still equal in magnitude and opposite in phase with respect to point 11. The voltage drop across circuit 6 is now added vectorially to the induced voltages. Thus, the potential at one side of the secondary, say point *c*, will be the sum of the induced voltage (11*c*) and voltage across 6; while the potential of the other side, point *d*, will be the difference between the drop in circuit 6 and the voltage induced in secondary position 11*d*. In the last case, then, the input voltage to the upper rectifier is much greater than that to the lower one. Hence, the voltage drop across resistor 12 will be greater than that across 13, and the cathode end of resistor 12 will be positive with respect to the grounded end of resistor 13. When the signal frequency impressed on primary circuit 6 is off resonance in the opposite direction, the cathode end of resistor 12 becomes negative with respect to ground. The sense of detuning thus determines the polarity of the cathode end of resistor 12; the amount of detuning determines the magnitude of the AFC bias. As stated before the magnitude and the polarity of the

potential at the cathode side of the resistor 12 determines the magnitude of the reactance reflected across tank circuit 18 by tube 22. If the AFC voltage applied to the grid of tube 22 is positive (thereby overcoming some of the initial bias applied in the cathode circuit of that tube) its mutual conductance is increased. This, in turn, acts as though the tuning condenser 20 had been decreased in value thereby causing the tuned frequency of the tank circuit 18 to increase. It will now be seen that the frequency difference between the signal and oscillator circuits is made automatically to shift towards the desired IF value as the receiver is tuned towards a desired station setting.

The AFC action commences as soon as a little of the energy of a carrier wave is applied to the primary circuit 6. The polarity of the AFC voltage E_2 with respect to ground depends on the phase of the coupling M. By way of example, it is pointed out that in Fig. 1 the coupling M may be phased so that E_2 becomes positive with respect to ground when the applied signal is lower than the desired center frequency of circuits 6 and 7. Heretofore the use of AFC has been recommended only for superheterodyne receivers having more than one stage of IF amplification because of the selectivity limitations of a discriminator system using a two-winding transformer. For example, as shown in my aforesaid copending application, the AFC, AVC and audio voltages are obtained from the resistors 12—13 of the discriminator network, but the audio selectivity of the discriminator is low so that two stages of IF amplification are required to secure adequate selectivity.

However, when a superheterodyne receiver is used, such as shown in Fig. 1, where it is desired to use but a single stage of IF amplification, it is necessary to resort to the present invention to accomplish satisfactory results. I have found that satisfactory selectivity can be secured in a superheterodyne receiver having only one IF amplifier, by the use of a third winding, on the discriminator transformer, feeding an audio diode. In working out a practical embodiment of this invention, however, it must be kept in mind that selectivity is only one of the characteristics of a discriminator circuit which are of interest in consideration of AFC action. In addition to audio selectivity, the following characteristics are also important: audio gain; AFC peak gain; AFC slope; and frequency separation of the AFC peaks. The audio, or signal, gain may be expressed as the ratio of peak value of signal input on the grid of the IF amplifier driving the discriminator to the direct current voltage in the audio diode.

The AFC voltage reaches a maximum in the positive sense at some frequency off the center frequency, and a maximum in the negative sense on the opposite side of the center frequency. The magnitude and separation of these two AFC peaks, and the slope of the characteristic passing through the center frequency, are of importance in discriminator action. If the peaks are too widely separated, the slope will be small, and if they are too close together signal modulation may be heard, before the AFC acts, as the frequency is varied. In a discriminator network using a circuit of the type shown in my aforesaid copending application, and wherein the audio voltage is taken off from the midpoint of resistors 12 and 13, it can be shown, operating with an IF of 460 kc., that the voltage selectivity, across resistor 13, is low.

In place of using the voltage E_3 developed across resistor 13 as the audio and AVC voltages, a separate diode rectifier 30 is employed. This rectifier is provided with a tuned input circuit 31, and the tertiary tuned circuit 31 is coupled magnetically, as at M_2, to the coil 7'. The coupling is arranged so that coil 32' of the tertiary circuit 31 is coupled only to coil 7', and not to the primary circuit 6. This is done, as schematically shown in Fig. 1, by using a few coupling turns 32 close to coil 7'. These turns are shown at the center of coil 7' and this arrangement should be followed physically in order to keep the capacity coupling of coil 32' symmetrical with respect to both sides of coil 7'. In order to keep the capacity coupling small and symmetrical, it is desirable to keep coil 32' and the leads thereto well separated from coil 7'; possibly even to the extent of putting coil 32' in a separate shield. The load resistor 40 is connected in series between the ground side of the cathode of diode 30 and the coil 32', a by-pass condenser being connected in shunt across the resistor 40.

The AVC connection 41, including proper alternating current filter resistors, is made to the grid circuits of the signal transmission tubes whose gain is to be automatically regulated. As shown in Fig. 1, the AVC connection 41 is made between the grid circuits of amplifier 2, first detector 3 and the anode side of the resistor 40. The grid circuit of IF amplifier 4' is connected by AVC lead 41' to an intermediate point on load resistor 40. The audio voltage developed across resistor 40 is transmitted to an audio frequency utilization network which may employ one, or more, stages of amplification followed by a reproducer. The voltage developed across the resistor 40 is denoted by the reference letter E_1.

The relations between E_1; E_2 and E_3 are graphically shown in Fig. 4. In the latter figure, there is plotted "kc off resonance" against "volts". As explained before, the discriminator network has little selectivity when the audio signal is taken from the center tap of the diode resistors 12 and 13, since the discriminator is primarily a phase responsive network. However, the discriminator acts as any tuned circuit, of the same Q and coupling, to a third circuit coupled to it, and the selectivity of this third circuit is, therefore, excellent. Capacity coupling dissymmetry produces departure from symmetry of both signal and AFC selectivity. For this reason, the physical arrangement between coil 32' and coil 7' recommended above is of advantage.

The following illustrative circuit constants are given, but it is to be clearly understood that they are purely illustrative in nature, and are supplied solely to enable those skilled in the art to readily practice this invention:

M—30 mh.
M_2—17.2 mh.
Condenser 10—100 mmf.
Resistor 40—0.25 megohm
Condenser 14—0.1 mf.
Resistor 12—0.5 megohm
Resistor 13—0.5 megohm

The tertiary circuit 31 acts to decrease, however, the AFC slope and separates the AFC peaks, since it acts as a resonant absorption circuit. Reduction of tertiary coupling decreases this effect, but also acts to decrease the signal circuit gain. While the slope of the AFC characteristic is some-

what decreased, the AFC gain is good. This arrangement for the discriminator network, and audio demodulator, gives satisfactory characteristics for a superheterodyne receiver using a single stage of IF amplification.

The use of separate diodes for AFC and audio demodulation imposes additional power output requirements on the IF amplifier driving the diodes. Voltage for the AVC action may be derived either from the center tap of the discrimination resistors 12 and 13, or from the load resistor 40. As shown in Fig. 4, the voltage E_3 is not symmetrical with respect to resonance, so that if this voltage is used for AVC purposes, the gain of the receiver will be higher on one side of the IF resonant frequency than on the other; producing slight asymmetry.

By using voltage E_1, derived from the signal circuit for AVC purposes it will be symmetrical about resonance. This is clearly shown in Fig. 4, and the voltage E_1 derived from across resistor 40 will not be subject to the asymmetry noted above. At normal bias the IF stage 4' will drive the diode satisfactorily but at high bias such as would be produced by full AVC control on the IF stage, curvature of the characteristic will occur. Approximately 20 volts will be required for AVC action in order to secure adequate control of large signals, assuming 3 tubes are to be controlled. In order that the audio output of the signal diode 30 shall be free from distortion, the characteristic should be straight. The range of signal inputs over which the characteristic is straight, determines the modulation percentage which may be handled without distortion. With 20 volts IF bias, 5.36 volts carrier will be required to derive 20 volts of AVC bias. For 100% modulation twice this input is instantaneously applied, and for such applied signal the characteristic will depart appreciably from a straight line. However, if only half of the developed AVC voltage is used on the IF tube 4', or 10 volts, when the total developed AVC bias is 20 volts, then 1.6 volts of signal is required. Under these conditions, the characteristic will be very nearly a straight line up to the 3.2 volts input required for 100% modulation. Accordingly, by applying one half AVC bias to the IF amplifier 4' which drives the diodes, and full AVC bias to the preceding tubes large signals can be handled without appreciable distortion, and using the discriminator network shown in Fig. 1.

In Fig. 2, there is shown a variation of the discriminator-demodulator network. Here the tertiary tuned circuit 31 of diode demodulator 30 is coupled, as at M_1, to the primary circuit 6. The secondary circuit 7 has an effect on the signal circuit selectivity nevertheless. The effect of the secondary on the tertiary is to act as an absorption circuit at resonance; thereby giving a double peak characteristic to voltage E_1. If M is reduced to minimize this effect, the AFC gain will be decreased and the AFC peaks approach relatively close to each other, even less than 8 kc. separation. Reduction of M_1 to improve selectivity decreases the gain of the signal circuit. While the AFC gain (about 50) and slope (approximately 28 volts per kc. per peak volt input) are excellent, the signal circuit gain and selectivity are not nearly as good as those for a simple diode circuit. This connection is desirable for "high fidelity" receivers, since selectivity is relatively good but high audio frequency side bands are not unduly attenuated.

In Fig. 3, there is shown a modification of the discriminator-demodulator network of Fig. 1, wherein the tuning of the tertiary circuit 31 is omitted. The coil 32' of circuit 31 is magnetically coupled to secondary circuit 7. It is important, as in the previous circuits, to keep the capacity coupling low and symmetrical with respect to the discriminator. The choke 50 is connected between the mid-tap of resistors 12 and 13 and the mid-point of coil 7'. In this network, merely by way of example, coil 50 has a value of 15 mh.; M may be 24 mh.; M_3 is 490 mh.; shunt condenser 51 may have a value of 100 mmf.

This network has less AFC gain than that of Fig. 1 (32 as compared to 59), but is steeper in AFC slope (12.8 compared to 8.8). The network of Fig. 1 has a signal gain at resonance of 34 and AFC peak separation of 13 kc.; the network of Fig. 3 has corresponding values of 38.5 and 11 kc. Further, the signal selectivity for the network of Fig. 3 is less than that of Fig. 1. However where such less selectivity can be tolerated, the network of Fig. 3 is satisfactory.

The diode 30 may be the diode section of a diode-triode tube, such as one of the 75 or 6Q7 type. Since a 6H6 type tube will normally be used for tube 5', the use of the diode section of the first audio amplifier tube involves the use of no additional tube over the type of circuit shown by me in Fig. 1 of my aforesaid co-pending application. In other words, it will be understood that the numeral 30 designates a tube of the well known multiple function type wherein the diode section functions as the diode demodulator and AVC rectifier, and the amplifier section of the tube is fed with the audio component of the voltage developed across resistor 40.

It is also to be clearly understood that the present invention is in no way dependent upon the particular nature of the frequency control network electrically associated with the oscillator tank circuit. The specific type of frequency control tube which has been disclosed in this application is merely shown by way of illustration. From the aforegoing disclosure it will be seen that with the characteristics of the described AFC systems using triple winding transformers, a superheterodyne receiver with a single IF amplifier stage may use such a control system and still maintain adequate selectivity.

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, as set forth in the appended claims.

What I claim is:

1. In a superheterodyne receiver of the type provided with a single amplifier having input and output circuits resonated to an operating intermediate frequency, a first detector network whose output is electrically associated with the amplifier input, a local oscillator network provided with a tank circuit and electrically associated with the first detector network, an automatic frequency control circuit electrically associated with the amplifier output circuit and the oscillator tank circuit, said control circuit comprising a pair of resonant circuits reactively coupled in cascade and tuned to the operating intermediate frequency, a pair of rectifiers operatively associated with the second of said resonant circuits in series opposition to produce a direct current voltage whose magnitude and polarity is

dependent upon the frequency departure of the output energy of said first detector network from said operating intermediate frequency, the first of said cascaded circuits being said amplifier output circuit, a load impedance, said rectifiers being in series opposition across the impedance, means establishing one terminal of the impedance at a fixed potential, means establishing the midpoint of the second of said cascaded circuits at the alternating potential of the high potential side of the amplifier output circuit, means connecting the impedance midpoint to said first midpoint, and means deriving said direct current voltage from the opposite terminal of said impedance, an additional rectifier having a signal input circuit reactively coupled to at least one of said cascaded circuits, an audio utilization network electrically coupled to said additional rectifier, and an automatic gain control circuit electrically associated with at least one of the signal transmission tubes preceding said cascaded circuits, said gain control circuit being connected to said additional rectifier for deriving therefrom a direct current component of rectified signal energy.

2. In combination with a source of electrical high frequency waves of a predetermined frequency, an automatic frequency control circuit comprising a pair of cascaded reactively coupled resonant circuits, said circuits being tuned to said predetermined frequency, a pair of rectifiers connected to the second of the cascaded circuits in such a manner that said second circuit acts as a common input circuit for the rectifiers, a common load impedance for the rectifiers, said rectifiers being in series opposition across the impedance whereby their direct current outputs are in opposition, means for utilizing the resultant direct current of said opposed rectifiers, and additional rectifier having a resonant input circuit, tuned to said predetermined frequency, reactively coupled to the second of said cascaded circuits, means for utilizing the audio component of signal currents rectified in said additional rectifier circuit.

3. In combination with a source of electrical high frequency waves of a predetermined frequency, an automatic frequency control circuit comprising a pair of cascaded reactively coupled resonant circuits, said circuits being tuned to said predetermined frequency, a pair of rectifiers connected to the second of the cascaded circuits in such a manner that said second circuit acts as a common input circuit for the rectifiers, a common load impedance for the rectifiers, said rectifiers being in series opposition across the impedance whereby their direct current outputs are in opposition, means for utilizing the resultant direct current of said opposed rectifiers, an additional rectifier having a resonant input circuit, tuned to said predetermined frequency, reactively coupled to the second of said cascaded circuits, means for utilizing the audio component of signal currents rectified in said additional rectifier circuit, each of said rectifiers being a diode, and a link coil coupling the input circuit of said additional rectifier to the said second of the cascaded circuits.

4. In a radio receiver, a coupling transformer comprising a pair of resonant circuits reactively coupled in cascade, said circuits being tuned to a predetermined operating frequency, a pair of rectifiers connected to the second of said cascaded circuits so that the second circuit acts as a common input circuit for the rectifiers, means establishing the midpoint of the second circuit at the alternating potential of the high potential side of the first of the cascaded circuits, a common load impedance for the rectifiers, said rectifiers being in series opposition across the impedance, means establishing one terminal of the impedance at a relatively fixed potential, means establishing the impedance midpoint at the potential of said first midpoint, and means for deriving from the opposite terminal of the impedance the resultant direct current which varies in magnitude and polarity, dependent upon the departure of an applied radio frequency from the predetermined operating frequency, a third signal energy input circuit reactively coupled to one of said cascaded circuits, and a third rectifier coupled to the third circuit so that the resultant current of said third rectifier varies in magnitude, but does not vary in polarity, as the frequency applied to said coupling transformer is varied from the predetermined operating frequency.

5. In a superheterodyne receiver of the type provided with a single amplifier having input and output circuits each resonated to an operating intermediate frequency, a first detector network having an output circuit coupled to said input circuit, a local oscillator network having a tank circuit, an automatic frequency control network connected between said amplifier output circuit and said oscillator network, said control network comprising a pair of rectifiers having a common input circuit resonated to said intermediate frequency, said common input circuit being reactively coupled to said amplifier output circuit in cascade, means for establishing the midpoint of said latter circuit at the alternating potential of the high potential side of said amplifier output circuit, a common load impedance for said rectifiers, the latter being in series opposition across said impedance, means for establishing the midpoint of said impedance at the same potential as said first midpoint, means establishing one end of the impedance at a relatively fixed potential, means connected to the opposite end of the impedance for deriving a direct current voltage whose magnitude and polarity is dependent upon the frequency departure of the first detector output circuit energy from the operating intermediate frequency, an auxiliary rectifier having an input circuit coupled to at least one said cascaded circuits to receive intermediate frequency energy therefrom, and a utilization network coupled to the auxiliary rectifier to utilize the rectified current of the latter.

6. In a superheterodyne receiver of the type provided with a single amplifier having input and output circuits each resonated to an operating intermediate frequency, a first detector network having an output circuit coupled to said input circuit, a local oscillator network having a tank circuit, an automatic frequency control network connected between said amplifier output circuit and said oscillator network, said control network comprising a pair of rectifiers having a common input circuit resonated to said intermediate frequency, said common input circuit being reactively coupled to said amplifier output circuit in cascade, means for establishing the midpoint of said latter circuit at the alternating potential of the high potential side of said amplifier output circuit, a common load impedance for said rectifiers, the latter being in series opposition across said impedance, means for establishing the midpoint of said impedance at the same potential

as said first midpoint, means establishing one end of the impedance at a relatively fixed potential, means connected to the opposite end of the impedance for deriving a direct current voltage whose magnitude and polarity is dependent upon the frequency departure of the first detector output circuit energy from the operating intermediate frequency, an auxiliary rectifier having an input circuit coupled to at least one said cascaded circuits to receive intermediate frequency energy therefrom, a utilization network coupled to the auxiliary rectifier to utilize the rectified current of the latter, said utilization network being adapted to utilize the audio component of the rectified current, and said auxiliary rectifier input circuit being coupled to the said common input circuit of said pair of rectifiers.

7. In a superheterodyne receiver of the type provided with a single amplifier having input and output circuits each resonated to an operating intermediate frequency, a first detector network having an output circuit coupled to said input circuit, a local oscillator network having a tank circuit, an automatic frequency control network connected between said amplifier output circuit and said oscillator network, said control network comprising a pair of rectifiers having a common input circuit resonated to said intermediate frequency, said common input circuit being reactively coupled to said amplifier output circuit in cascade, means for establishing the midpoint of said latter circuit at the alternating potential of the high potential side of said amplifier output circuit, a common load impedance for said rectifiers, the latter being in series opposition across said impedance, means for establishing the midpoint of said impedance at the same potential as said first midpoint, means establishing one end of the impedance at a relatively fixed potential, means connected to the opposite end of the impedance for deriving a direct current voltage whose magnitude and polarity is dependent upon the frequency departure of the first detector output circuit energy from the operating intermediate frequency, an auxiliary rectifier having an input circuit coupled to at least one said cascaded circuits to receive intermediate frequency energy therefrom, and a utilization network coupled to the auxiliary rectifier to utilize the rectified current of the latter, said auxiliary rectifier input circuit being resonated to said intermediate frequency and being coupled to the said common input circuit, and said utilization network including means for impressing at least a portion of the direct current component of said rectified current upon said amplifier as a gain control potential.

8. In combination with the local oscillator and intermediate frequency amplifier networks of a superheterodyne receiver, an automatic frequency control circuit, responsive to frequency shifts in the amplifier signal output energy from an assigned intermediate frequency, for impressing on the oscillator a frequency correction voltage dependent upon said shifts, said control circuit being of the type including a pair of resonant circuits, tuned to the assigned frequency, in cascade subsequent to the amplifier, an audio demodulator network comprising a rectifier having an input circuit coupled to the second of the cascaded pair of circuits, said last input circuit being tuned to said assigned frequency whereby the selectivity at that circuit is increased, and means for utilizing the audio component of the rectifier output current.

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