

Feb. 23, 1943.

W. H. BLISS

2,312,070

FREQUENCY DISCRIMINATOR CIRCUIT

Filed Dec. 7, 1940

2 Sheets-Sheet 1

Fig. 1.

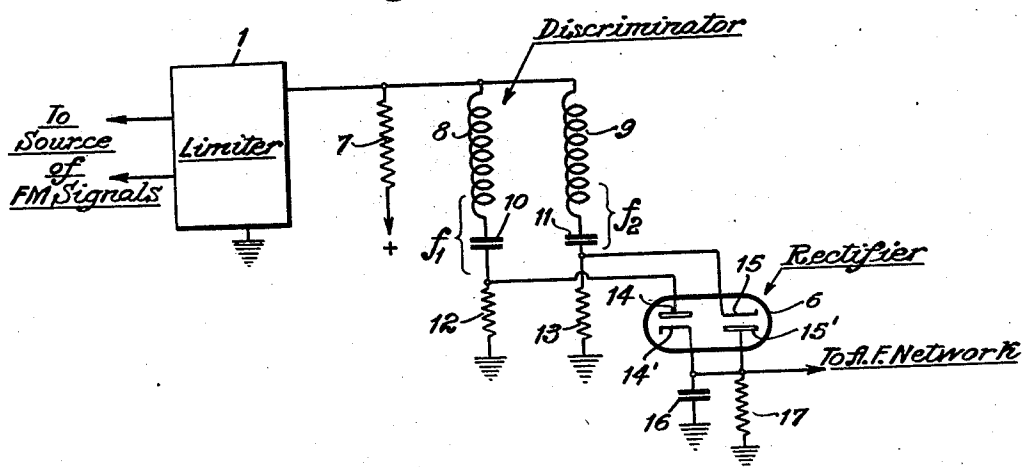


Fig. 1a.

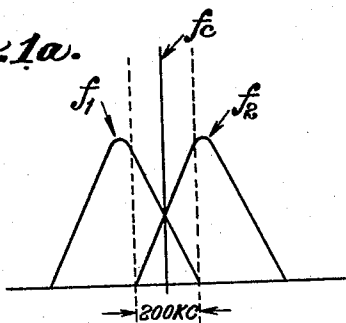
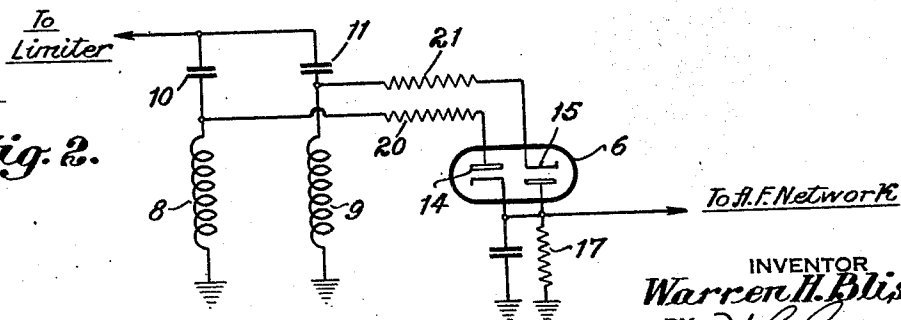


Fig. 2.



INVENTOR
Warren H. Bliss
BY H. S. Snover
ATTORNEY

Feb. 23, 1943.

W. H. BLISS

2,312,070

FREQUENCY DISCRIMINATOR CIRCUIT

Filed Dec. 7, 1940

2 Sheets-Sheet 2

Fig. 3.

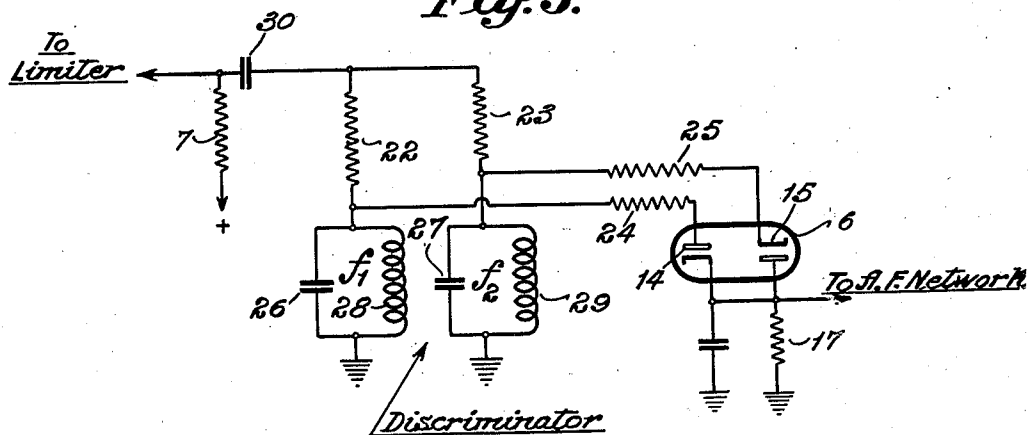
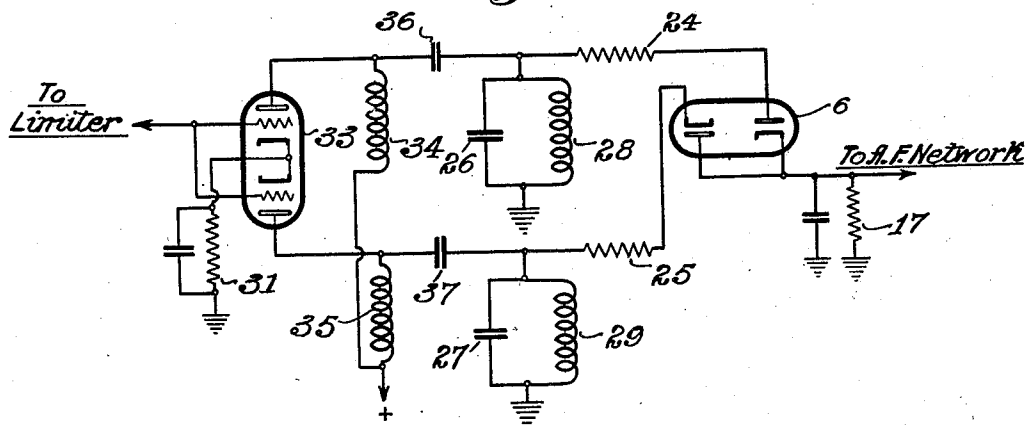


Fig. 4.



INVENTOR
Warren H. Bliss
BY *H. S. Snow*
ATTORNEY

UNITED STATES PATENT OFFICE

2,312,070

FREQUENCY DISCRIMINATOR CIRCUIT

Warren H. Bliss, Orono, Maine, assignor to Radio Corporation of America, a corporation of Delaware

Application December 7, 1940, Serial No. 369,017

3 Claims. (Cl. 250—27)

My present invention relates to frequency modulated carrier wave detectors, and more particularly to novel and improved discriminator-rectifier circuits for frequency modulation reception.

One of the primary objects of this invention is to provide simple inductive and capacitive elements in series, or parallel, arrangement thereby to convert a frequency modulated carrier wave into an amplitude modulated carrier wave, and a pair of opposed rectifiers having a common output resistor functioning to develop across the latter modulation voltage corresponding to the modulation variations in the amplitude of said carrier.

Still other objects of the invention are to simplify and render more efficient discriminator-rectifier circuits for frequency modulated carrier waves, and more especially to provide such circuits in a manner such that they may be easily manufactured and assembled.

The novel features which I believe to be characteristic of my 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 drawings in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings:

Fig. 1 shows a form of the invention,

Fig. 1a shows the discriminator characteristic of the circuit of Fig. 1,

Fig. 2 illustrates a modification of Fig. 1,

Fig. 3 shows another modification of the circuit of Fig. 1,

Fig. 4 illustrates a modified embodiment of the arrangement shown in Fig. 3.

Referring, now, to the accompanying drawings, wherein like reference characters in the different figures denote similar circuit elements, let it be assumed that the networks shown in Fig. 1 are inserted between the intermediate frequency amplifier and the audio frequency amplifier of a frequency modulation receiver of the superheterodyne type. The presently assigned band for frequency modulation reception is the 43-50 megacycle range. Of course, the present invention can be used in receivers operating over other frequency, or phase, modulated carrier reception bands. An intermediate frequency of 4.3 megacycles may be chosen so as to minimize image interference, but it will be understood that the

intermediate frequency may be chosen from a range of 2 to 5 megacycles. While the carrier frequency deviation may be narrow or wide, in present practice there is utilized a wide band frequency modulation channel. If the carrier has a maximum frequency deviation of 100 kilocycles, then the over-all band width is 200 kilocycles.

The center, or carrier, frequency at intermediate frequency would be, of course, 4.3 megacycles. As is well known, the stage prior to the second detector, or demodulator, is the limiter. This stage is designated in Fig. 1 by the numeral 1, and upon the input terminals of the limiter network are impressed amplified frequency modulated carrier waves of intermediate frequency. It is not believed necessary to describe the detailed method of deriving the intermediate frequency energy from the received carrier waves. However, the frequency modulated waves acquire a certain amount of amplitude modulation due to passage through the cascaded resonant stages. Furthermore, noise impulses and fading will produce amplitude variation effects. The limiter stage is constructed in the manner of an easily overloaded amplifier. Those skilled in the art are so fully acquainted with the manner of constructing amplitude limiters for frequency modulation receivers that it is believed that the present general reference to the function thereof will be sufficient. The limiter acts to eliminate all amplitude variation from the modulated carrier thereby supplying to the following discriminator a frequency-variable carrier of constant amplitude. Of course, the limiter may possess as much gain as is desired.

The resistor 7 is connected from a positive point on the voltage supply source to the limiter tube output electrode. The discriminator itself generally comprises a pair of parallel reactive impedance paths, the paths being resonant to frequencies which are spaced on opposite sides of the intermediate frequency by equal frequency amounts. Thus, one of these paths consists of coil 8, condenser 10 and resistor 12 arranged in series between the high potential side of the network and ground. The second path consists of coil 9, condenser 11 and resistor 13 all arranged in series. The second path is connected in shunt across the first path. Voltages developed across resistors 12 and 13 are impressed upon diodes 14-14' and 15-15' respectively.

The numeral 6 denotes a double diode tube of the 6H6 type, and anode 14 may be connected

to the junction of condenser 10 and resistor 12, whereas cathode 15 is connected to the junction of condenser 11 and resistor 13. The cathode 14' and anode 15' are connected in common to the high potential end of the common load resistor 17, the condenser 16 being shunted across the load resistor to by-pass intermediate frequency currents. Audio frequency voltage developed across resistor 17 is transmitted to one or more audio frequency amplifiers which may be followed by any desired type of reproducer.

Considering the operation of the network shown in Fig. 1, it is again emphasized that alternating current voltage developed across resistor 12 is applied to the diode anode 14, whereas alternating current voltage developed across resistor 13 is applied to the cathode 15 of diode 15—15'. The wide band frequency modulated wave, after proper amplification at intermediate frequency, is limited and the resulting limited energy is applied to the discriminator. The path 8—10 is series tuned to a frequency f_1 spaced from the center frequency f_c by a predetermined frequency value. It is desirable to have frequency f_1 slightly below the lower end of the frequency modulation band. For example, if the band width is 200 kilocycles then the frequency f_1 may be spaced from f_c by a value somewhat greater than 100 kilocycles. Similarly, the path including coil 9 and condenser 11 is tuned to a frequency f_2 which is slightly above the upper limit of the frequency modulation band, but it is desirable that the frequency spacing of both f_1 and f_2 be equal.

In Fig. 1a there is graphically shown the relation between the resonance curves of each of the reactive paths, and the relation between the center frequency of the frequency modulation band and the resonant frequencies of the discriminator paths. For suitable operation resistors 12 and 13 should be small compared to the reactances of the condensers and coils of the discriminator at the center frequency. With circuit elements properly adjusted the amplitude of the alternating current voltages developed across resistors 12 and 13 will be the same as f_c . Since these equal potentials are applied to polarity opposed rectifiers, the net potential developed across load resistor 17 will be zero when the center frequency of the intermediate energy is equal to f_c .

As the frequency f_c of the applied frequency modulated wave instantaneously increases toward the value f_2 the potential across resistor 13 increases due to approaching the resonant value of 9—11. The potential across resistor 12 will conversely fall due to recession from resonance of 8—10 at f_1 . This will cause a voltage of negative polarity to be developed across resistor 17. In a similar manner if the center frequency of the applied modulated carrier waves falls below f_c toward f_1 , then the voltage developed across resistor 17 will be positive. By a proper selection of circuit elements there may be secured a linear relationship between the voltage developed across load resistor 17 and the applied carrier frequency deviation. Those skilled in the art will understand that this is the desired type of characteristic for satisfactory frequency modulation to amplitude modulation conversion. Since the presence of resistors 12 and 13 cause the resonant circuits to have broad tuning this type of discriminator is best suited to wide band frequency modulation conversion.

In the modification of Fig. 2 the resistors 12 and 13 are dispensed with. The connections to

each of diodes 15—15' and 14—14' is made through resistors 21 and 20, respectively. Resistor 21 connects to the junction of condenser 11 and coil 9, while resistor 20 connects to the junction of condenser 10 and coil 8. While the circuit of Fig. 2 operates in the same manner as Fig. 1, the alternating potentials for the rectifiers are taken from the ungrounded ends of the inductances. The resistors in series with the diodes are necessary to decrease interaction between the mid-points of the resonant paths. Because the circuit of Fig. 2 may offer a highly variable impedance load to the driver tube some interaction between the two resonant paths still results.

Fig. 3 offers a circuit which is capable of greater efficiency. Parallel resonant paths are used in place of the series tuned paths of Fig. 1. Thus, parallel resonant circuit 26—28 is tuned to f_1 , and is in series with resistor 22. Parallel resonant circuit 27—29 is tuned to f_2 , and is arranged in series with resistor 23. The functioning is the same as explained in Fig. 1a. Each resonant circuit in Fig. 3 has a high impedance at its resonance point, and, hence, delivers a high alternating voltage to its respective rectifier. The alternating voltages for the diodes are taken off from the ungrounded ends of the parallel resonant circuits. As in Fig. 2, the voltages are fed to diode cathode 15 and diode anode 14 through resistors 25 and 24 respectively. The magnitudes of series resistors 22 and 23 are made high compared to the normal reactances of the coils and condensers of the discriminator. The direct current blocking condenser 30 is inserted in the high potential side of the network between resistors 7 and 22.

In the modification of Fig. 4 the discriminator parallel resonant circuits are driven by separate high impedance triodes of the twin-triode tube 33. Radio frequency chokes 34 and 35 are used to supply plate potentials to the triode anodes. Direct current blocking condensers 36 and 37 are in circuit with the high potential ends of resonant circuits 26—28 and 27—29 respectively. The series resistors 22 and 23 are omitted, and each parallel resonant circuit is connected from the high potential side of the feed line to ground. The circuit is otherwise similar to that shown in Fig. 3. Both triode grids in tube 33 are connected in common to the limiter output, while 31 denotes the usual by-passed self-biasing resistor for tube 33. The separate triodes are used to prevent interaction, and the parallel resonant circuits are connected directly across the driver anodes. High impedance tubes are used so that variation in the impedance of the resonant circuits will not appreciably alter the alternating component of the anode current. The high impedance chokes 34 and 35 are used so that the full value of the direct current plate voltage will be available.

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 discriminator network for frequency modulated carrier waves having a relatively wide frequency deviation band, a pair of input terminals and a pair of output terminals, a pair of

reactive paths connected in shunt across said input terminals, one of said paths including an inductive reactance and a series capacitive reactance, a resistor in series with said path, said path being tuned to a frequency differing from the center frequency of the modulated waves by a predetermined frequency value, the second path including an inductive reactance and a series capacitive reactance, a second resistor in series with the second path, the second path being tuned to a second frequency differing from said center frequency by said predetermined frequency value but in the opposite direction, the tuned frequencies of said two paths being located outside the limits of said wide band, separate rectifiers coupled to respective ones of said two resistors of said paths to rectify alternating voltages developed thereacross, and a common resistive impedance connected to said rectifiers, said rectifiers being arranged in polarity opposition.

2. In a discriminator network for frequency modulated carrier waves having a relatively wide frequency deviation band, a pair of input terminals and a pair of output terminals, a pair of reactive paths connected in shunt across said input terminals, one of said paths including an inductive reactance, a capacitive reactance and a first resistor all in series, said path being tuned to a frequency differing from the center frequency of the modulated waves by a predetermined frequency value, the second path including an inductive reactance, a capacitive reactance and a second resistor all in series, the second path being tuned to a second frequency differing from said center frequency by said pre-

determined frequency value but in the opposite direction, separate rectifiers coupled to respective ones of said two resistors of said paths to rectify alternating voltages developed thereacross, and a common resistive impedance connected to said rectifiers, said rectifiers being arranged in polarity opposition, the two resistors having magnitudes which are small compared to the reactances of said paths at the said center frequency.

3. In a discriminator network for frequency modulated carrier waves, a pair of input terminals and a pair of output terminals, a pair of reactive paths connected in shunt across said input terminals, one of said paths including an inductive reactance and a capacitive reactance, said path being tuned to a frequency differing from the center frequency of the modulated waves by a predetermined frequency value, the second path including an inductive reactance and a capacitive reactance, the second path being tuned to a second frequency differing from said center frequency by said predetermined frequency value but in the opposite direction, separate rectifiers coupled to said paths to rectify alternating voltages developed thereacross, and a common resistive impedance connected to said rectifiers, said rectifiers being arranged in polarity opposition, a separate resistive impedance arranged in series in each of said paths with respective inductive and capacitive reactances, and each of said separate rectifiers being coupled to a respective one of said resistive impedances to derive alternating voltage developed thereacross.

WARREN H. BLISS.