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FREQUENCY DISCRIMINATOR

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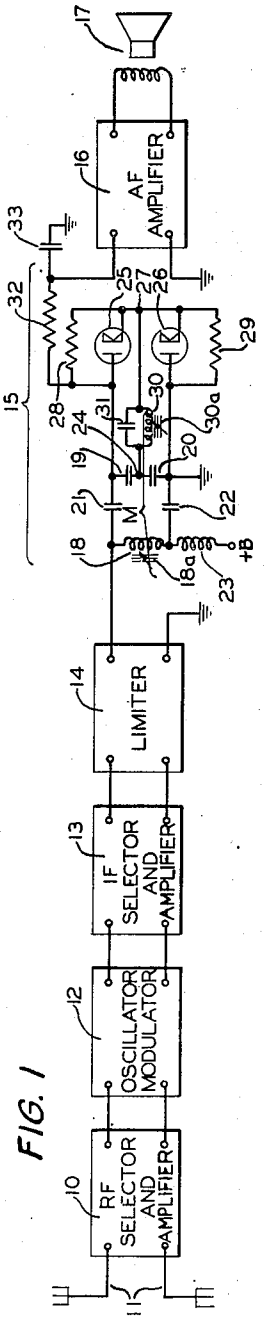


FIG. 1

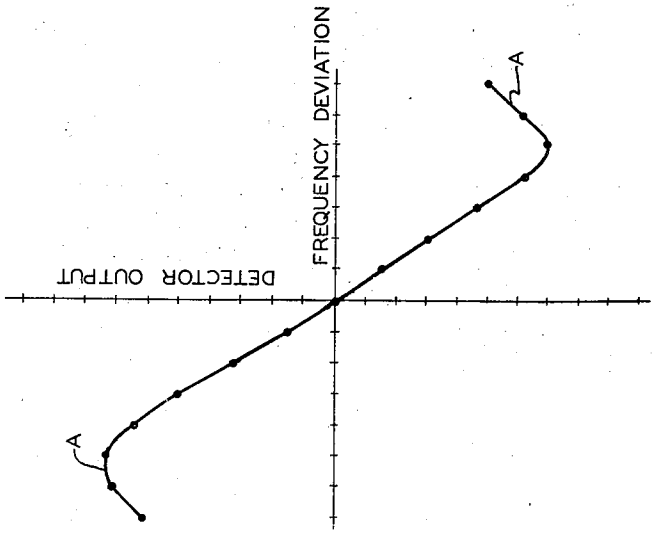


FIG. 2

INVENTORS
CLYDE K. HUXTABLE
JOHN A. RANKIN
BY Mueller, Dodds & Mason
ATTORNEYS

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FREQUENCY DISCRIMINATOR

Clyde K. Huxtable, Evanston, and John A. Rankin, Park Ridge, Ill., assignors to Belmont Radio Corporation, Chicago, Ill., a corporation

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This invention relates to frequency-responsive networks and more particularly to such networks of the phasing type including only a single rectifier cathode potential.

It is well known that the conventional phasing type of frequency-responsive networks, used as frequency discriminators in amplitude-modulation receivers or as frequency detectors in frequency-modulation receivers, comprise inductively coupled primary and secondary tuned circuits with a connection for introducing the primary signal into the midpoint of the secondary circuit and pair of rectifiers so connected to the secondary circuit as individually to rectify the sum-and-difference of the primary and secondary signals, the output signal being the algebraic sum of the two rectified voltages. In a design of such frequency-responsive networks there are several features which it is desirable to incorporate; for example, provisions for permeability tuning of the network, which precludes the use of the more conventional midtap on the transformer secondary winding; a symmetrical circuit, which is required to minimize the distortion of the output signals; the connection of the rectifier load resistors in such a way as to constitute a minimum loading on the tuned circuits; and the connection of the rectifier circuit in such a way as to require only a single rectifier cathode potential, thereby permitting the use of a single cathode, twin-diode vacuum tube, such as the type 7K7.

It is an object of the invention, therefore, to provide a new and improved frequency-responsive network having one or more of the desirable features described above.

It is another object of the invention to provide a new and improved frequency-responsive network which permits the use of a twin-diode rectifier tube with a single cathode.

In accordance with the invention, a frequency-responsive network comprises a first tuned circuit having an electrical midpoint, a rectifier circuit coupled across the first tuned circuit and having an electrical midpoint, and a second tuned circuit coupled to the first tuned circuit and connected between the electrical midpoints. The network also includes circuit means for applying a signal to one of the tuned circuits and a signal-utilization circuit connected to the rectifier circuit.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying

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drawings while its scope will be pointed out in the appended claims.

Referring now to the drawings, Fig. 1 is a circuit diagram, partially schematic, of a complete broadcast receiver of the frequency-modulation type incorporating the frequency-responsive network of the invention, while Fig. 2 is a graph illustrating a response characteristic of the frequency-responsive network of the system of Fig. 1.

Referring now to Fig. 1 of the drawing, there is represented a frequency-responsive network embodying the invention incorporated in a frequency-modulation receiver. The receiver comprises a radio-frequency selector and amplifier unit 10 having its input terminals connected to an antenna system 11. Connected in cascade to the unit 10, in the order named, are an oscillator-modulator 12, an intermediate-frequency selector and amplifier 13, a limiter 14, a frequency-responsive network or detector 15, described hereinafter, an audio-frequency amplifier 16 and a signal reproducer or loud speaker 17.

The receiver system as a whole is conventional in construction and operation so that a detailed description thereof is deemed unnecessary. In brief, frequency-modulated carrier signals intercepted by the antenna system 11 are applied to the unit 10 wherein they are selected and amplified and applied to the oscillator-modulator unit 12. The signals are converted in the unit 12 to an intermediate-frequency signal which is applied to the unit 13 for further selection and amplification and are thereupon impressed upon the limiter 14 wherein the intermediate-frequency signal is limited or clipped to derive a frequency-modulated signal of substantially constant amplitude. The signal thus limited is applied to the frequency detector 15, described hereinafter, to develop the modulation signal, which is applied to the audio-frequency amplifier 16 for further amplification and to the loud speaker 17 for signal reproduction.

The frequency-responsive discriminator network 15 of the invention comprises a first tuned circuit, specifically a primary circuit, including an adjustable inductance arm 18, comprising a single inductor having an adjustable magnetic core 18a, and a capacitance arm in parallel with the inductor 18 comprising condensers 19 and 20 connected in series across the inductor 18 through a direct-current blocking condenser 21 and the radio-frequency by-pass condenser 22. Space current for the limiter unit 14 is supplied through the primary tuned circuit described from a suit-

able source +B through a radio-frequency choke coil 23. The junction of the condensers 19 and 20 provides an electrical midpoint 24 for the primary tuned circuit described.

The frequency detector includes also a rectifier circuit coupled across the primary tuned circuit and having an electrical midpoint. Specifically, the rectifier circuit comprises a pair of diode rectifiers 25 and 26 connected in series opposition across the primary tuned circuit; that is, with their anodes individually connected to opposite terminals of the primary tuned circuit and with their cathodes connected together to form an electrical midpoint 27. Load resistors 28 and 29 are individually connected across the rectifiers 25 and 26, respectively.

The frequency-responsive network also includes a secondary tuned circuit comprising an inductor 30 having an adjustable magnetic core 30a tuned by a condenser 31 to the intermediate frequency of the carrier signal and inductively coupled to the inductor 18 by mutual inductance M. The secondary tuned circuit is connected between the electrical midpoints 24 and 27, as illustrated. The primary tuned circuit 18–22, inclusive, is connected in the output circuit of the limiter 14 which is effective to apply thereto an intermediate-frequency signal. A signal-utilization circuit such as the amplifier 16 is connected to the rectifier circuit, specifically across the load resistors 28 and 29 in series, through a filter circuit including a series resistor 32 and a shunt condenser 33.

It is believed that the operation of the frequency-responsive network of the invention will be apparent from the foregoing description. The limited intermediate-frequency carrier signal is applied to the primary tuned circuit 18–22, inclusive, and develops thereacross a signal voltage. The inductive coupling between the primary and the secondary tuned circuits induces in the secondary tuned circuit an intermediate-frequency signal approximately in quadrature with that across the primary tuned circuit. By virtue of the connection of the secondary tuned circuit between the electrical midpoints 24 and 27, the signal voltages impressed upon the rectifiers 25 and 26 represent the sum and difference of the primary and secondary signal voltages, which are in quadrature. As is well understood in the art, the algebraic sum of these rectified sum and difference voltages comprises a signal having an instantaneous value varying substantially linearly with the deviation of the carrier signal from its mean or nominal value. This characteristic of the frequency detector is illustrated in Fig. 2 in which curve A represents the instantaneous signal output across the resistors 28 and 29 in series for deviations of the carrier-frequency signal over its normal range. It is understood that, in practice, if the carrier signal is modulated by an audio-frequency signal so that its deviations vary in amount with the amplitude of the audio-frequency signal and at a rate varying with the frequency of the audio-frequency signal, the signal developed across the load circuit of the discriminator will be a detected audio-frequency signal. The filter comprising resistor 32 and condenser 33 is effective to by-pass the intermediate-frequency carrier signal from the input to the amplifier 16. This filter may be designed to serve also as a de-emphasis network to compensate for the audio-frequency pre-emphasis generally introduced at the frequency-modulation transmitter.

It will be noted that, in the frequency-detector circuit described, the cathodes of the rectifiers 25 and 26 are at the same potential so that they may be combined in a twin-diode rectifier having a common cathode, such as the type 7K7 rectifier tube.

While it is apparent that the circuit constants of the frequency-responsive network of the invention may vary within wide limits in accordance with the performance requirements of a particular installation, there follow by way of example the circuit constants of one frequency-responsive network embodying the invention and providing satisfactory operating performance:

Intermediate carrier frequency ____mc__	4
Frequency deviation ____kc__	±75
Inductor 18 ____microhenries__	40
Inductor 30 ____do____	40
Condensers 19, 20 and 21, each micro-microfarads__	100
Condenser 22 ____microfarad__	0.05
Condenser 31 ____micro-microfarads__	40
Resistors 28 and 29, each ____megohm__	0.5
Rectifiers 25, 26 ____type	7K7

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit or scope of the invention.

What is claimed as new is:

1. A frequency-responsive network comprising, a first permeability-tuned circuit including an adjustable inductance arm and a capacitance arm having an electrical midpoint, a rectifier circuit coupled across first said tuned circuit and having an electrical midpoint, said rectifier circuit comprising two diodes having their cathodes disposed at the electrical midpoint of said rectifier circuit, a second permeability-tuned circuit magnetically coupled to said first tuned circuit and connected between said electrical midpoints, circuit means for applying a signal to said first tuned circuit, and a signal-utilization circuit connected to said rectifier circuit.

2. A frequency-responsive network, comprising a first permeability-tuned circuit including an adjustable inductance arm and a capacitance arm comprising capacitors balanced with respect to an electrical midpoint, a rectifier circuit coupled across said first tuned circuit and having an electrical midpoint, said rectifier circuit comprising two diodes having their anodes respectively connected to said balanced capacitors in said first tuned circuit and having their cathodes disposed at the electrical midpoint of said rectifier circuit, a second permeability-tuned circuit magnetically coupled to said first tuned circuit and connected between said electrical midpoints, circuit means for applying a signal to said first tuned circuit, and a signal-utilization circuit connected to said rectifier circuit.

3. A frequency discriminator comprising, a first permeability-tuned circuit including an adjustable inductance arm and a capacitance arm having an electrical midpoint, a rectifier circuit coupled across said first tuned circuit and having an electrical midpoint, said rectifier circuit comprising two diodes having their cathodes disposed at the electrical midpoint of said rectifier circuit, a second permeability-tuned circuit magnetically coupled to said first tuned circuit and connected between said electrical midpoints, circuit means for applying a signal to said first tuned circuit,

and a signal-utilization circuit connected to said rectifier circuit, said last-mentioned circuit including two resistors respectively shunting said diodes, a ground connection at the anode terminal of one of said diodes, and an audio signal connection at the anode terminal of the other diode.

CLYDE K. HUXTABLE.
JOHN A. RANKIN.

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