June 6, 1944. W. H. BLISS 2,350,869

FREQUENCY DEMODULATOR

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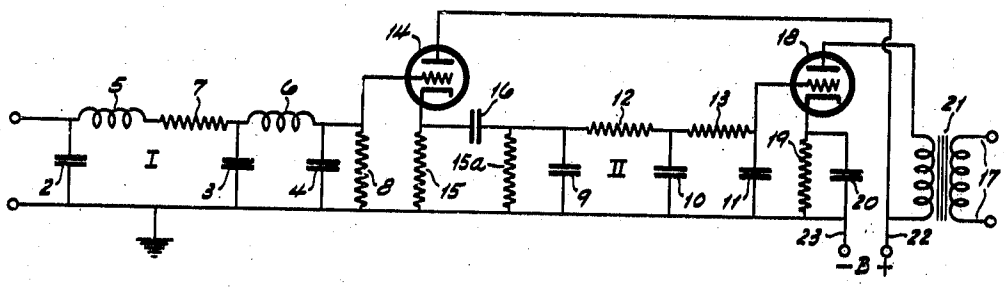

Fig. 1

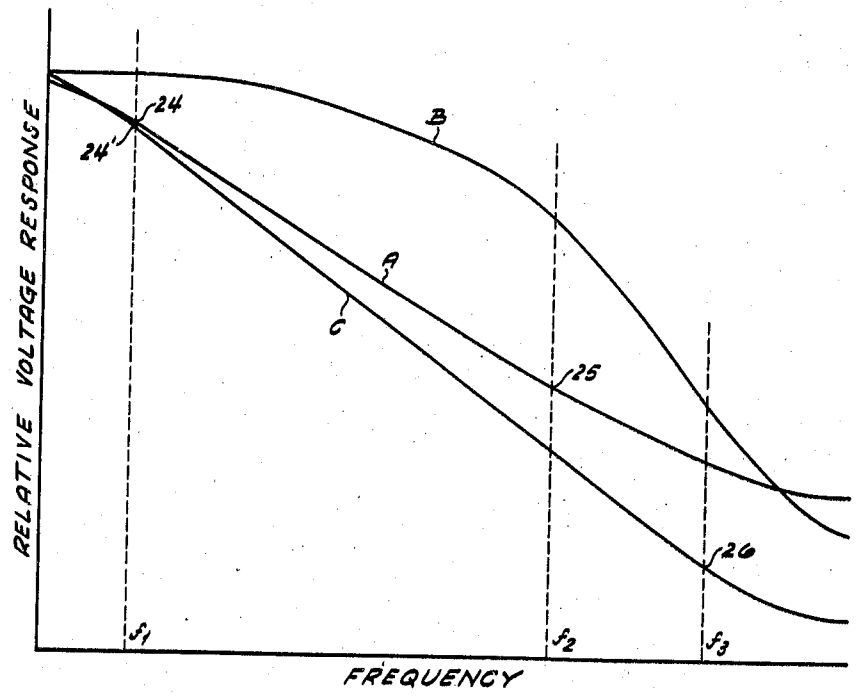

Fig. 2

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FREQUENCY DEMODULATOR

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8 Claims. (Cl. 250—27)

This invention relates to frequency demodulators or means for converting frequency modulation into amplitude modulation.

Frequency modulation of a carrier wave is used in radio telegraphy and telephony to a certain extent to avoid static and fading effects. In the transmission of pictures or facsimile telegraphy, the percentage of frequency shift in the modulation process is preferably much greater than that used in other branches of the art and the normal types of filter demodulators are not particularly well suited for picture and facsimile uses. This is because the linearity of the voltage-frequency characteristic does not extend over a sufficiently wide range.

It is accordingly an object of this invention to produce a demodulator having a much greater range of linearity than the usual converter.

Another object of the invention is to construct a demodulator of two sections, serially arranged so that the departure from linearity in one of the sections is compensated by a reverse departure of the other section.

Other objects of the invention will appear in the following description, reference being had to the drawing, in which:

Figure 1 is a circuit diagram of the demodulator.

Figure 2 is a series of graphs showing the voltage-frequency characteristics of the individual sections and of the demodulator as a whole.

Referring to Figure 1, section I consists of a filter of the low-pass type with shunt condensers 2, 3 and 4 and series inductances 5 and 6. This is given as an example only and different numbers of condensers and inductances may be used as desired. Resistance 7 is incorporated in this filter section to control the curvature of the characteristic of this section. This also produces a low Q circuit, Q being the ratio

$$\frac{2\pi fL}{R}$$

Terminal resistance 8 furnishes the proper output impedance for this filter.

The second section II of the demodulator consists of shunt condensers 9, 10 and 11 with series resistances 12 and 13, the number of condensers and resistances being by way of example only.

Sections I and II are connected by a high impedance coupling tube 14, shown as a triode, but a pentode or electron tube of any other number of electrodes may be used. The input circuit of tube 14 is connected across output resistance 8 through cathode resistor 15 and load resistance 15a of section II is connected across resistance 15 through condenser 16.

To couple the demodulator to the input 17 of the next element in the circuit (not shown), a second high impedance coupling such as tube 18 is used. This tube is shown as a triode, but it may be a pentode or a tube of any other number of electrodes as desired. The input of tube 18 is connected across condenser 11 and the cathode circuit may have a negative bias such as resistor 19, for example. This resistor also may have a by-pass condenser 20. The plate circuit of tube 18 is coupled to the input 17 by transformer 21 or in any other desired way. The supply leads 22, 23 may be used to furnish the plate voltage on both of the tubes 14 and 18. Negative lead 23, as usual, may be grounded.

The resistance-capacity section is preferably designed so that the successive condensers 9, 10, 11 and resistors 12, 13 have impedance values considerably greater than those of the preceding elements. For example, resistor 13 may have ten times the resistance value of resistor 12, condenser 11 may have one-tenth of the capacity of condenser 10 and the latter one-tenth of the capacity of condenser 9.

The voltage-frequency characteristic of section II of the demodulator is shown by graph A in Figure 2. It will be seen that this graph is substantially linear in respect to frequency response between the points 24 and 25, but departs from linearity beyond point 25. The voltage-frequency characteristic of section I of the demodulator is shown by graph B of Figure 2. This graph is concave downwards and the output of the demodulator as a whole will be the product of the various values of graphs A and B. The curve of the products is shown by graph C and substantial linearity extends from point 24', frequency f_1, to point 26, frequency f_3. The shape of the curve B between frequencies f_1 and f_3 on graph B is controlled largely by the value of resistance 7.

Any desired frequency range may be obtained by the combination of the two sections. All that is necessary is to use suitable values of resistors, inductances and capacitances in sections I and II.

The coupling tube 14 can be eliminated, provided that the input impedance of section II is several times the output load impedance of the low-pass K section I, but I have found that the vacuum tube described is a convenient coupling element for the two sections.

It will be understood how this frequency demodulator operates, but it may be briefly said

that the variable carrier wave, which may be a sub-carrier in many cases, will pass frequencies between the points **24** and **26** substantially linearly. The output of the combined sections therefore converts the variable frequency wave, preferably made constant by a suitable limiter, into a variable frequency wave of variable amplitude. By rectifying and filtering the output, either single-wave or full-wave, a substantially smooth direct current amplitude modulation results which can be used to operate a recorder or any other indicator after suitable amplification. The limiters, rectifiers and amplifiers referred to, as well as various other units in a radio or wire circuit, are not shown, as these per se form no part of the invention.

While I have shown sections I and II as the input and output units, respectively, this of course may be reversed by use of proper coupling arrangements.

Various modifications may be made without departing from the spirit of the invention.

Having described my invention, what I claim is:

1. In a frequency demodulator, a constant K filter and a resistance-capacity filter coupled in series, one of said filters having means for determining the values to cause the voltage-frequency characteristics to depart from linearity in opposite directions and produce a sloping linear characteristic throughout a predetermined range of frequencies.

2. In frequency demodulators, a low-pass resistance-capacity filter having a non-linear voltage-frequency characteristic between two predetermined frequencies, a low-pass inductance-capacity filter having between said predetermined frequencies a non-linear voltage-frequency characteristic of opposite curvature to that of the first characteristic, means for coupling said filters in series, and a resistor in series with the inductance of the second-mentioned filter of such value as to produce a sloping over-all voltage-frequency characteristic of the combined filters that is substantially linear between said predetermined frequencies.

3. A selective system for converting frequency modulation to amplitude modulation comprising a first selective network arranged to provide a curved voltage-frequency characteristic, a second selective network arranged to provide a voltage-frequency characteristic having a curvature opposite in sign to that of said first network, and coupling means between said networks in cascade, one of said networks having means for controlling the voltages so as to cause the curvature of one of said characteristics to offset that of the other, whereby the product of the voltages of said characteristics produces a third frequency-amplitude characteristic that is substantially linear over a wide range while providing a large ratio of response at the extremities of said range.

4. In frequency demodulators, a constant K filter, a resistance-capacity filter, said filters having oppositely curved voltage-frequency characteristics, an electron discharge device having its input terminals connected to the output terminals of one of said filters and having an impedance in its cathode return circuit connected to the input terminals of the other of said filters, and one of said filters having means to produce an over-all sloping and linear voltage-frequency characteristic for the combined filters over a wide range of frequencies.

5. In a frequency demodulator, an inductance-capacity filter having a sloping voltage-frequency characteristic curving in one direction between two predetermined frequencies, a resistance-capacity filter having a sloping voltage-frequency characteristic curving in the opposite direction between said frequencies, an electron discharge device having its input terminals connected to the output terminals of one of said filters and having an impedance in its cathode return circuit connected to the input terminals of the other of said filters, said inductance-capacity filter having a resistance of such value as to produce between said predetermined frequencies an over-all sloping and linear voltage-frequency characteristic for the combined filters.

6. Frequency demodulation apparatus comprising a tube having an anode, cathode and grid, means for subjecting the grid and cathode to frequency-modulated waves, a cathode return impedance in series with said cathode, a frequency-to-amplitude converting circuit having its input terminals connected across said cathode return impedance, and means for utilizing the output of said frequency-to-amplitude converting circuit.

7. Apparatus as claimed in claim 6, characterized by the fact that said utilization means includes an electron discharge device having its input electrodes connected to the output terminals of said frequency-to-amplitude converting circuit.

8. Apparatus as claimed in claim 6, characterized by the provision of an additional frequency-to-amplitude converting circuit having its output terminals connected to the grid and cathode of said electron discharge device, and its input terminals to a source of frequency varied waves.

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