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CARRIER WAVE DETECTOR CIRCUIT

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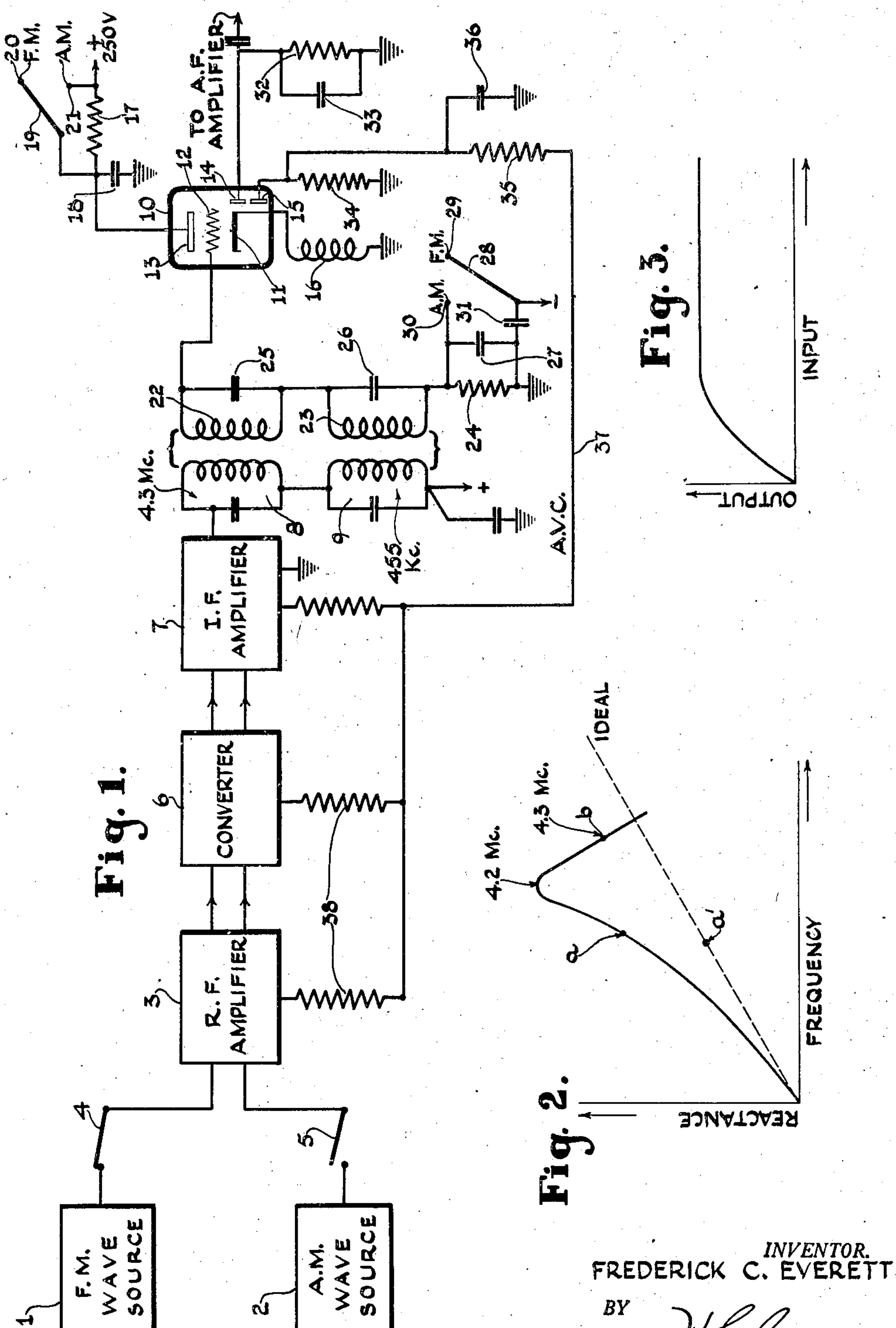

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CARRIER WAVE DETECTOR CIRCUIT

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9 Claims. (Cl. 250—27)

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My present invention relates generally to detectors of modulated carrier waves, and more particularly to novel and simplified detectors of frequency modulated carrier waves or amplitude modulated carrier waves.

The reception of frequency modulated ("FM" hereinafter for brevity) carrier waves in the past has usually involved relatively complex circuits in order to provide a signal reasonably free of noise and distortion. Simplification of FM receiving equipment is always desirable, especially where the equipment is to be used in mobile or portable services. In the latter type of equipment size, weight and current drain are factors that compel simplification. Again, receiver systems constructed to receive waves in the FM or AM (amplitude modulation) frequency bands make it desirable to reduce the number of circuit components required for reasonably satisfactory reception.

One of the main objects of my present invention is to provide a compact and simplified detector for FM carrier waves, wherein a single tube and a minimum of circuit components provide the functions of discrimination, rectification, amplitude limiting and automatic volume control.

Another important object of my present invention is to provide a simplified detector circuit constructed so as to detect either FM or AM signals with but minor adjustment of a switching element free of any high frequency connections.

Another object of my invention is to provide an economical, practical and simplified means for converting an AM detector of the type shown in my copending application Serial No. 456,739, filed August 31, 1942, granted October 31, 1944 as U. S. Patent No. 2,361,616, into an FM detector capable of limiting amplitude variations without the need of a special amplitude limiter tube.

Another object of my invention is to provide a circuit, including a duplex diode-triode tube, capable of providing discrimination, rectification and limiting for FM reception on one frequency channel, and detection for AM reception on a substantially different frequency channel.

Still another object of my invention is to provide a novel form of FM discriminator which consists of a simple reactive element whose magnitude is a function of frequency variations; the reactive element being traversed by space currents free of amplitude variation.

The novel features which I believe to be characteristic of my invention are set forth with 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 drawing, in which I have indicated diagrammatically a circuit organization whereby my invention may be carried into effect.

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In the drawing:

Fig. 1 shows, partly in schematic form, an FM-AM receiver employing an embodiment of the invention,

Fig. 2 graphically shows the respective ideal and actual frequency v. inductive reactance characteristics of the discriminator element,

Fig. 3 shows the "input v. output" characteristic of the detector triode section for FM reception.

Referring now to Fig. 1, which shows a superheterodyne receiving system employing an embodiment of the invention, the various well known networks up to the detector tube are schematically represented. The illustrative receiving system embodies a demodulator adapted to provide audio frequency voltage and AVC (automatic volume control) voltage in response to AM or FM signal reception. When functioning as an AM demodulator the latter is constructed and arranged in accordance with the disclosure of my aforesaid patent. A simple direct current switch means, free of any high frequency connections, is all that is needed to convert the AM demodulator into an FM demodulator operating in accordance with the principles of my invention. While I have shown herein the FM detector circuit applied to a multi-band receiver of the AM—FM type, it is to be clearly understood that the FM detector circuit may be used in a system for receiving solely FM signals.

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 present FM broadcast band 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 the generic expression "angle modulated" is intended to include frequency modulation, phase modulation or hybrid modulations thereof. From a very general viewpoint my invention is intended to relate 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 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 each 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 broadcast band. In AM transmission the carrier wave is modulated in amplitude in accordance with the modulation signals. The carrier frequency 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 are provided for 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 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. Multiband selector circuits and switching devices for suitable changeover are well known to those skilled in the art of radio communication.

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. value 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 connection. Conversely, when switch 5 is closed, and switch 4 is open, all AM selector circuits are in operative connection, and 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 tube 10 is shown, by way of example, as a duplex diode-triode tube. A tube of this type comprises a triode section and two diode sections, a common cathode supplying electrons for all three sections. The triode section consists of cathode element 11, control grid 12 and plate 13. Of course, a screen grid and/or suppressor grid may be inserted between the grid 12 and plate 13, if desired. Anodes 14 and 15 each function as a diode anode to receive a separate electron stream from common cathode 11. An inductance element 16 connects cathode 11 to ground, while plate 13 is connected to a point of positive potential, say +250 volts, of a direct current source through resistor 17. The condenser 18 connects the plate end of resistor 17 to ground in order to by-pass all alternating current components.

A switch arm 19 has one end thereof connected to the plate end of resistor 17, while a pair of spaced contacts 20 and 21 provide respective FM and AM adjustment positions for the switch arm. When switch 19—21 is closed, the resistor 17 is short-circuited and the full +250 volts are applied to plate 13. When arm 19 is shifted to contact 20, the switch position during FM reception, the resistor 17 functions to reduce the voltage on plate 13 to about +20 to +30 volts. Hence, for FM reception the plate voltage of tube 10 is very low, and of an order such as to cause ready saturation of the triode section. For AM reception the normal +250 volts are applied to plate 13. In either adjustment of switch arm 19, the plate circuit carries no alternating current components; indeed by-pass condenser 18 effectively prevents such current flow. Hence, switch 19 is solely a direct current switch, and is free of any audio frequency or radio frequency connection.

The control grid 12 is connected to the grounded end of cathode inductor 16 through a path comprising coils 22 and 23 and resistor 24 all in series. Condenser 25 shunts coil 22, condenser 26 shunts coil 23, and condenser 27 shunts resistor 24. Coil 22 and condenser 25 provide the tuned secondary circuit coupled to primary circuit 8, each of said circuits being resonated to the operating I. F. value in the FM band. It has been stated previously that such I. F. value may be 4.3 mc. Coil 23 and condenser 26 provide the tuned secondary circuit coupled to primary circuit 9. Each of these circuits 9 and 23, 26 is tuned to the operating I. F. value (455 kc.) in the AM band. Condenser 27 and resistor 24 cooperate to provide a well known resistor-condenser network used in limiters of the grid circuit type. The time constant of R_{24}—C_{27} is so chosen that the grid limiting action is fast-acting. For example, resistor 24 can be 100,000 ohms, and condenser 27 about 100 micro-micro-farads.

The network 24—27 is effectively short-circuited during AM reception, it being in active operation only during FM reception. Switch arm 28 is provided with spaced FM contact 29 and AM contact 30 for this purpose. The contact 30 is connected to the ungrounded end of resistor 24, while contact 29 is free. The fixed end of arm 28 is coupled by condenser 31, of a low impedance to currents of the AM frequency, to the grounded end of resistor 24. The fixed end of switch arm 28 is additionally connected to a point of suitable negative potential. The negative bias to be applied to the grid 12 is effective solely when switch 28—30 is closed. The bias will be sufficient, together with the +250 volts on plate 13, to cause the triode section to operate as a class A amplifier. When switch 28—30 is opened for FM reception the negative bias is removed from grid 12, and network 24—27 is effective to provide automatic grid biasing in response to input voltages in excess of a predetermined magnitude.

Modulation voltage, specifically audio frequency voltage, is provided across load resistor 32 connected between anode 14 and ground. Condenser 33 shunts resistor 32, and condenser 33 has a magnitude such as to by-pass all high frequency components. Diode 11—14 functions, therefore, as a rectifier of modulated carrier wave current applied to it. The input element for diode 11—14 is the inductance element 16. It will be noted that inductance 16 arranged in series with the space current path of diode 11—14 and with the load resistor 32. The carrier currents across inductor 16 will have amplitude variations regardless of whether FM or AM reception is had. During FM reception the action of inductor 16 is discriminatory thereby providing translation of FM signals into corresponding AM signals. During AM reception inductor 16 functions as a cathode load element for the triode section of tube 10, as more clearly explained in my aforesaid patent.

Diode 11—15 functions as a rectifier during AM reception for the purpose of providing AVC voltage. For this purpose load resistor 34 is arranged in series between anode 15 and cathode element 16. During AM signal reception any increase in carrier amplitude above a predetermined level causes an increased rectified voltage across resistor 34. This increase in voltage is applied in a gain-reducing sense to the various control grids of the controlled tubes in networks 3, 6 and 7 over the usual AVC circuit. Resistor 35 and condenser 36 provide a filter network for preventing any pulsating current components from being fed over the AVC line 37. The filter 35—36 is moreover given a time constant value such that the AVC circuit is slow-acting, and responds only to slow changes in carrier amplitude. Resistors 38 are included in the connections from the AVC line to each of the controlled tubes to provide additional filtering. The AVC circuit is effective only during AM reception, and does not function during FM reception because of the current limiting characteristics of the triode seciton of tube 10 during such reception.

The selector circuits feeding the FM signal energy to grid 12, assuming the system is adjusted for FM reception, will have an overall selectivity characteristic such that the entire swing of the FM carrier is transmitted efficiently with substantially no amplitude variation due to the selectivity characteristic of each selector circuit. This is best accomplished by having the cascaded selector circuits constructed to have band-pass characteristics at least 150 kc. wide and flat-topped. The tuned transformer feeding grid 12, and comprising tuned circuits 8 and 22—25, should have such a flat-topped resonance curve characteristic at least 150 kc. wide. For AM reception the AM channel selector circuits will have an overall selectivity characteristic which is chosen to pass a band 10 kc. wide with uniform amplitude. Those skilled in the art will readily know that such a characteristic is provided by selector circuits having flat-topped, band-pass response curves.

Assuming first that switch arms 28 and 19, as well as switch 5, have been adjusted for AM reception, the triode section of tube 10 will function in the manner disclosed in my aforesaid patent. The grid 12 will have a negative bias supplied to it, and the plate 13 will be at a relatively high positive voltage. As explained in my aforesaid patent, the cathode load 16 acts as the output load of the triode section, and at the same time exerts minimum loading on tuned circuit 23—26. This provides increased gain and selectivity. It will be understood that for the operating I. F. value in AM reception the circuit 22—25 has negligible impedance. Therefore, circuit 22—25 does not affect the AM signals during AM reception. It has been previously explained that network 24—27 is effectively short-circuited. The triode section has considerable power handling capability, further enhanced by the degeneration produced due to the cathode inductance 16. Hence, regulation of the triode section is very good thereby preventing distortion as the signal voltage applied to diode 11—14 swings far positive with large percentages of modulation.

The rectified AM voltage developed across resistor 32 is utilized to provide the audio frequency voltage to a following audio frequency amplifier stage, as indicated in the drawing. One or more audio frequency amplifiers may be used, and any desired type of reproducer will follow the last audio amplifier. The gain through the triode section of tube 10 is unity. Hence, no amplification is obtained through that portion of the tube. However, the actual overall gain goes up, because of the reflected load into the plate of the preceding I. F. amplifier which is higher. This follows from the fact that the triode section of the tube 10 functions as an "infinite impedance" circuit. This means that the selectivity is, also, considerably increased. Those skilled in the art are fully acquainted with the purpose and functions of the AVC connection 37. Briefly, the AVC bias varies directly in magnitude with the carrier intensity. The gain of the prior controlled amplifiers is varied in a sense such as to obtain substantially uniform carrier amplitude at input circuit 23—26 regardless of wide carrier amplitude variations at the receiver source 2.

The presence of the two diode anodes 14 and 15 in the double diode-triode type of tube makes it easy to utilize one diode to deliver the audio frequency voltage and the other to supply the AVC bias. This eases the filter requirements, aids the stability of the receiver, and avoids loading of the diode audio circuit which might cause distortion. However, it is to be understood that both audio and AVC voltages can be obtained from a single diode anode, if only one is available within the tube envelope. When necessary the cathode coil 16 should be shielded.

Since cathode bias cannot be used without biasing the diode anodes, a separate source of negative bias is applied. This may be present in the receiver without any additions. Of course a special biasing cell may be used, or a small dry cell. The filter resistor usually present in the negative power supply lead of a receiver will provide the necessary few volts of negative bias. If desired, a part of the AVC bias may be used for the same purpose, although this is not an advantageous expedient. Of course, the diodes may be provided by a separate 6H6 type of tube without change in the circuit shown in Fig. 1.

The triode section of the tube 10 has sufficient negative bias on the grid to prevent it from going positive. Hence, the tuned circuit 23—26 is not loaded. However, the grid voltage is varied at a radio frequency rate, and the plate current variations correspond to the grid voltage excursions. The plate current flows through the cathode impedance 16 across which each of the diodes is shunted, and which provides excitation for each diode.

With very slight modification, consisting only of changing the direct current voltages applied to the grid 12 and plate 13, the tube 10 is made to translate FM signal energy to corresponding AM energy, to remove undesired AM effects (noise), and to rectify the translated desired AM energy. In other words it is only necessary to shift switch arms 28 and 19 to the FM contacts, the switches 4 and 5 being as shown. The negative bias is now removed from grid 12, and network 24—27 is effective. Further, resistor 17 reduces the plate voltage to a low positive value. The plate current of the triode section will saturate with low input voltages. Any further increase in grid voltage will cause no further increase in the alternating current component of plate current. Fig. 3 shows the resulting "input v. output" characteristic of the triode section of tube 10 for FM reception. Undesired current amplitude variations across cathode load 16 are eliminated by virtue of the characteristic of Fig. 3.

The FM signals applied to grid 12 are derived from input circuit 22—25. The AM circuit 23—26 is ineffective, since the condenser 26 acts as a short-circuit at the I. F. value of 4.3 mc. Whereas for AM reception the frequency of the applied signal energy was a constant and only the signal intensity varied at grid 12, in FM reception this relation holds true across the cathode inductor 16:

$$E=I(2\pi f)L_{16}$$

where,

E=voltage
I=current
f=frequency
L_{16}=inductance of cathode coil 16.

Since the plate current is a constant due to operation along the saturation portion of the characteristic of Fig. 3, it follows from this formula that the voltage across the inductor 16 will depend upon the frequency variations of the applied input voltage. Also due to the limiting action of the circuits, undesired amplitude variations which appear on the FM wave at input circuit 22—25 are substantially prevented from appearing across the inductive load 16. Noise impulses will be prevented from passing to the rectifier 11–14 by the same token. However, any variations in frequency of input energy will cause corresponding changes in the voltage across the cathode inductor 16. Since diode 11–14 is connected across the element 16, the resulting voltage variations will be rectified. Since in the case of applied FM signals the voltage variations across load 16 are the AM variations corresponding to the instantaneous deviations of the FM carrier, the inductor 16 actually functions as a discriminator device to translate FM signals into corresponding AM signals.

The variation in inductive reactance of inductor 16 with changes in frequency is graphically presented in Fig. 2. The dotted line curve is the ideal characteristic. In practice the linear relation is secured only by employing a cathode load which may become somewhat complex. By suitable selection of values the load 16 can be a simple inductance, having the characteristic shown by the full line of Fig. 2.

It will be seen from Fig. 2 that the actual characteristic has a resonant peak at some frequency. This peak frequency should be chosen, of course, so that it is not too far from the center frequency F_c of the applied FM energy. For example, employing for coil 16 a magnitude of about 200 microhenries the coil will have a natural peak frequency of about 4.2 mc. It is desirable to have the operating I. F. value fall on a linear point on either slope of the solid line characteristic shown in Fig. 2. Two possible points of operation *a* and *b* are shown in Fig. 2, and in the case of the operating point *a* on the lower frequency slope the corresponding operating point *a'* on the ideal characteristic is shown by way of comparison. In actual practice it is found that the high frequency slope of the characteristic is more linear than the low frequency slope. Point *b* on the solid line curve would be the operating point (4.3 mc.). Where the frequency deviation ratio of the applied FM signals is high, it is preferred to employ an operating I.F. value such that operation will be had at the most linear portion of the high frequency slope of the characteristic of the cathode load. Where the applied FM signals, however, are of a relatively small deviation ratio, as where the frequency swing is of the order of 15 kc., it is preferred to employ an operating I.F. value such that operation will take place on either slope of the characteristic close to the peak where the slope is a maximum. The reason for this difference in operating point is that the greater the slope at the operating point on the characteristic shown in Fig. 2, the greater will be the audio voltage delivered by rectifier 11—14.

Should it be desired to approximate the ideal characteristic, instead of a simple coil 16 it may be necessary to employ in place thereof a specially designed network which has a more linear impedance-frequency characteristic. In general, the design of the cathode impedance 16 depends upon the frequency swing of the applied signals and the permissible distortion. Combinations of series and parallel resonant circuits could be used in place of coil 16 to improve linearity of the impedance-frequency characteristic.

The modulation voltage developed across resistor 32 is utilized in the following modulation amplifier network. The AVC circuit 37 is automatically inoperative for FM reception, because input signal amplitude variations are not repeated across the cathode load 16. This means that the various tubes in networks 3, 6 and 7 will operate at maximum gain, since AVC bias has been removed from the various receiver tubes. This is an important advantage in the receiver operation, because the various tubes are operated at a fixed bias thereby augmenting the limiting action in the triode section of tube 10.

While I have indicated and described a system 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 organization 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 combination with a tube having at least a cathode, input electrode and output anode, a frequency modulated carrier wave input circuit connected between the input electrode and ground, an inductive impedance adapted to be traversed by space current of the tube connected from cathode to ground, said impedance consisting of an unbypassed inductance whose natural frequency is of a magnitude such that it acts as a frequency discriminator, at least one diode connected to include said impedance as a signal input element, and means in circuit with the inductance and diode for developing modulation voltage from amplitude modulated carrier current rectified by the diode.

2. In a demodulator system for modulated carrier current, a tube having at least a cathode, a control grid and plate, a carrier input circuit between the grid and ground, a source of amplitude modulated carrier waves coupled to said input circuit, an unbypassed inductance connected from said cathode to ground, a first diode in shunt with said inductance, a resistor in circuit with the diode to develop rectified amplitude modulated carrier voltage, a second diode in shunt with the inductance, a second resistor in circuit with the second diode to develop a second rectified carrier voltage for gain control, a second input circuit in circuit with said control grid, a source of angle modulated waves coupled to the second circuit, said second source providing waves of a frequency widely spaced from the frequency of the first source, means for changing the operating direct current voltages of said grid and plate, when demodulating angle modulated waves, to an extent such that the space current through the inductance is limited at a low wave amplitude, said inductance having a natural resonant frequency such that it functions as a discriminator to translate angle modulated current into corresponding amplitude modulated current, and said first diode rectifying said translated current to provide modulation voltage across said first resistor.

3. In combination with a tube having at least a cathode, input electrode and output anode, a frequency modulated carrier current input circuit connected between the input electrode and ground, an inductance coil connected in circuit with the input electrode and from cathode to ground, said inductance having a natural frequency such that it possesses a frequency discrimination characteristic, at least one diode having its anode connected in a closed series circuit with said inductance through solely a resistor, and means for developing audio voltage across said resistor from rectified modulated carrier current flowing through the diode.

4. In a demodulator system for frequency modulated carrier current, a tube having at least a

cathode, a control grid and plate, a carrier input circuit, an unbypassed inductance connected in series between said grid and said cathode, a diode including said inductance as a signal input element, solely a resistor in circuit with the diode and inductance to develop rectified amplitude carrier voltage, and said inductance having a frequency discriminating characteristic whereby frequency modulated input current is translated into corresponding amplitude modulated carrier voltage across the inductance.

5. In a demodulator system for modulated carrier current of the type comprising a tube having at least a cathode, a control grid and plate, a carrier input circuit between the grid and ground, a source of amplitude modulated carrier waves coupled to said input circuit; the improvement which comprises an unbypassed inductance connected from said cathode to ground, a first diode in shunt with said inductance, a resistor in circuit with the diode to develop rectified amplitude modulated carrier voltage, a second diode in shunt with the inductance, a second resistor in circuit with the second diode to develop a second rectified carrier voltage for gain control, a second input circuit in circuit with said control grid, a source of angle modulated waves coupled to the second circuit, said second source providing waves of a frequency widely spaced from the frequency of the first source, means for changing the operating direct current voltages of said grid and plate, when demodulating angle modulated waves, to an extent such that the space current through the inductance is limited at a low wave amplitude, and said inductance acting as a discriminator to translate angle modulated current into corresponding amplitude modulated current.

6. In combination with a grid-controlled electron discharge device, said device including at least a cathode, anode and control grid, an angle modulated carrier current input circuit connected to the grid, an unbypassed coil connected between said cathode and the low potential side of the input circuit, said coil being located in the space current path of the device, the operating direct current voltages of said device being chosen to permit it to saturate at a low input current value, said coil having a natural frequency differing from the carrier frequency by a predetermined amount so that the coil acts as a frequency discriminator of the input waves, and means in circuit with said coil to derive modulation signal voltage therefrom.

7. In a demodulator system for frequency modulated carrier current, a tube having at least a cathode, a control grid and plate, a carrier input circuit connected between said grid and ground, an unbypassed inductance connected in series between ground and said cathode, said inductance being the sole reactive element between the cathode and ground and having a frequency discriminating characteristic whereby frequency modulated input current is translated into corresponding amplitude modulated carrier voltage across the inductance, and means in circuit with the inductance for deriving modulation signals from the amplitude modulated carrier voltage.

8. In combination with a tube having at least a cathode, input electrode and output anode, a frequency modulated carrier input circuit connected between the input electrode and ground, an unbypassed coil connected from cathode to ground, and said coil being naturally resonant to a frequency sufficiently different from the carrier

frequency whereby the coil acts as a frequency discriminator.

9. In a demodulator system, a tube having at least a cathode, a control grid and plate, a signal input circuit between the grid and ground, a source of amplitude modulated signal waves coupled to said input circuit, an unbypassed inductance connected from said cathode to ground, a rectifier in circuit with said inductance, a resistor in circuit with the rectifier to develop modulation voltage from rectified amplitude modulated signal waves, a second signal input circuit in circuit between said control grid and ground, a source of angle modulated waves coupled to the second circuit, said second source providing waves

of a frequency substantially different from the frequency of the first source, and said inductance being of a magnitude such that it functions as a discriminator to translate angle modulated current into corresponding amplitude modulated current.

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