

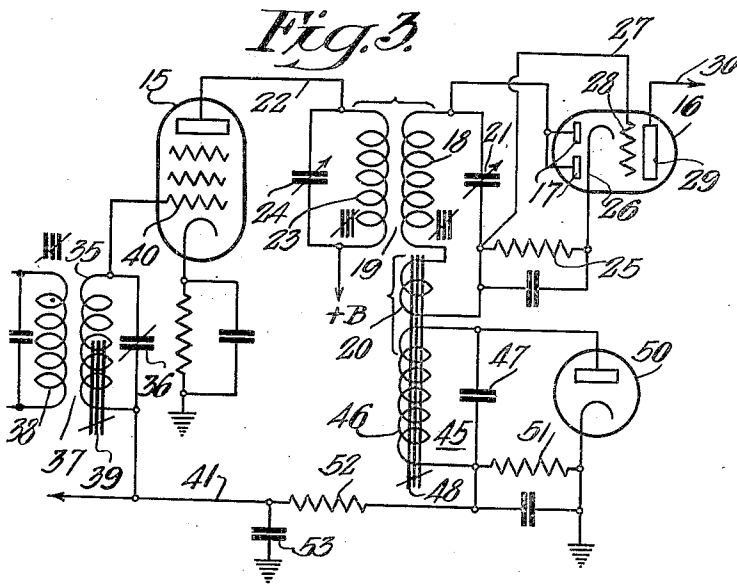
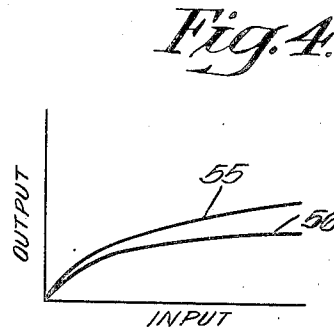
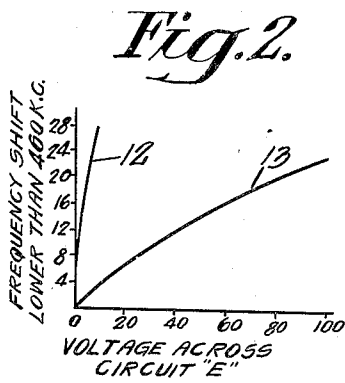
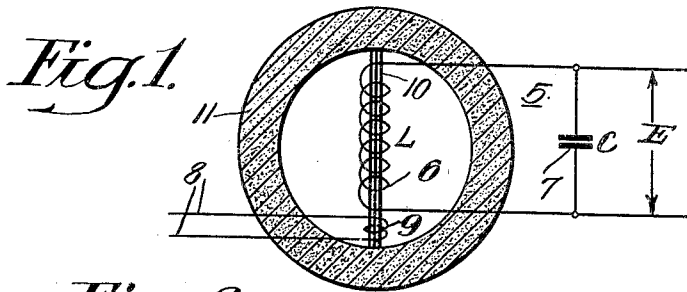
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TUNED RADIO SIGNAL CIRCUIT

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TUNED RADIO SIGNAL CIRCUIT

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The present invention relates to tuned radio signal circuits, and more particularly to signal circuits of the type having ferro-magnetic or magnetite core inductance tuning.

In conventional circuit design with inductance tuning of the type above referred to, the change in permeability is made relatively small and usually is not measurable because of the low flux density and relatively large volume of the cores ordinarily provided. It has been found, however, that with magnetite core tuning inductances, the permeability may be varied appreciably as the flux density in the core is increased to a relatively high value.

The flux density may be increased by the presence of strong signals as in an IF amplifier, to increase the signal current flow through the inductance, or the core volume may be decreased to a relatively small percentage of a normal core volume. It has been found that as a result of a relatively higher flux density than has heretofore been used for high frequency signal circuits, it is possible to shift or vary the resonant frequency of a tuned circuit embodying such an inductance, over a relatively wide frequency range with a relatively narrow range of variation in the strength of the applied signal or signal voltage, because of the change in permeability, and that, for maximum change of flux density with relatively small voltage change, a low L/C ratio in the tuned circuit is necessary.

It is, therefore, an object of the present invention to provide an improved tuned radio signal circuit embodying a tuning inductance or inductive reactance device of the magnetite core type, wherein a higher than normal flux density for radio signal circuits is provided in the core in response to an applied signal voltage to cause the frequency response of the tuned circuit to be varied in response to variations in applied signal strength or voltage.

It is also an object of the present invention to provide an improved radio signal circuit of the magnetite core inductance tuned type which is responsive to variations in signal strength to cause a corresponding variations in permeability and frequency response, whereby the circuit is adapted for use in compensating circuits for high frequency amplifiers, for example, as employed in the RF and IF circuits of a superheterodyne receiver, and also in connection with AVC and AFC circuits for radio receiving apparatus and the like.

The invention is particularly adapted for use in connection with the tuned signal conveying circuits of radio and other high frequency apparatus, and has for its further object to provide an improved tuned signal conveying circuit, the resonant frequency of which may be varied over a relatively wide range in response to relatively

small variations in the strength of the applied signal or in response to variations in the applied signal voltage.

It is also a further object of the present invention to provide an improved tuned signal conveying circuit, the resonant frequency of which may be varied in response to variations in the strength of the applied signal or in response to variations in the applied signal voltage when such voltage variations are relatively wide and the applied signal is relatively strong.

In providing a circuit embodying the invention, a tuning inductance or inductive reactance of the ferro-magnetic core type in which the core material is of magnetite is arranged to operate with a relatively high flux density for high frequency signal circuits. With magnetite cores in the tuning inductances, this has been found to increase the effective permeability and to cause an increase in the inductance value and a corresponding lowering of the resonance frequency of the tuned circuits.

It is, therefore, a still further object of the present invention to provide an improved tuning inductance element for high frequency radio signal circuits wherein the effective permeability of a ferro-magnetic core may be varied in the presence of strong signals and with a relatively low variation in signal strength or voltage.

In a tuned radio signal circuit such as the circuit of an intermediate frequency amplifier, it has been found that the permeability variation of a ferro-magnetic core tuning inductance may be increased by making the L/C ratio of the circuit low, that is, by making the inductance relatively low and the associated shunt tuning capacity relatively high in value, thereby to provide an increase in signal current flow since the flux in the core depends upon the factor I^2L . The flux, therefore, is proportional to I^2 . It is, therefore, an object of the present invention to provide a permeability tunable inductance for high frequency tuned radio circuits arranged to take advantage of the increased current available in a circuit having a low L/C ratio to increase the effect of frequency variation with variations in permeability.

It is also an object of the present invention to provide an improved high frequency radio signal circuit of the ferro-magnetic tuned type comprising a tuning inductance having a magnetite core and which, in the presence of strong signals, responds to variations in signal strength or voltage to provide a change in the permeability of the core and the inductance value thereof, and an improved control circuit, such as an AVC circuit for radio receiving apparatus and the like, embodying such tuning inductance or inductances.

Since an increase in signal strength or voltage in a tuned circuit embodying the invention pro-

vides a decrease in resonance frequency, the circuit may be utilized to compensate for variations in capacity on the circuit caused by variations in controlling potentials on associated amplifier tubes such, for example, as variation in capacity provided by an associated control grid in response to variations in AVC potential thereon to maintain the resonance frequency substantially constant.

The invention will, however, be better understood from the following description when considered in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the drawing,

Figure 1 is a schematic circuit diagram of a tuned radio signal circuit embodying the invention;

Figure 2 is a graph showing curves representing operating characteristics of the circuit of Fig. 1 under differing conditions of adjustment;

Figure 3 is a circuit diagram of an intermediate frequency amplifier and second detector for a superheterodyne radio receiving system also embodying the invention; and

Figure 4 is a graph showing curves illustrating an operating characteristic of the circuit of Fig. 3.

Referring to Fig. 1, a tuned radio signal circuit 5 is provided with a tuning inductance 6 and a shunt tuning capacitor 7 for said inductance. A signal input circuit 8 is coupled through a winding 9 with the inductance 6. This represents any suitable signal conveying circuit adapted to be tuned to resonance at a predetermined frequency.

In accordance with the invention, the inductance 6 is of the ferro-magnetic core type having a core 10 of magnetite of such volume or cross-section that the flux density therein is relatively high.

The magnetic circuit of the core 10 is preferably closed through a suitable path provided by magnetic core material providing a relatively large volume or cross-sectional area. In the present example, the ends of the core 10 engage the inner surfaces of a ring 11 of magnetic material having a large cross-sectional area with respect to that of the core 10.

By this arrangement, the core volume or cross-section under the winding is decreased. The signal intensity applied to the input circuit 8 and the voltage E in the tuned circuit 5 may be relatively high as in an intermediate frequency amplifier, with the result that the flux density in the core 10 is increased to such a point that the permeability of the core is affected and, as hereinbefore pointed out, the effect is to increase the permeability with increase in the flux density so that it is possible to shift the resonant frequency of the tuned circuit 5 over an appreciable frequency range by variation in the signal intensity or voltage E across the tuned circuit.

As shown in Fig. 2 by the curve 12, it has been found to be possible to shift the resonant frequency of the tuned circuit 5 from 460 kc., for example, to 430 kc. with an RF voltage change of from zero to substantially ten volts. This is with a low L/C ratio in the tuned circuit 5. With a higher L/C ratio, the response curve may be as indicated at 13 in Fig. 2, requiring a wider variation of voltage E across the tuned circuit to obtain the same shift of the resonance point.

The value of the capacitor 7 or the value of

C in the circuit 5 was 400 mmf. for obtaining the curve 13, while for obtaining the curve 12, a capacity of 4000 mmf. was employed across the tuning inductance. The lower L/C ratio provides a higher current through and a lower voltage across the tuning inductance. With a higher value of tuning capacity, it is obvious that for the same frequency or frequency range the value of the inductance 6 and the number of turns on the winding must be lower. However, it has been found that with a lower number of turns, the flux through the core is increased appreciably because of the fact that the flux varies as the square of the current and only as the first power of the inductance.

The ratio of the reactance of the inductance 6 to its high frequency resistance, or the Q of the coil, is reduced with increase in the strength of the signal applied through the circuit 8 to the circuit 5, because the high frequency resistance increases at a higher rate than the inductance or the effective permeability, and this results in a decrease in the gain of any amplifier stage in which the circuit is connected, which is a desirable feature since it reduces the gain for strong signals and permits increased gain automatically for weak signals.

This is for the reason that, in the present system, the core of the inductance operates with high frequency currents far below the knee of the permeability-magnetomotive force or saturation characteristic curve, but still relatively higher than has heretofore been used in such systems. This causes the permeability to rise with increased RF voltage at E. The relatively high flux density herein referred to is a flux density which is high for that ordinarily obtainable in high frequency signal circuits and should not be confused with that used in power and audio frequency circuits. On a usual saturation curve, for example, a point above the upper bend or knee is that which is ordinarily considered to represent a high flux density for power and audio frequency circuits, while a point on or above the lower bend of the same curve would indicate a high radio frequency flux density. The flexing of the curve is opposite for the two cases, and it will therefore be seen that the tangent to the curve more nearly approaches the vertical for the radio frequency circuits and, accordingly, in this region, as the RF voltage and current increases, the permeability increases, since the tangent to the curve becomes further more nearly vertical.

As will be seen from the curves of Fig. 2, the voltage E required to change the resonant point or tuning of the circuit 5 through a relatively wide frequency range may be varied over a relatively wide range or a relatively narrow range, depending upon the L/C ratio of the tuning elements in the circuit. This permits considerable latitude in the design of the circuit.

In any case, however, the range of frequency variation and the variation of the Q of the coil is relatively high only when the flux density is increased to a relatively high value for such high frequency circuits as hereinbefore noted, and this is accomplished not only by providing an inductance winding having a magnetite core of relatively low volume or cross-section whereby the flux density for high frequency circuits is high per unit volume of the core, but is also made possible at a lower input voltage E, by providing the tuned circuit with a low L/C ratio.

In any tuned circuit, it is unnecessary to depart from the desirable features of magnetite core tuning to obtain a shifting of the resonant point or a frequency variation in the tuned circuit, since to obtain this characteristic, it is merely necessary to decrease the length and diameter of the coil and core assembly in such a manner that the flux density per unit of volume of the core is increased, and for a maximum change in frequency with low voltage change, a low L/C ratio is used in the tuned circuit.

Referring now to Fig. 3, an intermediate frequency amplifier circuit is shown in which a tube 15 is provided as the last intermediate frequency amplifier stage preceding a second detector tube 16 in the signal channel of the receiver. The detector is of the diode rectifier type comprising a pair of diode electrodes 17 connected to the secondary 18 of IF coupling transformer 19 which is connected in series with a coupling coil 20 and is tuned by a shunt adjustable capacitor 21.

The output circuit 22 of the IF amplifier tube 15 is connected with the tuned primary winding 23 also provided with a shunt tuning capacitor 24 so that the two tuned circuits may respond to the same frequency, such as 460 kc., for example.

The secondary circuit 18—20—21 is connected at its low potential end through a diode output resistor 25 to the cathode 23. Audio frequency signal output is derived from the resistor 25 through an output lead 27, connected in the present example to an amplifier grid 28 in the same envelope with the diode detector. Audio frequency signals for further amplification and utilization are derived from the output anode 29 associated with the grid 28, through the output circuit 30.

The IF amplifier tube 15 is provided with a tuned input circuit comprising a tuning inductance 35 and a shunt tuning capacitor 36 therefore forming the tuned secondary circuit of an IF transformer 27, the tuned primary of which is indicated at 38. The secondary 25 is tuned by the shunt capacitor 36 and also by a core 39 of magnetic material such as magnetite arranged therein in any suitable manner and being of such cross-sectional area or volume that, in response to normal signals supplied through the channel, the voltage across the circuit 35—36 causes the flux density in the core to be relatively high for high frequency circuits although far below the upper bend of the usual saturation curve for inductance elements in audio frequency and low frequency power circuits, thereby to decrease the frequency of resonance of the input circuit by an amount at least sufficient to overcome the effect on the circuit of the input or control grid 40 of the amplifier which is connected thereto and through the inductance 35 with a source of AVC potential provided by the lead 41. As is well known, the increase in negative bias provided in response to increased signal strength in an AVC system causes the capacity of the tuned circuit to be decreased and the frequency response to be shifted toward a higher resonant frequency. This tendency is overcome by the present arrangement.

To take advantage of the variable permeability in response to variations in signal strength to vary the tuning of a resonant circuit having inductance ferro-magnetic core tuning means, a tuned circuit 43, comprising a tuning inductance 46 and a shunt capacitor 47, is associated with the coupling winding 20 in such a manner that, as indicated in the drawing, the latter winding is

coupled to the tuning inductance electromagnetically for the transfer of energy to the circuit 45. The windings 20 and 46 are associated or coupled in much the same manner as indicated in Fig. 1 at 5 and 6, respectively, on a magnetite core 48 of low volume or cross-section to permit saturation or the relatively high flux density, hereinbefore referred to, at normal signal levels, thereby to change the permeability of the core and the tuning of the circuit 45, the frequency being decreased with increased signal strength.

As hereinbefore described, the increase in permeability causes an increase in inductance of the windings 46 and tunes the circuit to a lower frequency, and to increase this effect, the magnetic circuit is preferably closed, as in the arrangement of Fig. 1, and, furthermore, the ratio of the inductance 46 to the capacity at 47, that is, the L/C ratio, is made low. This provides a relatively high current and low inductance in the winding 43 for a given frequency.

With an intermediate frequency circuit tuned to 460 kc., the circuit 45 may be tuned to 480 kc., for example, with weak signal input. As the applied signal strength is increased, the 480 kc. circuit 45 will shift in resonant frequency to a lower frequency, approaching the intermediate frequency 460 kc. as a limit, thus increasing the coupling to the secondary 18 and causing the output voltage from the tuned circuit 45 to increase at a higher rate than the signal.

A signal rectifier of the diode type indicated at 50 having a diode output resistor 51 may be connected across the tuned circuit 45 to provide controlling potentials for the AVC circuit 41, the connection being made as indicated, through a suitable filter comprising a series resistor 52 and a shunt filter capacitor 53. This causes a better AVC characteristic than is normally provided, as indicated in the curves of Fig. 4, in which the curve 55 is a response curve for a normal AVC connection, whereas the curve 56 represents the AVC control characteristic of the circuit of Fig. 3, clearly showing that the AVC characteristic is much flatter in the present system.

I claim as my invention:

1. In a tuned radio signal circuit, an inductive reactance responsive to the flow of relatively strong signal currents therethrough to vary the tuning of said circuit from a higher to a lower resonant frequency, said reactance comprising an inductive winding and a core element therefor so proportioned that the flux and permeability increase with an increase in signal potential across said circuit and a resulting increase in signal current through said winding.

2. In a tuned radio signal circuit, an inductive reactance responsive to relatively strong signal current therethrough to vary the tuning of said circuit from a higher to a lower resonant frequency with increase in signal potential across said circuit, said inductive reactance comprising an inductance winding and a ferro-magnetic core element therein subject to a relatively high flux density in response to signal current of a predetermined value through said reactance and an increase in the permeability of said core element in response to an increase in flux density effective to cause said lowering of the resonant frequency of said circuit with increased signal potential.

3. In a tuned radio signal circuit, an inductive reactance responsive to relatively strong signal currents therethrough to vary the tuning of said circuit from a higher to a lower resonant frequency with increase in signal potential across said cir-

cuit, said inductive reactance comprising an inductive winding having a ferro-magnetic core element providing a relatively high flux density in response to the flow of signal currents in the winding and an increase in the permeability of said core element.

4. In a tuned radio signal circuit, an inductive reactance responsive to relatively strong signal currents therethrough to vary the tuning of said circuit from a higher to a lower resonant frequency with increase in signal potential across said circuit, said inductive reactance comprising an inductive winding having a ferro-magnetic core element providing a relatively high flux density in response to the flow of signal currents in the winding and an increase in the permeability of said core element, and means providing a shunt tuning capacitor for said inductive winding of a capacity value such that the L/C ratio of said circuit is relatively low.

5. In a tuned radio signal circuit, the combination of a tuning inductance and a shunt tuning capacitor therefor providing a circuit for the flow of signal currents through said inductance, a ferro-magnetic core element for said inductance of relatively small volume providing a relatively high flux density therein in response to an increase in signal currents through said inductance and an increase in the permeability, whereby the frequency response of said circuit is decreased with increased signal strength, and the L/C ratio of said circuit being relatively low for maximum frequency change in the resonance of said circuit in response to a relatively small signal voltage change in said circuit.

6. In a radio signal circuit, means for varying the tuning of said circuit in response to variations in a signal voltage applied thereto, said means comprising an inductance, a tuning capacitor in shunt therewith, a magnetite core element for said inductance providing a relatively high flux density in the core in response to signal current flow in said inductance, and means for applying radio signals to said circuit to cause the flux and the permeability of said core to increase with increased signal strength, thereby to increase the value of said inductance and to lower the resonance frequency of said circuit.

7. In a tuned radio signal conveying circuit, means responsive to variations in signal voltage across said circuit for varying the resonance frequency of said circuit, said means comprising an inductive tuning reactance in said circuit, a ferro-magnetic core for said reactance providing an increase in flux density and permeability with an increase in said voltage, and means for applying signals of a predetermined strength to said circuit, said last-named means comprising an intermediate frequency amplifier circuit, a rectifier device connected with said first-named circuit, and a control circuit for deriving an automatic volume control potential therefrom.

8. In a tuned radio signal conveying circuit, means responsive to variations in signal voltage across said circuit for varying the resonance frequency of said circuit, said means comprising an inductive tuning reactance in said circuit, a ferro-magnetic core for said reactance providing an increase in flux density and permeability with an increase in said voltage, means for applying signals of a predetermined strength to said circuit, said last-named means comprising an inter-

mediate frequency amplifier tuned circuit, a rectifier device connected with said first-named circuit, and a control circuit for deriving an automatic volume control potential therefrom, said intermediate frequency amplifier circuit being tuned to a predetermined intermediate frequency and said first-named circuit being tuned to a higher frequency by an amount substantially equal to a range of frequency variation of said first-named circuit corresponding to a variation of the signal voltage across said first-named circuit from a minimum to a maximum value.

9. In a radio signal conveying channel, the combination of means providing a tuned signal circuit, an amplifier tube having a control grid connected with said tuned circuit, means for applying a biasing potential to said control grid to vary the gain of said tube and the capacity load provided thereby on said tuned circuit, and means in said circuit for compensating for variations in said capacity load to maintain the resonance frequency of said circuit substantially constant, comprising an inductive reactance winding in said tuned circuit and a ferro-magnetic core element therefor providing a relatively high flux density per unit volume in response to signals through said circuit thereby to increase the permeability of said core and to decrease the frequency response of said circuit with increased signal strength.

10. In a radio signal conveying circuit, the combination of a tuned signal circuit comprising a tuning inductance and a shunt capacitor therefor, an amplifier tube having a control grid connected with said circuit, means for applying automatic volume control potentials to said control grid in response to received signals, the capacity load provided by said control grid being thereby decreased with increased signal strength tending to increase the resonance frequency of said circuit, and means for compensating for said increase in resonance frequency comprising a magnetite core element for said inductance providing a relatively high flux density per unit volume in response to signals through said tuned circuit and a corresponding increase in the permeability and a decrease in the frequency response of said circuit substantially equal to the increase in frequency response tending to be effected by volume control of said grid.

11. In a radio receiver, an automatic volume control system, comprising in combination, a tuned signal circuit, a second tuned signal circuit coupled therewith, said second circuit being tuned to a higher frequency than said first-named circuit and comprising a tuning inductance having a magnetite core element of relatively small volume within said inductance to provide a relatively high flux density per unit volume in response to signals applied to said second circuit and of a value such that the permeability of said core element is increased thereby by an amount sufficient to decrease the frequency response of said second circuit with increased signal strength to substantially the resonance frequency of the first-named circuit, a rectifier device connected with said second-named circuit, and means for deriving automatic volume control potentials therefrom for said receiver.

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