

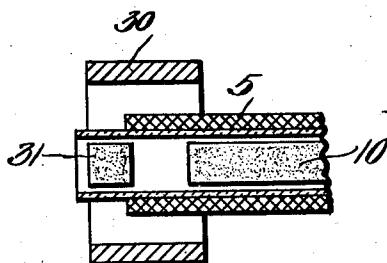
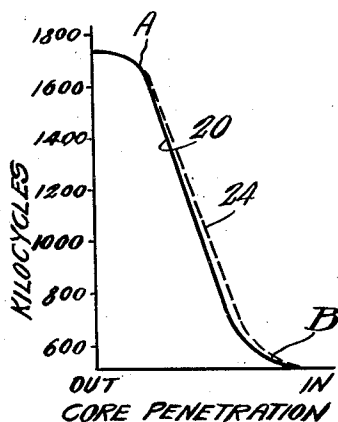
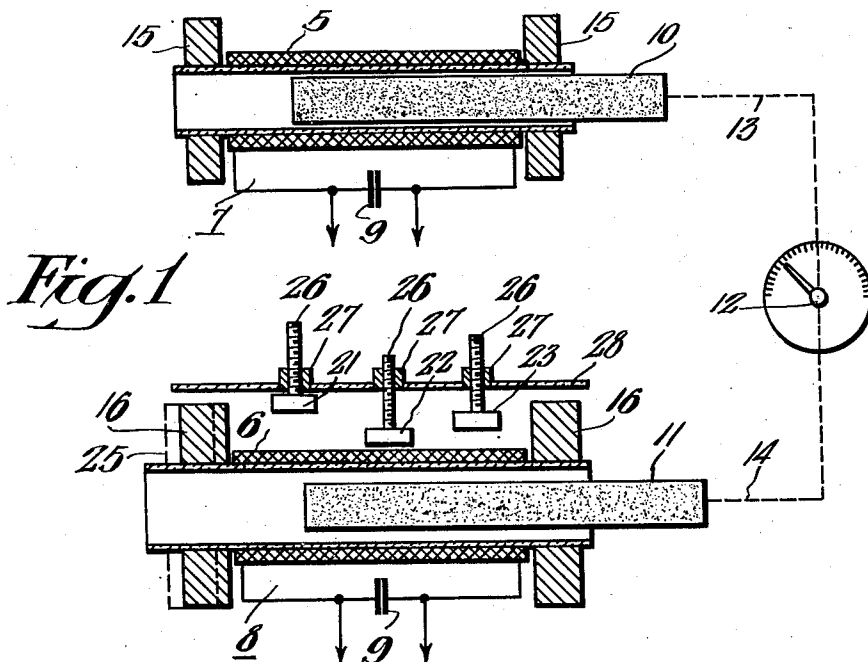
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VARIABLE PERMEABILITY TUNING SYSTEM

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VARIABLE PERMEABILITY TUNING SYSTEM

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This invention relates to variable permeability tuning systems comprising variable inductances provided with tuning cores of magnetic material movable in unison for varying the tuning or frequency response of a plurality of circuits in predetermined relation.

It has been recognized since an early date (Stone U. S. Patent 767,977), that cores of finely divided iron in an insulating binder were useful in improving inductances for use in high frequency radio circuits and the like. Such cores in gang relation have been known and used for tuning control for a long period of time (Fleming "The Thermionic Valve in Radio Telegraphy and Telephony", 1919 edition, page 230).

While such early cores had low loss properties they lacked high permeability because of the low density of the iron. The permeability characteristic was later improved by subjecting improved core material made from hydrogen treated iron to high pressures (Speed U. S. Patent 1,274,952—Journal of A. I. E. E., vol. 40, July 1921, page 596, "Magnetic properties of compressed powdered iron").

Even with comminuted cores of such improved permeability, variable permeability inductance tuning devices, of the simplified open core construction, could not be made to cover a relatively wide tuning range, such for example as the broadcast range of 550 to 1650 kc., which requires a change of inductance of at least 9:1 and a frequency change in a 3:1 ratio.

Tuning cores of the laminated open type having a permeability sufficiently high to cover the broadcast band were known in the early days of broadcasting (Marvel U. S. Patent 1,656,381), but the losses in this type of core are too high for a desired selectivity in connection with tuning systems for closely-spaced present-day broadcasting channels. The reduction of eddy current losses by laminating the cores is impracticable beyond certain limits.

One solution of the problem of obtaining an extended tuning range with a high degree of selectivity and gain, consists in the use of movable cores which are E-shaped in cross section, the central portion extending inside the winding and the outer portion surrounding the winding, in the maximum inductance position, thereby approaching a closed core arrangement. However, this core design has not been adopted commercially because of its massiveness and relatively high cost.

As a further solution of the problem, it has been and is the practice to use elongated rod-like cores, in an open core construction, to tune elongated solenoid windings or inductances, the ratio of the length to the diameter of the windings being made much greater than that known to be best for optimum values of the Q of the coils. To

cover the present broadcast or A band, this involves making very long coils and cores, of the order of 4 or 5 to 1 ratio of length to diameter, and a consequent sacrifice of the Q of the coil, as the leakage flux and the length of the wire employed in the coil construction is increased.

It is, therefore, a further object of this invention to provide a relatively wide tuning range or inductance variation, with high permeability and low loss, in a variable permeability tuning system, thereby to maintain a high degree of selectivity and gain in response to signals. This requires that the Q of the variable inductance windings in the signal responsive circuits be maintained at a relatively high value throughout the tuning range.

It is also a further object of this invention, therefore, to provide an improved variable permeability tuning system comprising an inductance having a magnetic core construction of the open type, the movable control element of which is operative over an extended tuning range, while maintaining a more favorable ratio of length to diameter of the said winding of substantially less than 4:1, thereby to improve the efficiency of the system without impairing said tuning range.

It is also a further object of this invention to provide a variable permeability tuning system having an improved straight line frequency tuning characteristic, and a higher maximum inductance without increasing the minimum inductance therein, whereby the tuning or frequency range is extended without impairing the efficiency of the system.

It is also a further object of this invention to provide an improved variable permeability tuning system having an open type core of magnetically permeable material and a solenoid winding within which the core is axially movable to vary the inductance of said winding through a range of inductance variation, in a ratio at least equal to or greater than 9:1 while maintaining the Q of the winding substantially constant and relatively high.

In carrying into effect the above and other objects which will hereinafter appear, it has been found that the magnetic core material at least for the movable core is preferably of finely divided iron having a density of the order of that of pure undivided iron and having a high permeability such as that disclosed by the aforesaid Speed U. S. Patent 1,274,952 and the A. I. E. E. Journal for July, 1921.

In accordance with the invention, at least one external fixed magnetic core element is provided adjacent one end of the coil in cooperative spaced relation to the movable core, thereby establishing an increased inductance effect in the winding when the movable core is in the maximum or low frequency tuning position. The core is of the

open type and may be considered to have one portion which is internal and movable axially for varying the tuning or the inductance of the winding, and another or others which may be external and substantially fixed, adjacent to the ends of the winding, and arranged to have substantially no effect upon the inductance when the movable portion or main core is withdrawn from the winding.

The external portion or portions preferably are formed as ring-like members at one or both ends of the winding, and are substantially isolated by an extended air gap between them when the core is withdrawn. Thus they have been found to have no appreciable effect upon the minimum inductance even when positioned closely adjacent to the ends of the winding. These portions, however, contribute largely to the increased inductance effect when the movable core is in the maximum tuning position within the winding and thus serve to increase the tuning range without increasing the winding length.

For a predetermined winding length, therefore, this system provides a wider frequency variation range, or for a given frequency or tuning range, a relatively shorter inductance may be employed than has heretofore been possible.

In radio and other apparatus requiring the simultaneous or conjoint tuning of two or more circuits over a predetermined tuning or frequency variation range, it is often essential that two or more of the circuits tune to the same frequency or to frequencies having a constant difference, as in the oscillator and radio frequency circuits of a superheterodyne receiver. Such circuits therefore vary in tuning or frequency in a predetermined manner, called tracking. It is an object of this invention to provide an improved variable permeability tuning system of that type, wherein the advantages of the end ring construction may be retained while improving the tracking relation between two or more variable permeability tuning circuits.

It is also an object of this invention to provide an improved variable permeability tuning system which provides simple and readily adjustable means for modifying or altering the tuning response or frequency characteristic of variable permeability tuning inductances in one or more tunable circuits, while at the same time permitting the circuit or circuits to be tuned in unison through predetermined frequency ranges with a high degree of efficiency and with a maximum tuning range.

In a preferred embodiment of the invention, the radio frequency or detector and the oscillator circuits of a superheterodyne receiver are permeably tunable through frequency ranges between which circuits a constant difference is established as determined by the intermediate frequency of the system.

It is also an object of this invention to provide an improved inductance winding and core arrangement whereby the tuning of two jointly variable inductance circuits may take place at different rates, the tuning of one circuit being accelerated with respect to that of the other.

The tracking system embodying the invention will, however, be understood more in detail from the following description, when considered in connection with the accompanying drawing, and its scope is pointed out in the appended claims.

In the drawing,

Figure 1 is a schematic representation, partly in cross section and substantially full size, of a

variable permeability tuning system embodying the invention,

Figure 2 is a graph showing a curve representing the tuning or frequency response characteristic of one of the variable tuning elements of the system shown in Fig. 1, and

Figure 3 is a view partly in section of a portion of one of the tuning elements of Fig. 1 showing a modification thereof.

Referring to Fig. 1, 5 and 6 are solenoid inductance windings in two jointly tunable circuits 7 and 8, respectively, representing the radio frequency and oscillator circuits of a receiver. The circuits are provided with shunt tuning capacitors 9 and are variable and tunable by means of movable rod-like tuning cores 10 and 11 actuated by suitable tuning control means 12 with which they are connected as indicated by the dotted connections 13 and 14. The cores are movable through the windings between end ring members of magnetic material, indicated at 15 and 16, in association with the windings 5 and 6 respectively.

Both the cores 10 and 11 and the external fixed core elements 15 and 16 respectively, may be composed of the same magnetic materials in a suitable binder or they may be made of materials having differing magnetic properties. For example, the core 10 may be composed of finely divided iron of the type disclosed by the U. S. patent to Speed, 1,274,952, hereinbefore referred to, while the end rings may be composed of less expensive iron such as Swedish or sponge iron, in a suitable binder, depending upon the tuning range desired. For the best results, it is preferable to have the density of the core and of the end rings of the order of that of pure undivided iron, thereby to maintain the permeability of the core and external core elements relatively high. In certain cases the density is such that the specific gravity of the molded cores is of the order of from 6 to 7 as compared with solid iron having a specific gravity of approximately 7.5. Both the core and the end rings may be molded in any suitable manner or otherwise formed with finely divided iron or other suitable magnetic material in a suitable insulating binder.

In accordance with the invention hereinbefore referred to, the end rings permit the use of a shorter tuning inductance winding without decreasing the inductance variation range, and at the same time impart to the tuning of a circuit substantially straight line frequency characteristics.

It will also be noted that the oscillator tuning inductance 6 is of larger diameter than the detector or R.-F. tuning inductance 5, in accordance with established practice, to cause the oscillator tuning to be "slower" than the R.-F. tuning, thereby aiding the tracking relation between the two circuits, since the R.-F. circuit must cover a frequency change of substantially 3:1, with an inductance change of the order of 9:1, while the oscillator tuning covers a frequency change of approximately 2:1, for example, the broadcast band of 550 k.c. to 1650 k.c.

The tuning response characteristic of the oscillator tuning inductance 6, for example, is indicated at 20 in Fig. 2, showing the straight line frequency response provided over the major portion of the tuning range by the use of the end rings. This characteristic may be altered by providing in conjunction with the rings 16, for example, one or more alignment plugs or buttons of magnetic material in spaced relation along the

length of the winding in one or more rows, one of which is indicated at 21, 22 and 23, the buttons or plugs being adjustable in any suitable manner as, for example, radially toward and away from the winding to differing positions as indicated.

By adjusting the plugs in the external field of the winding into close relation with the winding and the core which moves through it, the curve 20 may be modified as indicated by the curve 24, and by adjustment of the plugs in different spaced relation to the winding, different portions of the curve 24 may be made to coincide with or depart from the curve 20 as the core moves under the plugs, thereby to assist in the tracking or tuning alignment of winding 6 with other conjointly tunable windings, such as the winding 5.

While three alignment plugs or auxiliary tuning core members are shown, a greater or lesser number may be provided along the length of the winding in any desired spaced relation to each other. In aligning two circuits as shown, for tuning in the same or differing frequency ranges with a predetermined tracking relation between them, the cores may be entered in the windings as adjustment for the high frequency end of the range as at the point A on the curve 20, and the center or intermediate points along the curve may be caused to align for the tuning of the associated circuits by adjustment of the plugs 21, 22 and 23. At the low frequency end of the range the adjustment of the end ring 16 more remote from the entering end of the core may be adjusted axially as indicated by the dotted position 25 to provide alignment at the low frequency end B, of the tuning range, thus providing an accurate alignment for the tracking of the two circuits throughout the tuning range.

The cores or plugs 23 may be provided with any suitable mounting and adjusting means, such as screw-threaded stems 26 carried by threaded ferules 27 mounted in a supporting plate or casing wall 28, preferably of insulating material, thereby to reduce capacity coupling between the ends of the winding when the end plugs are close thereto.

Referring to Fig. 3, wherein the R.-F. coil is indicated at 5, and corresponding reference numerals refer to like parts as in Fig. 1, the end ring construction remote from the entering end for the core may be arranged as shown at 30 partly surrounding the end of the winding in spaced substantially concentric relation thereto and being axially movable to adjust the tuning characteristic at the low frequency end of the tuning range, and over an extended portion of the range, depending upon the length of the ring 30. A central plug 31 also of magnetic material at the remote end of the winding serves to couple the movable core 10 more fully with the end ring 30 in the extreme low frequency tuning range.

With this arrangement, the oscillator tuning inductance may be substantially of the same diameter as the R.-F. tuning inductance since the R.-F. tuning is, in this case, "faster" than the oscillator tuning, thereby covering the tuning range hereinbefore referred to with the same range of movement of the cores when connected in ganged relation, as shown.

From the foregoing description, it will be seen that an inductance winding for a variable permeability tuning system may have a more advantageous ratio of length-to-diameter and substantially less than a 4 to 1 ratio heretofore considered necessary, by providing the inductance with a winding the length of which is less than

four times the diameter and providing the same with end rings of magnetic material which are electromagnetically isolated when the core is withdrawn and electromagnetically coupled with the core when the same is fully inserted, thereby to increase the maximum inductance without substantially increasing the minimum inductance. This results in a substantially constant Q for the winding throughout a relatively wide tuning range and the tuning is made substantially straight line frequency in character without resorting to costly expedients which have heretofore been used for this purpose.

This arrangement has the advantage that the tuning of the R.-F. circuit is speeded up without resorting to expedients involving a higher manufacturing cost, as in the use of the large diameter oscillator winding. In this case, a simple molded ring 30 is provided at the low frequency end of the tuning inductance and a plug core member, if desired, may be included in one end of the coil as shown. Both of these items may be manufactured and assembled at low cost.

I claim as my invention:

1. A variable permeability tuning system comprising in combination, a pair of tuning inductance windings, tuning cores movable through said windings in unison, a relatively short magnetic core member positioned along a small portion only of the length of one of said windings between and spaced longitudinally from the ends thereof in fixed relation longitudinally, and means for moving said member radially toward and away from the winding and the path of movement of the core therethrough to alter the tuning response characteristic of said one of said windings and to establish a predetermined tracking relation between circuits including said windings in the tuning movement of said cores.

2. A variable permeability tuning system comprising in combination, a pair of inductance windings of the solenoid type each having a movable magnetic tuning core, a plurality of plug-like members of magnetic material positioned in substantially fixed relation longitudinally along the length and in the external field of one of the windings and spaced longitudinally from the ends thereof, each of said members having a relatively small dimension lengthwise of said winding, and means for moving said plug-like members individually toward and away from said winding to positions of adjustment establishing a predetermined tracking relation between circuits including said windings in the tuning core movement over a portion of the tuning range of movement thereof.

3. A variable permeability tuning system comprising in combination, a pair of inductance windings each having a movable tuning core, means for moving said cores in unison, a plurality of plug-like members of magnetic material positioned in spaced relation to each other along the length of one of the windings, each of said members having a relatively small dimension lengthwise of said one of said windings, means for individually moving said members radially toward and away from the winding to alter the inductance variation characteristic thereof, electrical insulating structure supporting said members for reducing capacity coupling between spaced portions of said winding through said members and additional means for accelerating the rate of inductance change of one of said windings.

4. A variable permeability tuning system com-

prising in combination, a pair of tuning inductance windings of different diameters, tuning cores of like diameters movable through said windings in unison, respectively, a semi-fixed magnetic core member positioned in concentric relation to one of said windings adjacent one of the ends thereof, and means for moving said member axially toward and away from the winding in the direction of the path of said tuning core to alter the tuning response characteristic of said one of said windings relative to that of the other of said windings.

5. The invention as set forth in claim 4 wherein said magnetic member is disposed adjacent the end of said winding of smaller diameter and remote from the entering end for the core thereof for substantially increasing the maximum inductance of said winding without substantially increasing the minimum inductance thereof.

6. A variable permeability tuning system comprising in combination, a pair of solenoid inductance windings, tuning cores movable through said windings in unison, respectively, the ratio of diameter of one of said windings to that of its core being substantially greater than the corresponding relation between the other of said windings and its core for causing said one of said windings to have a slower rate of change of inductance and a relatively smaller tuning range as said cores are varied from a minimum to a maximum inductance position, and substantially fixed magnetic means disposed adjacent one end of said other of said windings and remote from the entering end for the core thereof for substantially increasing the inductance range of said other of said windings.

7. A variable permeability radio frequency tuning system, comprising in combination, a pair of inductance solenoid windings of different inner diameters, each having a movable core of magnetic material, control structure for effecting axial movement of said cores in unison within said windings from positions of minimum inductance value to positions of maximum inductance values, respectively, means for causing circuits including said inductance windings to vary in tuning at substantially different rates comprising a difference in diameter relation between said windings and their respective cores, means for aligning said circuits at said position of minimum inductance, magnetic means positioned along the length of one of said windings in the external field thereof and having a relatively small dimension lengthwise of said winding for adjusting the tracking relation at a desired point between said minimum and maximum core positions, and substantially fixed magnetic means disposed at an end of said winding remote from the entering end for the core and axially movable for adjusting the tracking relation between circuits for said maximum position of said movable core.

8. A variable permeability radio frequency tuning system including at least two inductance windings of different inner diameters, ferromagnetic cores of substantially the same diameter for turning said windings, respectively, structure for moving said cores in unison within said windings from positions of minimum inductance to positions of maximum inductance, respectively, means whereby the difference in radial

spacing between said cores and their respective windings differs by a predetermined amount for causing the rate of change in inductance of a circuit including the winding of larger diameter to be less than that of a second circuit including the winding of small diameter for establishing a desired tracking relation between said circuits as said cores are moved from said position to minimum inductance to said position of maximum inductance, adjustable tracking means for modifying the relation between said rates of change for effecting a substantially constant tracking relation throughout said range comprising at least one element of magnetic material disposed in the external field of one of said windings intermediate the ends thereof and adjustable laterally, said means having a dimension lengthwise of said winding that is relatively small compared to the winding length.

9. A variable radio frequency permeability tuning system comprising in combination, first and second solenoid inductance windings, tuning cores of magnetic material for tuning said windings, respectively, over differing ranges of radio frequency, control structure for effecting axial movement of said cores in unison within said windings from positions of minimum to positions of maximum inductance values, respectively, means for causing the first of said windings to have a relatively slower rate of inductance change and a relatively smaller frequency change ratio in tuning from maximum to minimum, means for determining the minimum inductance values of said windings at the ends of said ranges corresponding to said core positions of minimum inductance values, substantially fixed magnetic means disposed at an end of one of said windings remote from the entering end thereof for the tuning core, and structure permitting limited axial adjustment of said magnetic means for determining the maximum inductance of said one of said windings in relation to that of the other of said windings for the core positions of maximum inductance values.

10. A variable radio frequency permeability tuning system comprising in combination, first and second solenoid inductance windings, tuning cores of magnetic material for tuning said windings, respectively, over differing ranges of radio frequency, control structure for effecting axial movement of said cores in unison within said windings from positions of minimum to positions of maximum inductance values, respectively, means for causing the first of said windings to have a relatively slower rate of inductance change and a relatively smaller frequency change ratio in tuning from maximum to minimum, and a substantially fixed magnetic member disposed adjacent one end of the second of said windings and remote from the entering end for the core thereof for substantially increasing the inductance range thereof and the maximum to minimum frequency ratio, said member being so shaped and disposed in the external field of said winding as to have substantially little coupling to said winding and core in said position of minimum inductance while having substantial coupling to said coil and core for said position of maximum inductance.

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