

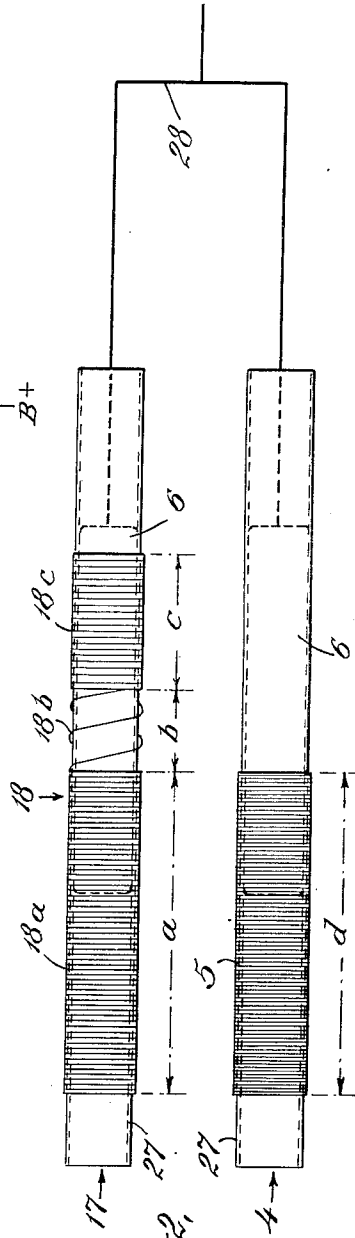
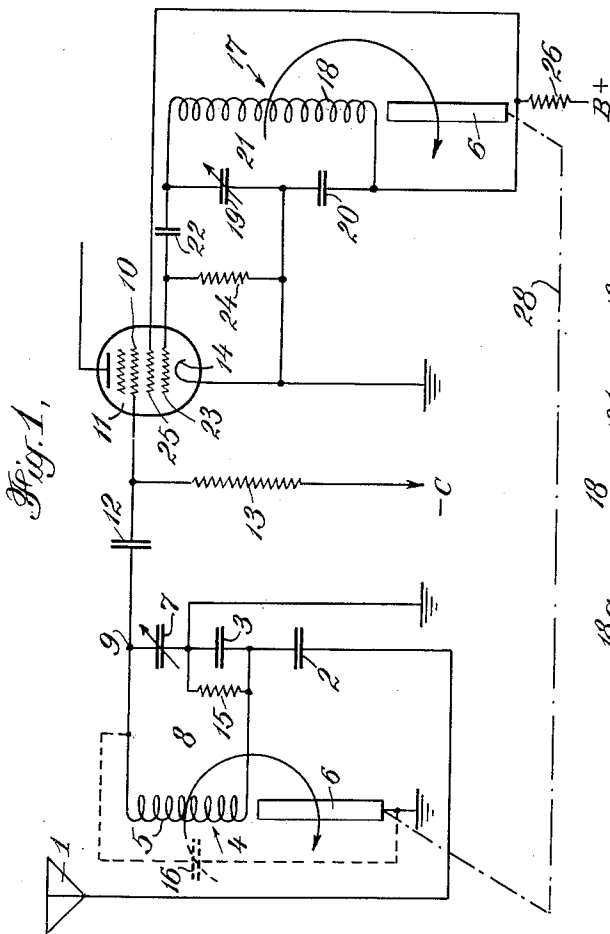
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PERMEABILITY-TUNED OSCILLATOR TRACKING ARRANGEMENT

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PERMEABILITY-TUNED OSCILLATOR
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This invention relates to high-frequency circuits and more particularly to those employed in radio receiving systems of the superheterodyne type, where the signal passes through one or more resonant circuits tuned to the signal frequency, is combined with locally generated oscillations to produce an intermediate frequency which is amplified and finally is demodulated to produce an audio-frequency current corresponding to the transmitted signal. The part of the system through which the signal passes before any change in frequency occurs usually includes an antenna circuit and one or more resonant circuits with or without a thermionic amplifying vacuum tube, and may be termed the preselector.

In a superheterodyne radio receiver, the locally generated oscillations, above referred to, are produced by a local oscillator the frequency of which differs from the signal frequency by the intermediate frequency of the receiver. Since the intermediate frequency remains fixed, the frequency of the oscillator must be varied as the signal frequency is changed. Although the oscillator frequency might be made lower than the signal frequency by an amount equal to the intermediate frequency, it is customary to operate the oscillator at a frequency equal to the sum of the signal frequency and the intermediate frequency. If this frequency difference is maintained throughout the range of signal frequencies, the oscillator is said to be aligned or in track with the preselector.

When the oscillator frequency is higher than the signal frequency, the oscillator must be tunable over a higher but narrower range of frequencies than that covered by the preselector. For example, if a receiver has an intermediate frequency of 465 kilocycles and is intended for the reception of signals between 540 and 2000 kilocycles, the oscillator must be designed to cover a frequency range of (540+465) or 1005 kilocycles to (2000+465) or 2465 kilocycles. The corresponding ratios of maximum to minimum frequency are 3.71 and 2.47, so that the oscillator covers a range approximately two thirds as wide as that covered by the preselector.

My invention is intended for use in connection with resonant circuits which are tuned over a range of frequencies by inductance variation. Such a system is the one disclosed by Polydoroff in United States Patent No. 1,940,228, in which a resonant circuit having an inductance coil and capacitor is adjusted over a range of frequencies by movement of a compressed comminuted ferromagnetic core relative to the inductance coil.

This method of tuning is commonly called permeability tuning. An improved form of such a system is disclosed by Schaper in United States Patent No. 2,051,012. Both Polydoroff's original system and Schaper's improved system readily cover an adequate range of frequencies and may easily be ganged to provide multiple unit systems. Permeability tuning is especially adapted for use in the preselector and oscillator of a superheterodyne radio receiver because its use permits these portions to be designed so as to provide substantially uniform gain and selectivity throughout the frequency range, thus overcoming the chief cause of non-uniformity of performance in this type of receiver.

It has been proposed to use differently shaped cores in the preselector and oscillator circuits of a superheterodyne radio receiver, and this method, if properly applied, will secure tracking. Alternatively, it is possible to employ separate series and shunt coils in the oscillator circuit so that it will track with the preselector circuits using identical cores. Both of these expedients are difficult and expensive compared with the means disclosed herein.

It is an object of my invention to provide means whereby a plurality of resonant circuits employing coils of similar diameters may be tuned, by identical cores moving in unison, over two different frequency ranges and may be maintained in track without the employment of additional corrective components.

This and other objects are realized, in accordance with my invention, by employing a coil in the oscillator circuit having a winding the turns distribution of which is so chosen with respect to the travel of the ferromagnetic core that movement thereof increases the inductance of a first portion of the coil while simultaneously decreasing the inductance of a second portion of the same coil, the number of turns in each portion being such that the over-all inductance of the coil increases due to movement of the core, but at a somewhat lower rate than would be the case were the same core to be employed with a coil of uniform turns distribution. Thus, by properly choosing the total inductance and turns distribution of each of the coils, the oscillator circuit may be tuned over a narrower and higher range of frequencies than the preselector using identical cores moving in unison. This arrangement is simple and compact, reducing the cost of manufacture and assembly.

The invention will be better understood if ref-

erence is made to the accompanying drawing, in which:

Fig. 1 is a schematic diagram of the preselector and oscillator portions of a superheterodyne radio receiver embodying one form of my invention; and

Fig. 2 is an elevation of the variable inductance devices employed in the receiver of Fig. 1.

Referring to Fig. 1 of the drawing, the antenna 1 is connected to ground through capacitors 2 and 3 in series. Variable inductance device 4, comprising inductance coil 5 and movable ferromagnetic core 6, is shunted by capacitors 3 and 7 in series, to form a resonant circuit generally indicated by numeral 8. The high-potential terminal 9 of resonant circuit 8 is connected to control-grid 10 of vacuum tube 11 through capacitor 12. Direct-current bias potential is supplied to control-grid 10 by grid resistor 13. Cathode 14 of vacuum tube 11 is grounded. Capacitor 3 is shunted by resistor 15 to provide a low-impedance path to ground for disturbing audio-frequency currents induced in antenna 1. Preselector core 6 has appreciable surface conductivity and is effectively grounded, either conductively as shown, or alternatively, through a low-impedance resistive path. The capacitance between the core 6 and the high-potential portion of coil 5 is represented in the drawing by dotted capacitor 16, the curved arrow passing through it to indicate that its capacitance varies as core 6 moves relatively to coil 5.

Variable inductance device 17, comprising inductance coil 18 and movable ferromagnetic core 6, is shunted by capacitors 19 and 20 in series to form the oscillator resonant circuit generally indicated by numeral 21. The upper terminal of resonant circuit 21 is connected, through capacitor 22, to oscillator-grid 23 of vacuum tube 11. Grid resistor 24 is connected between oscillator-grid 23 and ground. The junction of capacitors 19 and 20 is grounded. The lower terminal of resonant circuit 21 is connected to oscillator-anode 25 of vacuum tube 11 and, through resistor 26, to a source of positive potential. Since capacitor 20 is common to both the grid and plate circuits of the oscillator portion of vacuum tube 11, this tube oscillates at the resonant frequency of resonant circuit 21. Oscillator core 6 is preferably not grounded.

As shown more clearly in Fig. 2 of the drawing, inductance devices 4 and 17 comprise insulating tubes 27 of similar diameter and length, and having an inside diameter sufficient to slidably receive cores 6. Coil 5 is uniformly spaced, but coil 18 consists of three portions, closely spaced portions 18a and 18c being separated by portion 18b having a few widely spaced turns. Portion 18a has the same axial length and begins at the same point as coil 5, but has substantially fewer turns. Cores 6 are ganged for simultaneous operation, as indicated by line 28, and have the same relative axial positions throughout their travel into and out of coils 5 and 18, respectively.

In operation, movement of cores 6 with respect to coils 5 and 18, respectively, tunes preselector circuit 8 over a range of signal frequencies, and tunes oscillator circuit 21 over a second and higher and narrower range of frequencies, such that the oscillator frequency always differs from the signal frequency by an amount substantially equal to the intermediate frequency of the receiver. In the maximum frequency position, cores 6 are entirely withdrawn from coil 5 and portion 18a of coil 18, respectively, but os-

cillator core 6 lies within the field of portion 18c of coil 18, thus increasing the inductance of this portion of coil 18. The resonant circuits are aligned under this condition by means of adjustable capacitors 7 and 19. As cores 6 are moved into coils 5 and 18, the inductance of coil 5 and of portion 18a of coil 18 increases and the respective resonant frequencies of resonant circuits 8 and 21 decrease. An oscillator core 6 enters portion 18a, however, it is being gradually withdrawn from portion 18c, so that the total effective inductance of coil 18 increases at a lower rate than that of coil 5. By employing the proper number of turns on the coils and the proper relative axial spacings of the turns, it is readily possible, in accordance with my invention, to provide a system having substantially exact tracking throughout the upper portion of the signal-frequency range to be covered. Tracking in the lower portion of the frequency range is secured, in accordance with my invention, by virtue of the fact that preselector core 6 is effectively grounded so that the increase of capacitance 16 between the core and coil 5 during the latter half of the movement of core 6 as it enters coil 5 accelerates the lowering of the resonant frequency of resonant circuit 8.

In one successful embodiment of my invention, in accordance with Figs. 1 and 2 of the drawing, insulating tubes 27 have a length of 4.11 inches, an outside diameter of 0.340 inch, and an inside diameter of 0.316 inch. Coil 5 is 1.6875 inches long and consists of 277 turns of No. 36 plain enamelled wire, and has a self-inductance of 125 microhenries. Portion 18a of coil 18 is 1.6875 inches long, and comprises 159 turns of No. 36 plain enamelled wire. Portion 18b, of the same wire, has 2.5 turns spread over an axial length of 0.4375 inch. Portion 18c comprises 31 turns and occupies a space of 0.6875 inch. Coil 18 has an inductance of 48 microhenries. Cores 6 have a length of 1.875 inches and a diameter of 0.3125 inch. With these inductance devices, the signal-frequency range is from 540 to 2000 kilocycles, and the intermediate frequency is 465 kilocycles. The maximum loss in gain due to mistracking within this frequency range, with reasonable care in construction and alignment, is four decibels.

With the above illustrative example as a guide, those skilled in the art will be enabled to employ my invention under widely differing conditions, and such constructions will all be within the scope thereof, as set forth in the appended claims. The essential feature of my invention is the employment of an oscillator coil materially longer than the ferromagnetic core which is employed to vary its inductance, so as to secure a rate of change of inductance less than is the case when the same core is used with a coil of length approximately equal to that of the core. Additionally, I may so arrange the turns on the oscillator coil as to favorably control the increments of inductance as the core is moved, to secure more nearly perfect alignment at a fixed frequency difference with respect to the signal-frequency circuits. Lastly, I take advantage of the varying capacitance between the core and the coil, and of the fact that the capacitance is greater if the core is grounded, by combining this effect with the variation secured by the use of the longer oscillator coil.

It will be understood that where in the specification I state that one resonant circuit is "tunable over a narrower range of frequencies" than 71

a second circuit, reference is made to the fact that the ratio of the maximum frequency to which the first circuit is tunable to the minimum frequency to which the same circuit is tunable is less than the equivalent ratio for the second circuit. Where it is stated in the specification that one circuit is "tunable over a higher range of frequencies" than a second circuit, reference is made to the fact that the minimum frequency of the first circuit is higher than the minimum frequency of the second circuit and that the maximum frequency of the first circuit is higher than the maximum frequency of the second circuit.

Having thus described my invention, what I claim is:

1. A high-frequency system including signal-frequency and oscillator circuits; means for varying the resonant frequencies of said circuits comprising substantially identical ferromagnetic cores and mechanism for moving said cores in unison; and means for maintaining the resonant frequencies of said circuits at a substantially constant difference including a uniformly wound coil for said signal-frequency circuit of length substantially equal to the length of said cores and a non-uniformly wound coil for said oscillator circuit of length materially greater than the length of said cores, and having a uniformly wound first portion of length substantially equal to said signal-frequency coil but of fewer turns and a second non-uniformly wound portion of length materially less than said signal-frequency coil; said resonant circuits being initially adjusted to produce said frequency difference with one of said cores outside of said signal-frequency coil and the other of said cores within said second portion of said oscillator coil.

2. A high-frequency system including signal-frequency and oscillator circuits; means for varying the resonant frequencies of said circuits comprising substantially identical ferromagnetic cores and mechanism for moving said cores in unison; and means for maintaining the resonant frequencies of said circuits at a substantially constant difference including a first coil for said signal-frequency circuit of length substantially equal to the length of said cores and a second coil for said oscillator circuit of length materially greater than the length of said cores, said first coil being uniformly wound and said second coil having three uniformly but differently wound portions; said resonant circuits being initially adjusted to produce said frequency difference with one of said cores outside of said first coil and the other of said cores within one of said portions of said second coil.

3. A high-frequency system including signal-frequency and oscillator circuits; means for varying the resonant frequencies of said circuits

comprising substantially identical ferromagnetic cores and mechanism for moving said cores in unison; and means for maintaining the resonant frequencies of said circuits at a substantially constant difference including a first coil for said signal-frequency circuit of length substantially equal to the length of said cores and a second coil for said oscillator circuit of length materially greater than the length of said cores, said first coil being uniformly wound and said second coil having a first uniformly wound section of length substantially equal to said first coil but of fewer turns than said first coil and a second uniformly wound section of length and turns materially less than said first section, said first and second sections being axially spaced from each other and series-aidingly connected; said resonant circuits being initially adjusted to produce said frequency difference with one of said cores outside of said first coil and the other of said cores within said second section of said second coil.

4. A high-frequency system including variably tunable signal-frequency and oscillator resonant circuits each comprising a capacitor, an inductance coil and a cooperating ferromagnetic core; and mechanism for moving said cores in unison; said cores being substantially identical, said signal-frequency coil being of length substantially equal to the length of said cores, said oscillator coil being substantially longer than said cores and comprising first and second portions separated by a third portion, and said resonant circuits being initially adjusted to produce a desired frequency difference with one of said cores outside of said signal-frequency coil and the other of said cores within said second portion of said oscillator coil; whereby said frequency difference is substantially maintained as said cores are moved.

5. A high-frequency system including variably tunable signal-frequency and oscillator resonant circuits each comprising a capacitor, an inductance coil and a cooperating ferromagnetic core; mechanism for moving said cores in unison; and a grounding connection to the core associated with said signal-frequency circuit; said cores being substantially identical, said signal-frequency coil being of length substantially equal to the length of said cores, said oscillator coil being substantially longer than said cores and comprising first and second portions separated by a third portion, and said resonant circuits being initially adjusted to produce a desired frequency difference with one of said cores outside of said signal-frequency coil and the other of said cores within said second portion of said oscillator coil; whereby said frequency difference is practically maintained as said cores are moved.

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