July 12, 1949. L. O. VLADIMIR 2,475,637

VARIABLE INDUCTANCE TUNING SYSTEM

Filed Sept. 20, 1946

Fig. 1

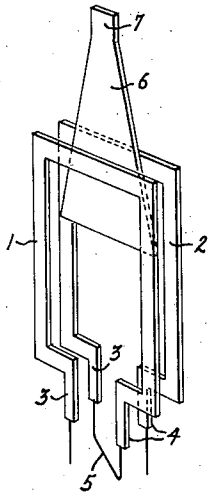



Fig. 2.

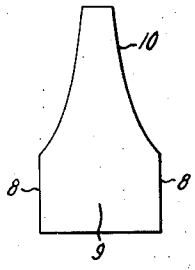



Fig. 3.

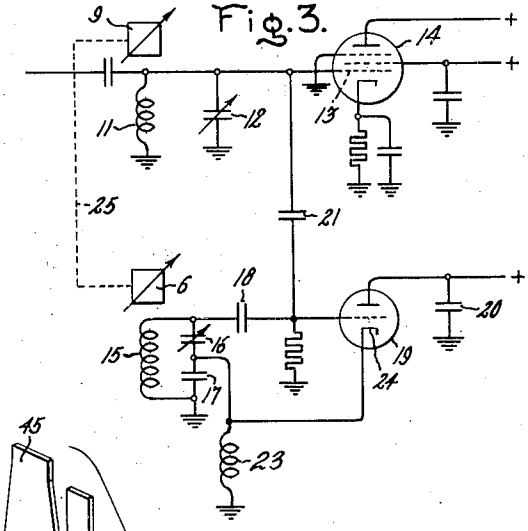



Fig. 5.

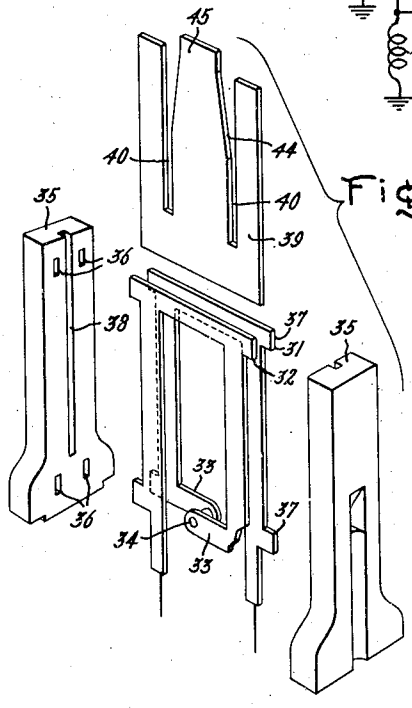



Fig. 4.

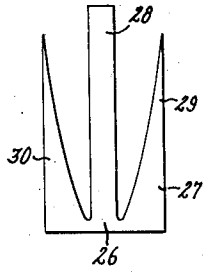



Fig. 6.

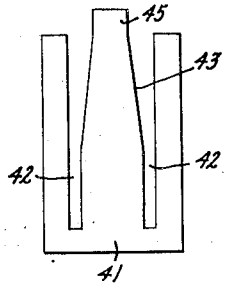
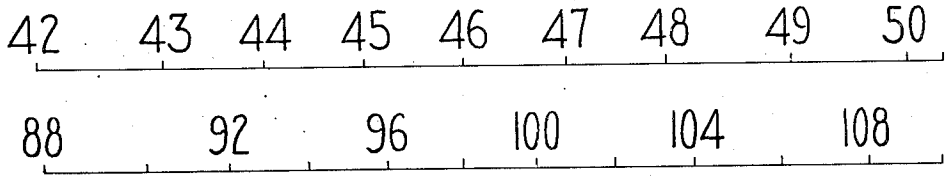



Fig. 7.




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## VARIABLE INDUCTANCE TUNING SYSTEM

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5 Claims. (Cl. 250—40)

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My invention relates to a variable inductance tuning system for superheterodyne receivers and, more particularly, to the construction of the inductors and the variable element utilized to tune the signal frequency and oscillator circuits of such receivers for obtaining tracking between these circuits.

The tuning of the resonant signal frequency circuit and oscillator circuit in a superheterodyne receiver is usually accomplished by varying capacitances associated with the resonant circuits, the capacitances being mechanically linked for unicontrol operation. Alternatively, in some receivers, the inductance associated with the resonant circuits is varied by movement of a ferromagnetic core with respect to an inductance coil. At higher frequencies, however, such as are employed in receivers adapted to receive frequency modulated signals of the order of 100 megacycles, the capacitors employed are very small and require extensive insulation of the rotor shaft to avoid coupling between the tuned circuits. Even with sufficient precautions to avoid coupling, mechanical resonances are encountered in the variable capacitance structure. On the other hand, if variable inductances of the type varied by movement of a ferromagnetic core are employed, the coils required at frequencies of this order require a very few turns of a large size wire in order to obtain satisfactory operation. Accordingly, it is a primary object of my invention to provide a new and improved type of variable inductance which may be employed in both the oscillator and signal input circuits and constructed to track accurately one with the other throughout a large range of high frequencies.

Still another object of my invention is to provide a new and improved variable inductance in which a vane is moved between the turns of the inductance and is so constructed that the resonant frequency of an oscillator circuit and a signal frequency circuit may be tracked accurately over a substantial range of high frequencies.

It is a further object of my invention to provide a new and improved variable inductance which satisfactorily tracks a plurality of circuits over a predetermined range and simultaneously varies linearly the tuning frequency of all of the circuits.

One of the features of my invention is the use of a two-turn inductance constituted by a pair of peripherally incomplete rectangular pieces of metal having a central aperture therein and a vane which is adapted to be inserted between the two turns to vary the inductance thereof. The vane is given a shape such that the resonance

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frequency of the inductance and its associated trimmer capacitor varies linearly at a predetermined rate so that a plurality of such inductances may be employed to tune both a signal frequency circuit and an oscillator circuit over a predetermined range and maintain a desired difference frequency between the tuned frequencies of the two circuits.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 is a perspective view of a variable inductance of my invention; Fig. 2 illustrates a modification of a tuning vane employed with the inductance of Fig. 1; Fig. 3 is a portion of the high frequency circuit of a superheterodyne receiver utilizing a pair of variable inductances of my invention; Fig. 4 illustrates a modification of the tuning vane which may be employed with the inductance of Fig. 1; Fig. 5 illustrates a modification of the variable inductance of Fig. 1; Fig. 6 illustrates a further modification of the tuning vane which may be employed with the inductance of Fig. 5; and Fig. 7 illustrates the calibration of a dial scale employed with a superheterodyne receiver employing the inductances and tuning vanes of the type illustrated in Figs. 5 and 6.

Referring to Fig. 1 of the drawings, I have illustrated therein a variable inductance which comprises a pair of juxtaposed peripherally incomplete rectangular metallic loops 1, 2. Each of the loops, at its incomplete side, is provided with a pair of depending terminal posts 3, 4 and the post 4 of loop 1 is connected to terminal post 3 of loop 2 by conductor 5 so that the loops are serially connected to form a two-turn inductance. The inductance may be connected in a desired circuit by means of conductors attached to terminal post 3 of the loop 1 and terminal post 4 of loop 2. The inductance of the structure is determined by the size of the loops and the spacing between the loops. This inductance is varied over a substantial range by means of a tuning element comprising a metallic vane 6 which is supported in a plane intermediate the loops and adapted to be inserted between the loops 1, 2 and in effect to vary the size of the loops. The vane 6 is substantially in the form of an isosceles trapezoid and preferably is adapted to be moved linearly

in a plane parallel with the planes of the loops and in a direction of the loops, i. e., from top to bottom. Such movement of the vane 6 varies both the self inductances of both loops 1, 2 as well as their mutual inductances. By varying the base angle and the inclination of the sides of the trapezoid with respect to the base, I have found that the tuning curve of a circuit employing an inductance of this type and a trimmer capacitor varies substantially linearly with vertical motion of the vane 6. Preferably, the vane is provided with an upper or tab portion 7 which may be employed for supporting the vane and for moving it relative to the loops 1, 2 and which portion does not enter into the region between the loops so that it does not affect the shape of the calibration curve. I have found that such a construction is particularly useful in the circuit of the local oscillator normally employed in a superheterodyne receiver, the tuning vane being so shaped that it decreases the rate of variation of inductance at the high frequency end. Preferably, the shape of the vane is such that the inductance of the loops varies inversely as the square of the longitudinal displacement of the vane. The inductance, of course, is highest and the resonance frequency of a circuit employing the variable inductance is lowest when the vane 6 is entirely withdrawn from the region between the loops or inductors 1, 2. The rate of change is greatest as the vane 6 begins its descent between the loops 1, 2. Assuming that vane 6 is descending at a constant speed, since the amount of metal which is introduced between the loops per increment of time decreases as the vane 6 approaches the terminal posts 3, 4, the rate of change of inductance decreases likewise. Consequently, by controlling the amount of metal so introduced between the loops and the rate of change of the effective size of the loops, the rate of change of self and mutual inductances may be controlled so that the resonant frequency of a tuned circuit employing this variable inductance varies linearly over the entire frequency range.

In Fig. 2 I have shown the shape of a vane which may be employed with the tuned radio frequency circuit of a superheterodyne receiver employing the inductance of Fig. 1 in its local oscillator circuit and in which the resonance frequency of the oscillator circuit is greater than that of the radio or signal frequency. In such a case, the radio frequency circuit must have a slightly greater inductance variation than the oscillator circuit in order to track properly and maintain the difference frequency constant as the frequency of both the circuits is varied over the frequency range of the receiver. Such a greater variation of inductance at the low frequency end of the range is obtained by providing a vertical portion 8 to the tuning vane 9. For obtaining a desired variation in the higher frequency end of a desired range, the vane 9 is also provided with a curved portion 10, the curvature of which is correlated with the frequency range to provide linear variation of the resonance frequency as the vane is inserted between the pair of loops 1, 2.

Fig. 3 illustrates a portion of the high frequency circuit of a superheterodyne receiver employing the variable inductances of my invention. In the diagram of Fig. 3, a circuit resonant at the signal frequency comprises an inductance 11 which may be varied by means of the tuning vane 9. The upper terminal of inductance 11 is



supplied with high frequency signals from preceding circuits of the receiver which may include an antenna and a tuned antenna circuit. The inductance 11 is connected to ground and is shunted by a trimmer capacitor 12 to resonate at the desired frequency range. The upper terminal of the resonant circuit is connected to the control electrode 13 of a mixer tube 14. The local oscillator circuit of the receiver comprises an inductance 15 varied by means of the tuning vane 6 and shunted by a trimmer capacitor 16 connected in series with a capacitor 17 to provide feedback so that the oscillator resonates at the desired frequency. The upper terminal of the tuned circuit is connected through a direct current isolating capacitor 18 to the control electrode of an electron discharge device 19. The cathode of the device 19 is connected to the common terminals of capacitors 16, 17. The anode of device 19 is supplied with operating potential from a suitable source indicated conventionally by the legend + and is by-passed to ground for high frequency current by means of capacitor 20. The control electrode of device 19 is likewise connected through a capacitor 21 to the control electrode 13 of mixer tube 14 to provide in a well-known manner in the circuit of control grid 13 signals of a frequency equal to the difference in frequency of the local oscillations and the input signals. An inductance 23 is connected between cathode 24 of device 19 and ground to provide a direct current path for the cathode currents. However, inductance 23 preferably has an impedance sufficiently large for currents of high frequency that its presence has little or no effect upon the resonant circuit comprising elements 15—17. Tuning vanes 6 and 9 are mechanically linked, as shown by the dotted line 25, for unicontrol operation so that, as the vanes 6 and 9 are inserted between the turns of inductances 11, 15, the tuned frequencies of their respective circuits are varied simultaneously in an amount sufficient to maintain the difference frequency constant over the range of frequencies desired to be received.

In Fig. 4 I have shown a modification of the tuning vane of Figs. 1 and 2 in which the vane 26 is provided with perpendicular outer edges 27. The vane 26 has a centrally located rectangular portion 28. The desired variation of the inductance with insertion of the vane between a pair of loops 1, 2 is obtained by varying the shape of the outer portions 29, 30 of the vane by cutting away a portion of these outer sections. One of the advantages of a vane of this type is that it permits guiding the vane in its descent between the loops 1, 2 by allowing the edges 27 to slide in a suitable track, not shown.

In Fig. 5 I have shown an exploded view of a modification of my variable inductance which comprises two similarly constructed metallic loops 31, 32. These rectangular loops are peripherally incomplete, having three complete legs and a fourth leg 33 which extends only part way between the adjacent legs. The loops 31, 32 are identical in construction and are oriented by rotating the loop 32 through 180° with respect to the loop 31 so that the legs 33 partially overlap and may be connected together by means of a rivet 34 to form a mechanically rigid structure and maintain the loops in desired spaced relation. The loops are adapted to be supported in insulators 35 having a plurality of recesses 36 for receiving arms 37 extending outwardly at the four edges of the rectangular loops. Insulators

35 are likewise provided with longitudinal slots 38 adapted to slidably receive a tuning vane 39. The outer edges of the vane 39 fit into the slots 38 sufficiently snugly that the vane may be supported in an adjusted position. At the same time, preferably the fit is such that the vane may be easily raised or lowered in the slots to effect variation of the inductance to tune a resonant circuit in which it is employed. The vane 39, as illustrated, is preferably for use in a signal frequency circuit of a superheterodyne receiver and is provided with a pair of similarly constructed vertical slots 40, which are narrow at their bottom end and enlarged at their upper end.

In Fig. 6 I have illustrated the shape of a vane 41 of an inductance adapted to be employed in the circuit of the local oscillator used in a superheterodyne receiver employing the inductance of Fig. 5 in its signal frequency circuits. The vane 41 is likewise provided with two vertical slots 42. Assuming that a receiver employing the inductances of Figs. 5 and 6 operates with local oscillations higher in frequency than the frequency of a received signal, the slots 42 extend closer to the bottom edge of the vane 41 than the slots 40 of the vane 39 in order that a greater rate of variation of inductance is provided for the signal frequency circuits at the low frequency end than for the oscillator circuit. Likewise, the slots 42 are made wider than the slots 40. Assuming unicontrol of the movement of vanes 39, 41 for tuning the signal and oscillator circuits, the tapered portion 43 of vane 41 enters the region between loops 30, 31 earlier than does the tapered portion 44 of vane 39. The exact width of the slots 40, 42 and the taper of the portions 43, 44, of course, depends upon the frequency range to be covered by the resonant circuits. Each of the vanes 39, 41 is provided with a tab portion 45 which does not extend into the effective region between the loops 31, 32 and which may be used for effecting adjustment of the position of the vanes relative to their associated inductors.

In Fig. 7 I have shown the calibration of a dial scale employed with a superheterodyne receiver utilizing the inductances of Figs. 5 and 6. The receiver for which the calibration of Fig. 7 applies was constructed to receive frequency modulation signals varying over the ranges of 42–50 megacycles and 88–108 megacycles. The tuning vanes 39, 41 are employed for tuning the resonant circuits over both of these ranges, the difference in resonance frequency of the associated circuits being obtained by connecting different trimming capacitors in shunt with the variable inductances. As is evident from an inspection of the calibration of Fig. 7, tuning over both of the ranges is substantially linear so that equal increments of movement of the usual tuning knob provide equal increments of frequency change.

An important advantage of my invention is that it provides a variable inductance, the rate of change of which may be controlled simply by controlling the shape of the metal plate introduced between the two turns of the inductance. Thus, the shape of the vanes 6, 9 or 39, 41 may be carefully determined through tests in the design of a receiver. Thereafter, the exact tuning curve may be reproduced by simply constructing a die to stamp out plates which have shapes identical with that obtained in the test. In this way, variable inductances may be constructed easily and cheaply and with great accuracy so that circuits having identical characteristics are easily reproduced in a large number of receivers.

While I have shown particular embodiments of my invention, it will of course be understood that I do not wish to be limited thereto since various modifications may be made, and I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A variable inductance device comprising a pair of serially connected peripherally incomplete juxtaposed rectangular metallic loops, a metallic vane supported in a plane parallel with and intermediate said loops and arranged for linear movement in said plane longitudinally of said loops, said vane having a portion varying in width along the longitudinal axis thereof, the shape of said portion being such that the inductance of said device varies inversely as the square of the longitudinal displacement of said vane relative to said loops.

2. In a multi-tuned circuit system comprising a pair of independent tuning circuits, each of said independent tuning circuits consisting of a capacitance and an inductance comprising a pair of juxtaposed serially connected peripherally incomplete metallic loops, means for tuning said circuits simultaneously comprising metallic vanes disposed respectively between the loops of said respective inductances and arranged for movement simultaneously longitudinally of said loops in a plane intermediate said loops and parallel therewith, said vanes having portions of width varying such that the difference in the resonant frequency of said circuits remains substantially constant as said vanes are moved.

3. A signal receiving sytem comprising a signal circuit and an oscillating circuit, each of said circuits comprising a capacitance and an inductance comprising a plurality of parallel serially connected peripherally incomplete metallic loops and a vane arranged for linear movement in a plane intermediate and parallel with said loops, said vane having a portion of varying width and the vanes of the inductances of both of said circuits being arranged for simultaneous movement, said widths being adjusted relative to said movement to give said circuits a substantially constant frequency difference throughout the operating range of said circuits.

4. A tuning system for a pair of inter-connected high frequency circuits comprising a pair of variable inductances, each of said inductances being included in respective of said circuits, each of said inductances comprising a pair of parallel serially connected loop-like metallic conductors, and metallic vanes adapted for movement between said conductors to tune said circuits over a band of frequencies, said vanes being connected for simultaneous movement and adjustment with respect to said conductors, said vanes having portions of varying width, the length of said vanes being substantially equal to that of said conductors, and said vanes being arranged for movement longitudinally of said conductors a distance substantially equal to the length of said conductors, the shape of said portions being such that the difference between the square root of the inductances of said pairs of conductors remains substantially constant as said vanes are moved.

5. A variable inductance comprising a pair of supports having parallel faces having recesses therein, a pair of juxtaposed peripherally incomplete metallic loops, each of said loops com-

prising a plurality of coplanar legs forming a peripherally incomplete rectangle, means connecting said loops in series, said loops having outwardly extending portions adapted to fit in said recesses to be maintained in fixed spaced relation thereby, a vertical slot in said supports intermediate said recesses, and a metallic vane adapted to move in said slot longitudinally of said loops, said vane having a pair of longitudinal slots of varying width, the shape of said longitudinal slots being such that the inductance of said device varies inversely as the square of the longitudinal displacement of said vane relative to said loops.

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## REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 2,137,392 | Cobb | Nov. 22, 1938 |
| 2,190,082 | Polydoroff | Feb. 13, 1940 |
| 2,341,346 | Summerhayes | Feb. 8, 1944 |