Nov. 21, 1944. J. VAN DER HEEM 2,363,101

DEVICE FOR SIMULTANEOUSLY TUNING OSCILLATORY CIRCUITS

Filed July 22, 1941

Fig. 1

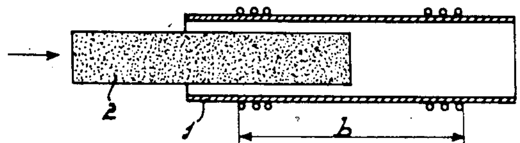
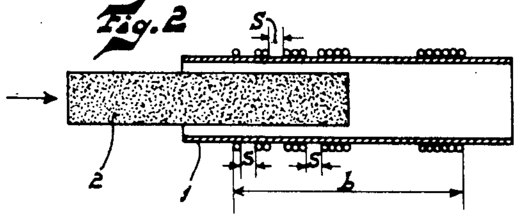


Fig. 2



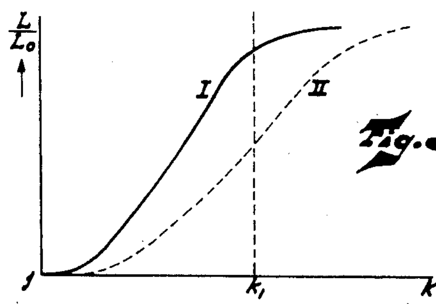


Fig. 3.

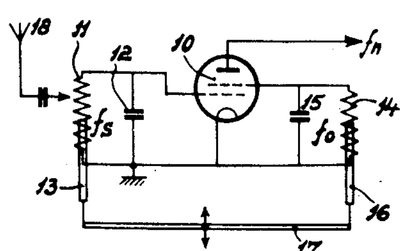


Fig. 4

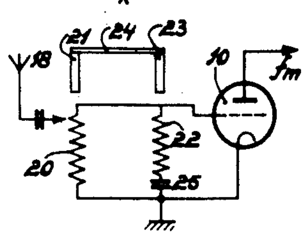


Fig. 5

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DEVICE FOR SIMULTANEOUSLY TUNING OSCILLATORY CIRCUITS

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In the Netherlands October 16, 1940

2 Claims. (Cl. 250—40)

This invention relates to the simultaneous tuning, i. e., by means of equal and synchronous means capable of being set by a single operating member, of two oscillatory circuits whose resonance frequencies must differ by a constant value. Such a tuning device is used, for example, in superheterodyne receivers in which the input circuit or circuits, hereinafter briefly referred to as the preselector, must be tuned to the signal frequency whilst the local oscillatory circuit must be tuned to a frequency which relative to the signal frequency exhibits a difference equal to the intermediate frequency to which the remaining portion of the apparatus is tuned. The preselector of a superheterodyne receiver also frequently utilises a circuit which must be tuned to the mirror image of the desired signal and whose resonance frequency relative to the signal frequency must consequently have a difference equal to twice the intermediate frequency for which the apparatus concerned is designed.

The invention more particularly relates to the obtainment of a constant frequency difference between the tuning of two oscillatory circuits tunable with the aid of equal means capable of being set in the same manner, the tuning of these circuits being effected by varying the position of cores of magnetic material relative to the coils so as to vary the inductance active in the circuits. Since the inductance variation with a displacement of the magnetic core is obtained by the variation of the magnetic permeability of the medium comprised by the coil, this manner of tuning of an oscillatory circuit is frequently referred to as permeability tunning. This term will also be used hereinafter to refer to the tuning method embodying the invention.

With the known methods of obtaining tuning with constant frequency difference use is made of variable elements which for both circuits give the same variation of the magnitude to be varied and, further, auxiliary elements are included in one or in both circuits, which permit of equalizing the frequency difference to the desired value in at least a certain number of positions of the synchronous tuning means, whilst in the intermediate positions small differences are permissible. Such circuits are known, for example, from Dutch patent specification No. 41,633 for circuits tuned by means of synchronous variable condensers. In principle, similar circuits may, of course, be developed for circuits tuned by means of synchronous permeability tuning. However, these circuits have the drawback that a great many circuit elements must be used, and furthermore, the correct adjustment to the desired difference frequency for all frequencies in the tuning range is not obtained.

Now, the invention provides a device for simultaneously tuning two oscillatory circuits, whose resonance frequencies must differ by a constant value, by means of slidable, equal magnetic cores, in which auxiliary elements for adjusting the synchronism are not required and in which the synchronism is absolute. According to the invention, for this purpose use is made of coils having equal winding widths which are at most equal to the length of the magnetic core, but in which the winding density of at least one of the coils is not constant. The term "winding density" is to be understood in this case to mean the number of turns per unit of length, measured in the direction of the axis of the coil.

The invention will be explained more fully by reference to the accompanying drawing, of which Figs. 1, 2 and 3 relate to the fundamental solution of the problem underlying the invention and Figs. 4 and 5 are diagrams showing the use of the invention.

Fig. 1 shows diagrammatically the longitudinal section of a coil having a winding width b constituted by n turns which are wound with constant winding density on the coil bush 1. In the latter a magnetic core 2 is movable which is preferably a little longer than the winding width b. If now, the core is pushed into the coil (for example in the direction of the arrow in Fig. 1) the inductance will at first increase slowly when the core is not far pushed-in and subsequently increase more rapidly until the front of the core has approached the centre of the coil. After that, the increase gradually decreases again and at last becomes zero at the moment in which the centre of the core coincides with the centre of the coil. If, then, the core is pushed-in still farther the inductance decreases again. The foregoing is shown diagrammatically in curve I of Fig. 3, in which on the horizontal axis is indicated on an arbitrary scale the position k of the core relatively to the coil, whereas on the vertical axis, likewise on an arbitrary scale, commencing at the value 1, is shown the ratio between the inductance L with pushed-in core and the inductance L_0 of the coil without core.

If, however, the coil is wound with a non-uniform winding density the inductance variation exhibits a quite different curve on inserting the magnetic core, since the field intensity in the axis of the coil will vary in a manner different from that in the coil with constant winding density. One form of construction of a coil having a non-uniform winding density is shown in Fig. 2 in which the coil bush is again indicated by 1 and the magnetc core by 2. The coil with the winding width b is now built up from a certain number of sections of tightly wound wire, the spaces s between the various sections being constant but the sections themselves comprising different numbers of turns. In the drawing the sections comprise successively 1, 2, 3 . . . $(k-1)$, k turns. Of course, the invention is not limited to the said order of numbers of turns. The number of sections and the series of the numbers of turns in each separate case are determined in accordance with the inductance variation required. It is alternatively possible to obtain a non-uniform winding density in a manner other than that consisting in winding sections of different numbers of turns, for example by making the numbers of turns of the sections as well as the spaces between the sections different, or by winding with a variable pitch. It is evident that all these forms of construction fall under the scope of the invention.

The inductance variation during the insertion of the magnetic core into a coil according to Fig. 2 in the direction indicated by the arrow is represented diagrammatically by the curve II of Fig. 3, which has a variation different from that of curve I. The most obvious differences are those that the maximum rate of the inductance increase does not occur before the centre of the core has passed already along the centre of the coil, whilst the maximum value of the inductance is only obtained when the core is again pushed out of the coil.

If the coils are to be used for the simultaneous tuning by the same movement of the magnetic cores of two oscillatory circuits whose resonance frequencies must differ by a constant value, it appears from Fig. 3 that only a portion of the total possible inductance variation of the coils can be used (according to Fig. 3 approximately up to the position k_1 of the cores since beyond a definite position the measures of the inductances variations no longer exhibit the required curve. In fact, the inductance which varied most rapidly before the critical position was obtained, varies beyond this position more slowly than the other which varied the slowest before the critical position. To obtain the maximum useful range, it is consequently desirable that not one, but both coils should be made with a non-uniform winding density, in which case the variation of the densities must, of course, be different.

Fig. 4 shows diagrammatically the use of a device according to the invention in a superheterodyne receiver. In this figure, 10 indicates a mixing tube, of which one grid has supplied to it the signal oscillation having a frequency f_s and another grid the auxiliary oscillation having a frequency f_o generated by the local oscillator, while the oscillation having a frequency f_m, being the difference between f_o and f_s, is taken from the anode. The signal circuit or preselection circuit, which is supplied in some way or other by the aerial 18, is constituted by the coil 11 whose inductance may be varied by means of the slidable magnetic core 13, and the condenser 12. The circuit for the auxiliary oscillation is constituted by the coil 14, whose inductance may be varied by means of the magnetic core 16, and the condenser 15. 17 shows diagrammatically a member by means of which the cores 13 and 16 are pushed simultaneously and in the same manner into the associated coils.

When the apparatus is tuned, it is necessary that in any position of the tuning means the condition is fulfilled that the difference between f_s and f_o is equal to a constant value f_m. It is usual that f_o is higher than f_s so that then the condition f_o-f_s=constant must be fulfilled. For a definite range of f_s, the ratio between the maximum and minimum values is in this case larger than for the corresponding range of f_o. Consequently, the inductance variation in the circuit 11, 12, 13 must be larger than that in the circuit 14, 15, 16, while in the latter this variation has to take place less rapidly than in the first-mentioned circuit. It appears from Fig. 3 that with the use of a coil of Fig. 1 in the preselection circuit and a coil of Fig. 2 in the circuit of the local oscillator these conditions can be satisfied.

Another application of a device according to the invention is shown diagrammatically in Fig. 5 which shows a preselector for a superheterodyne apparatus comprising special means for the suppression of the image frequency. In this figure, 18 is the aerial which supplies the signal to a preselector and 10 is the mixing tube which supplies an oscillation of the intermediate frequency f_m. Between the signal grid and the cathode of the tube 10 is connected a series resonant circuit 22, 25 which is tunable by means of the magnetic core 23. This circuit is tuned to the image frequency of the signal frequency f_s, i. e., to the frequency f_s+2f_m. For the frequency f_s the circuit 22, 23, 25 behaves as a capacitative reactance. By means of this reactance the coil 20, together with the magnetic core 21, is tuned to the signal frequency f_s, so that the signal of this frequency is transmitted with the highest possible intensity to the input grid of the mixing tube. The inductances of the coils 20 and 22 are varied by means of a member 24 which displaces the two cores 21 and 23 in the same manner. However, in order to satisfy the condition that the parallel circuit and the series circuit must exhibit a constant frequency-difference, the said inductances must be varied in different manners and to different extents, which may be obtained by utilising a device according to the invention.

What I claim is:

1. In a device for simultaneously tuning a plurality of oscillatory circuits to resonant frequencies differing by a substantially constant amount throughout the tuning range of the device, the combination of a plurality of tuning coils and movable magnetic cores slidable within the coils for varying the inductance thereof, each of said coils having substantially the same diameter and winding width and at least one of said coils having a winding comprising three winding sections, each winding section being spaced from the adjacently positioned winding section by a constant amount and having an inductance progressively larger than the adjacently positioned winding section the winding width of said coil being less than the length of the associated core.

2. In a device for simultaneously tuning a plurality of oscillatory circuits to resonant frequencies differing by a substantially constant amount throughout the tuning range of the device, the combination of a plurality of tuning coils and movable magnetic cores slidable within the coils for varying the inductance thereof, said coils comprising single layer solenoids having substantially the same diameter and winding width and at least one of said coils having a winding comprising three winding sections, each winding section being spaced from the adjacently positioned winding section by a constant amount and having an inductance progressively larger than the adjacently positioned winding section the winding width of said coil being less than the length of the associated core.

JAN VAN DER HEEM.